DIPLOMA THESIS

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MASTER OF ARTS IN LANDSCAPE ARCHITECTURE AND GARDEN ART

Urban Renewal Through Low Carbon Green Development

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Abstract

On the background of continued global warming, addressing the challenges posed by climate change has become a common task for all countries in the world. As one of the world's largest carbon emitters, China has responded positively to the call of the global organization and proposed the ambitious goal of achieving carbon neutrality by 2060. This brings a new development direction for old urban communities, whose green renovation and renewal are of great significance for achieving the carbon neutral goal.

This study will focus on the green renovation and renewal of old urban communities and explore effective ways to achieve carbon neutrality. Combined with the aesthetics of the site, the needs of residents' lives and the concept of low-carbon and green renewal, through in-depth analysis of the status and problems of the old community, targeted renovation programs and measures are proposed. These strategies aim to enhance the carbon sink potential of the community by increasing the area of green space, optimizing plant groupings and promoting vertical greening. It is also expected to contribute to the realization of China's carbon neutral goal.

This study not only provides scientific basis and practical guidance for green space planning in old communities, but also will provide useful references and examples for the renovation of old communities in other cities and regions, and jointly promote the process of global climate governance.

Keywords: Low Carbon; Carbon Sink; Carbon Storage; Landscape Design; Old community; Green development.

1. Introduction

1.1. Research Background

1.1.1. Global Climate Warming

High energy consumption in the process of rapid global economic development has brought about many problems. Excessive emissions of greenhouse gases have led to a rapid increase in carbon dioxide concentrations, causing phenomena such as global warming and the greenhouse effect, which have become important issues affecting the development of the international community. At present, human beings have raised the earth's temperature by about 1.1 degrees Celsius since the 19th century, mainly due to excessive carbon dioxide emissions from burning coal, oil and natural gas for energy. 2022 global carbon emissions data show that the top few countries are mainly populous developing countries and a small number of highly

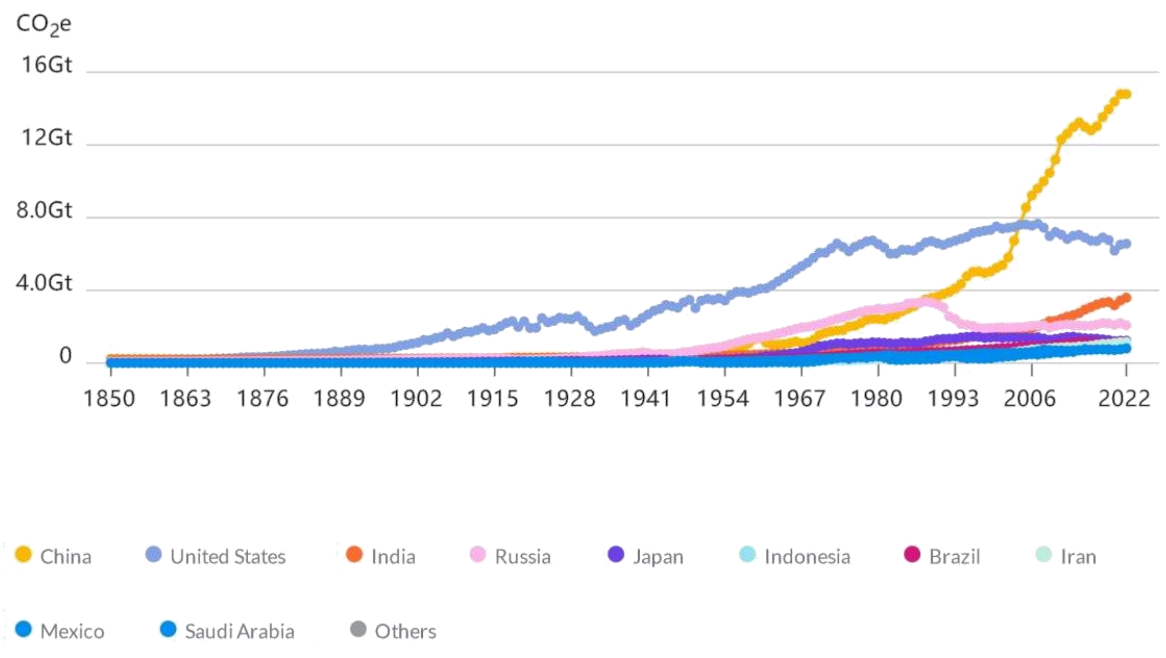


Fig. 1-1 Carbon emissions of the world's countries, 1850-2022. Source: Internet (climate watch)

developed countries. China, which is currently undergoing rapid development and has a large population, tops the list with 14,400 metric tonnes of carbon emissions in 2022. The United States is second, with 6,390 tonnes of carbon emissions in 2022.

Because it started its industrial revolution at the end of the 18th century, the growth phase of carbon emissions is over. It is followed by India, Russia, Japan and Brazil.

Increased carbon emissions have led to a range of natural disaster phenomena such as high levels of air pollution, land droughts, and melting glaciers.In July 2019, Australia experienced severe forest fires, with hot weather and severe drought being the main causes of forest fires that have been burning for months across the country. And it has been predicted that at the current rate of temperature increase, some coastal countries will be inundated by sea water due to melting glaciers by 2050 [1]. The adverse effects of global warming are not limited to environmental degradation, but also include the destabilization of natural ecosystems. In regions with cold climates, the decrease in plant and animal habitats highlights the far-reaching ecological impacts. Urban centres are densely populated centres where the potential for extreme weather events is increasing as a result of the rising impacts of climate change. These challenges highlight the need for concerted global action to mitigate the harmful effects of climate change and promote sustainable development pathways.

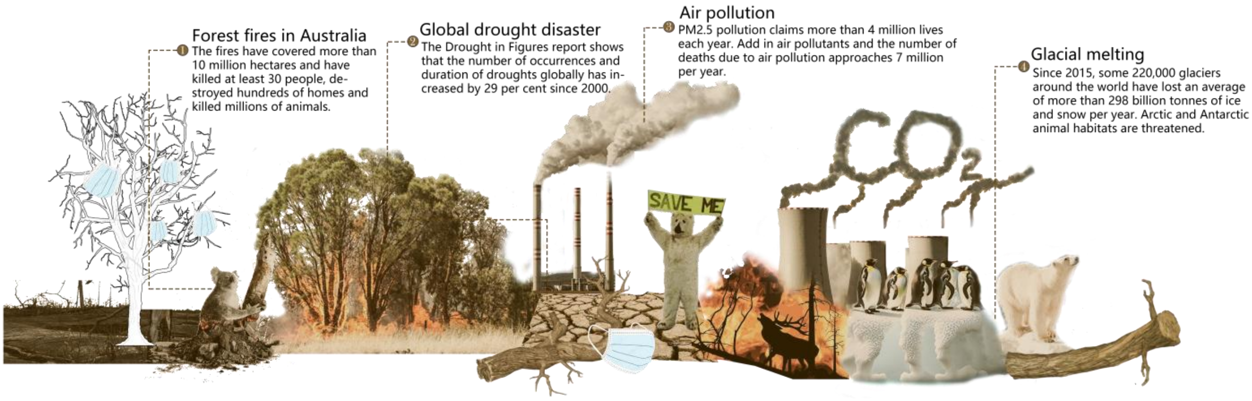


Fig. 1-2 A series of natural disasters caused by carbon emissions. Source: by author

1.1.2. Carbon Sink Policies in the World and China

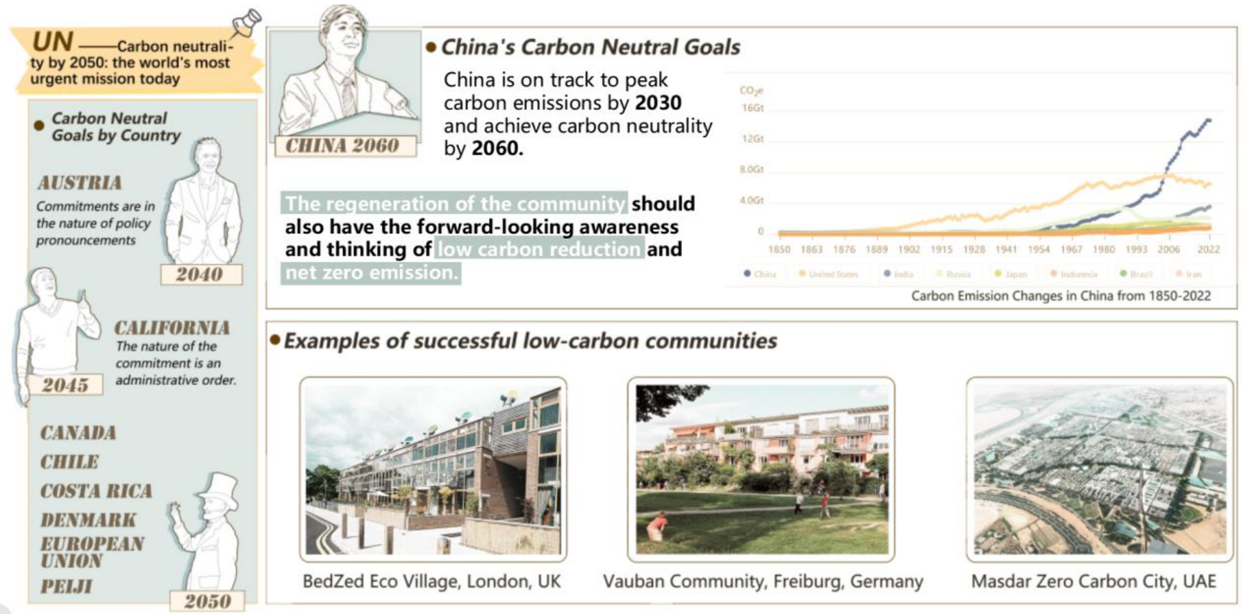


Fig. 1-3 Carbon neutrality targets for countries around the world. Source: by author

In the face of existential threats, the United Nations Climate Change Conference emphasized in the Copenhagen Accord that countries around the globe should join hands and actively advocate the concept of low carbon in order to achieve the goal of sustainable development, thereby effectively addressing the huge challenges posed by climate change. Therefore, achieving carbon neutrality and global temperature control has become a general consensus among countries. Every country, city and enterprise should formulate and implement low-carbon emission plans to jointly combat climate change and promote inclusive and sustainable green growth. We must act now and strive to reduce global carbon emissions by 45 per cent by 2030 compared with 2010.

According to the relevant policies, governments of all countries have made different commitments on the basis of fulfilling their own responsibilities. Australia is the first country to commit itself to achieving the carbon neutrality target, setting the target at 2040. It is followed by countries such as Canada and the European Union, which have promised to achieve the carbon neutrality target by 2050. China has promised to aim for peak carbon emissions by 2030 and endeavour to achieve the carbon neutrality target by 2060, thus contributing to global emission reduction.

Achieving carbon neutrality by 2060 means that our lives will change dramatically in the future, in ways of living, travelling, supplying and consuming energy, and so on. Therefore, as landscape architects, we must be forward-thinking and need to consider factors such as low carbon emissions and achieving net zero emissions to shape the future landscape of our cities. This includes creating more environmentally friendly and sustainable urban environments through design innovations that incorporate the characteristics of natural ecosystems to provide better spaces and conditions for future human life.

1.1.3. Significant carbon sink effect of urban green space

Research on urban green space began at the beginning of the last century, when experts, scholars and city officials focused mainly on the beautification of the city and the relationship and distance between the urban green space system and residential areas. It was only after the middle of the last century that people began to pay attention to the relationship between urban green space, urban climate and urban environment.

Now the whole world has entered the construction planning of "low carbon city", and it is well known that urban green space has an irreplaceable role in improving and upgrading the urban environment, which has been paid attention by urban planners and builders earlier. In recent years, with the process of urbanization and the improvement of people's environmental awareness, urban residents are not only concerned about the greening and beautification of the urban environment, but also more concerned about the spiritual pleasure and physical health brought by urban green space, and the ecological function of urban green space has therefore received more and more attention.

Urban green space not only plays an important role as a carbon sink, but also has far-reaching implications for achieving carbon neutrality. The key to carbon neutrality lies in balancing the amount of carbon dioxide emitted with the amount removed or stored. As well as achieving this by reducing carbon emissions and increasing the amount of CO2 absorbed by plants, urban green spaces are themselves the only natural carbon sinks in cities. Plant growth is the only method of carbon sink that does not consume energy, and not only does it not increase energy consumption, but also effectively reduces carbon emissions compared to other carbon sink methods.

In addition, urban green spaces have multiple functions and meanings. They can not only improve the quality of the urban environment and absorb harmful substances in the air, but also provide a place for recreation and entertainment and enhance the quality of life of urban residents. Moreover, urban green spaces help to protect biodiversity and improve the stability of urban ecosystems and their ability to withstand natural disasters.

Studies have shown that mastering the distribution pattern of plants and their influencing factors is the key to effectively achieving carbon neutrality. Through the rational layout of green space, as well as the density and size of green space patches, urban green space can realize the cold island effect, thus reducing energy consumption such as air-conditioning in summer and achieving indirect emission reduction [2]. Simulation studies in Los Angeles have shown that a tree can save energy consumption equivalent to 18kg less carbon emissions per year, while the carbon it absorbs itself is only 4.5-11kg per year [3]. Of course, the construction and management of urban green space should itself achieve emission reductions through material reuse and the use of clean energy.

Currently, urban green space is useful in promoting the goal of carbon neutrality in four ways: sequestering carbon and releasing oxygen, reducing the urban heat island effect, enhancing the stability of urban ecosystems and improving environmental quality.Firstly, sequestering carbon to release oxygen is the most direct way to increase carbon sinks. Plants absorb energy from sunlight through chlorophyll on the surface of their leaves and use water and carbon dioxide for photosynthesis [4], then fix large amounts of carbon dioxide in biomass, such as stalks, stems, trunks, and roots, and release oxygen molecules. Secondly, reducing the urban heat island effect can indirectly reduce emissions. Urban green space can reduce the degree of urban heat island effect by absorbing solar radiation, evaporative cooling, providing shady space, purifying air and lowering the surface temperature of buildings [5], which greatly improves the quality of the environment and people's living comfort [6]. Thirdly, increasing green coverage, improving vegetation diversity, improving soil quality and other measures can enhance the resilience of urban ecosystems, reduce the deterioration of the ecological environment and improve urban ecological stability.Finally, urban green space can absorb harmful gases and particles in the air, purify the air and improve air quality. Improving environmental quality can also reduce people's demand for energy, thereby reducing carbon emissions and contributing to the goal of carbon neutrality.

This highlights the importance of urban green spaces in the process of carbon neutrality and their irreplaceable role in promoting sustainable urban development and improving the quality of urban life. Therefore, we should fully recognize the value and significance of urban green spaces, strengthen the construction of urban green spaces and improve the quality and quantity of urban green spaces.

1.1.4. Older urban communities in need of low-carbon renewal

China's urbanization is showing a rapid trend, and with it the rapid growth of the urban population. A variety of factors such as outdated construction standards, an ageing population and poor management have combined to create a large number of old communities in cities. Older communities are urban residential areas that were built earlier and have more obvious problems such as deteriorating infrastructure, chaotic management and dirty environment. Most of these communities, which were previously built with government and institutional funding, are significantly out of step with the development of the times compared to those built after the 1998 commercial housing reform. According to preliminary statistics from China's housing and construction authorities, nearly 170,000 old communities exist nationwide, involving more than 42 million households and a total building area of about 4 billion square metre. However, buildings and facilities in residential areas are one of the main sources of carbon emissions in cities.

On the other hand, these old communities were originally not reasonably designed and had inadequate infrastructure. With the progress of time, the facilities in the community have continued to deteriorate, with inadequate and functionally inconvenient parking spaces, which have also made the living environment of the residents of the community less livable. In addition, these old communities are generally not energy-efficient and environmentally friendly, with high carbon emissions and low carbon sink capacity in green spaces[7].

In summary, the problems are mainly inadequate infrastructure and excessive energy use. Inadequate infrastructure is mainly reflected in the lack of public spaces and green areas, and inadequate parking spaces. Excessive use of energy is mainly due to excessive reliance on electricity, lack of new energy-saving equipment, waste disposal systems and renewable energy sources.

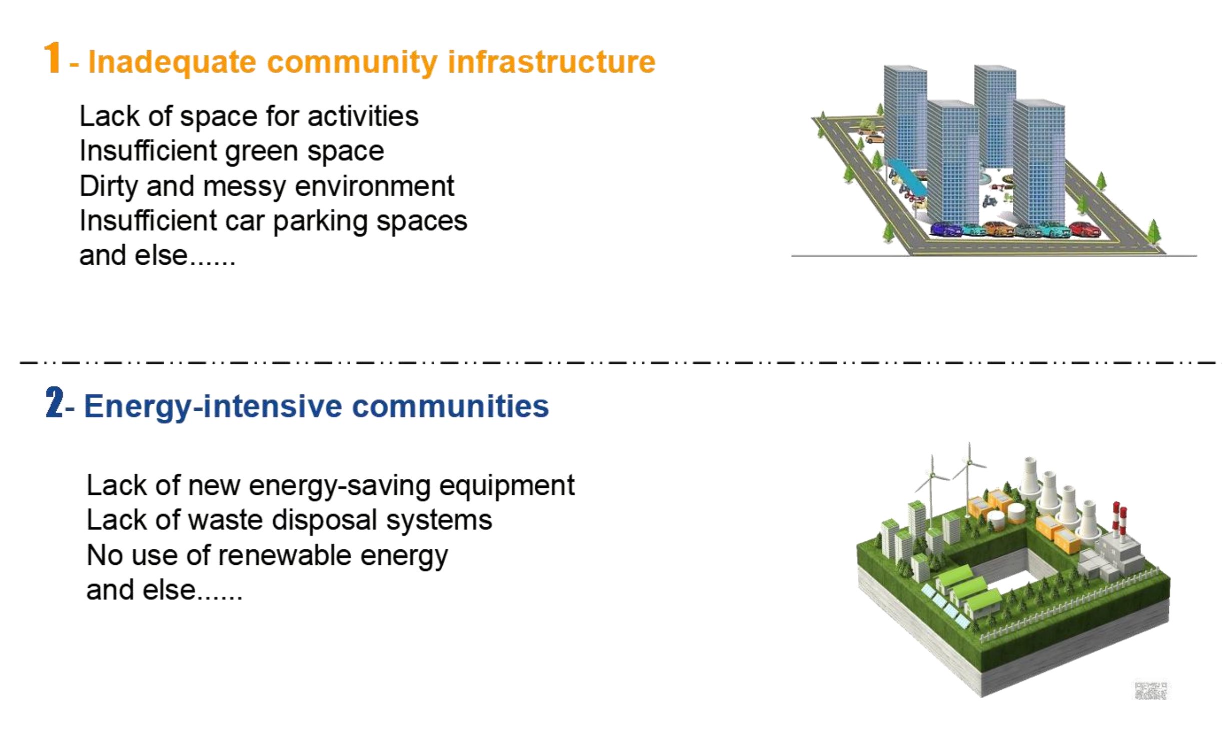


Fig. 1-4 Carbon neutrality targets for countries around the world. Source: by author

In order to solve these problems, we need to take effective measures to improve people's living environment and address the current situation and problems such as dirty, not low-carbon, not environmentally friendly and not beautiful. This includes upgrading infrastructure, improving energy efficiency, introducing energy-saving technologies and equipment, improving building energy efficiency and reducing energy consumption. This will not only enhance residents' quality of life and sense of well-being, and increase the attractiveness and competitiveness of the city, but also promote the sustainable development of China's cities and contribute significantly to the achievement of the 2060 carbon neutrality target.

1.2. Literature Review

1.2.1. Literature analysis

Analysing data from the literature can help to provide objective evidence, reveal research trends and identify gaps in current research.

This paper analyses data from current research on the carbon impact of urban green space. CiteSpace was used (Citespace is a scientific literature analysis tool jointly developed by Dr Chao-Mei Chen of Drexel University's School of Information Science and Technology and Dalian University of Technology's WISE Laboratory). The results were obtained from the Web of Science (WOS) Core Collection (1985-2023), which is a large database of English-language research results, and analysed and compared with the results of various subjects on the aspect of "research on the carbon impact of urban green space". The analysis was visualized and compared with the results of various subjects on the carbon impacts of urban green spaces.

In this way, we can judge the current status of research on this issue in different subjects, the related results, the current research deficiencies and the future development trend. It is hoped that this study will provide new research ideas and scientific planning directions for urban green space planning in China in the future.

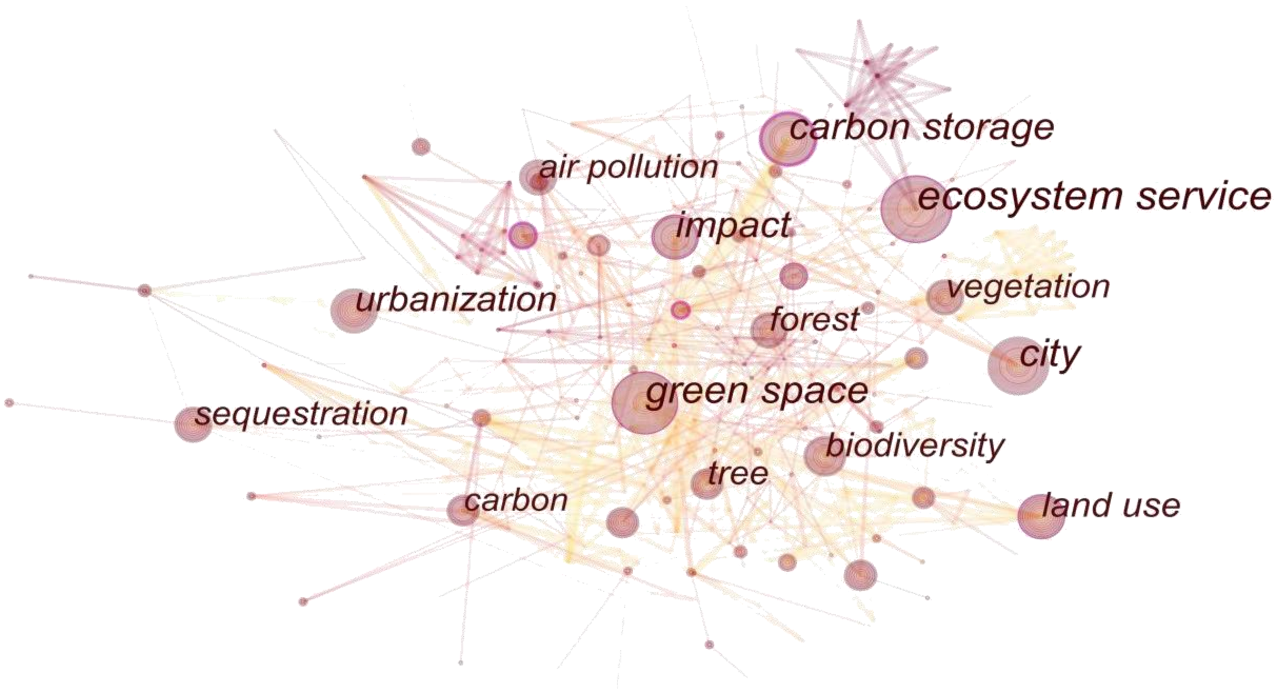


Fig. 1-5 Hot words in current research. Source: by author

1.2.1.1. Search keywords

In the WOS Core Collection database, 428 papers were searched with the keywords "carbon" AND "green space*", "greenbelt*", and "green field" and "green open space" for the years 1985-2023 in the English-language literature.

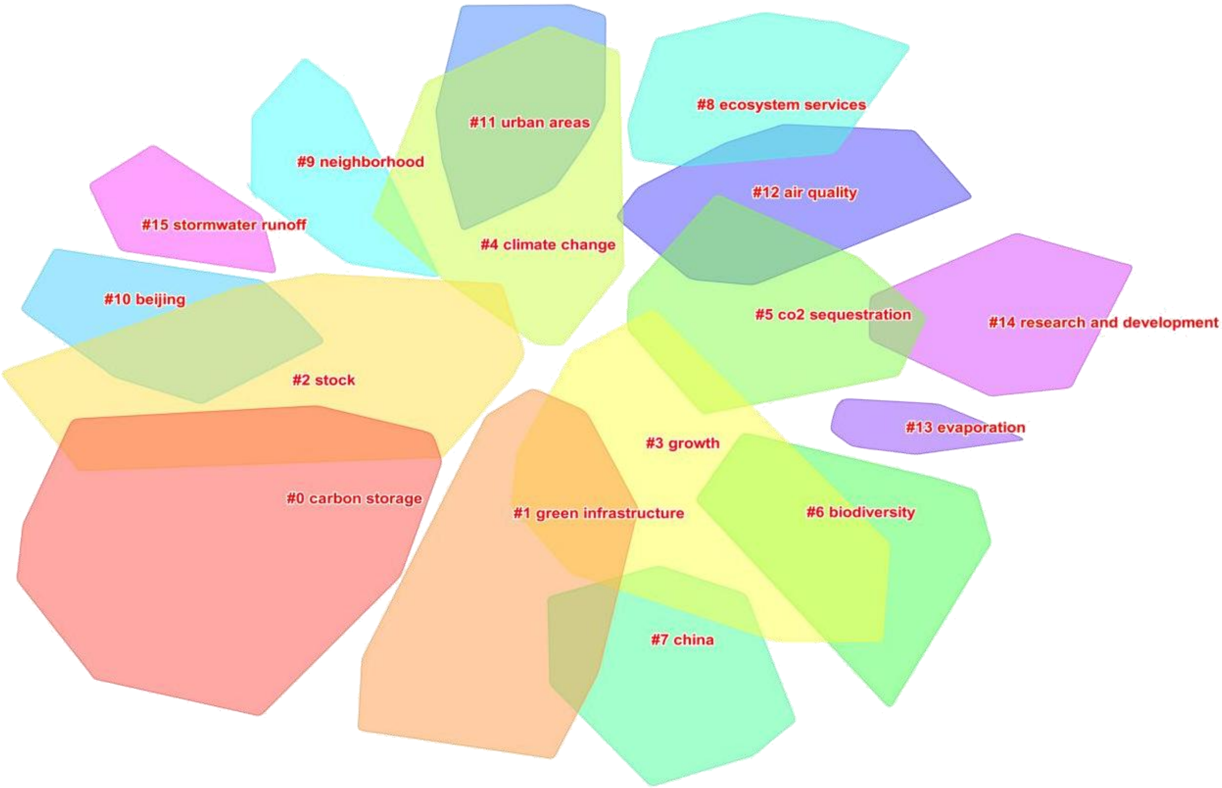


Fig. 1-6 Clustering diagram for keyword co-occurrence. Source: by author

1.2.1.2. Characteristics of keyword change

Based on the trend of keyword evolution, both Chinese and international research can be divided into four phases: the beginning, development, expansion and promotion, each of which has different performances and characteristics. There are some similarities between the development of Chinese and international research, and the differences are as follows: (1) Chinese research started relatively late, while the trend of rapid growth is relatively strong; (2) international research is more mature and closely integrated with the theoretical direction of the scientific advancement, while Chinese research is currently in a period of rapid development, and is more linked with national strategies and policies.

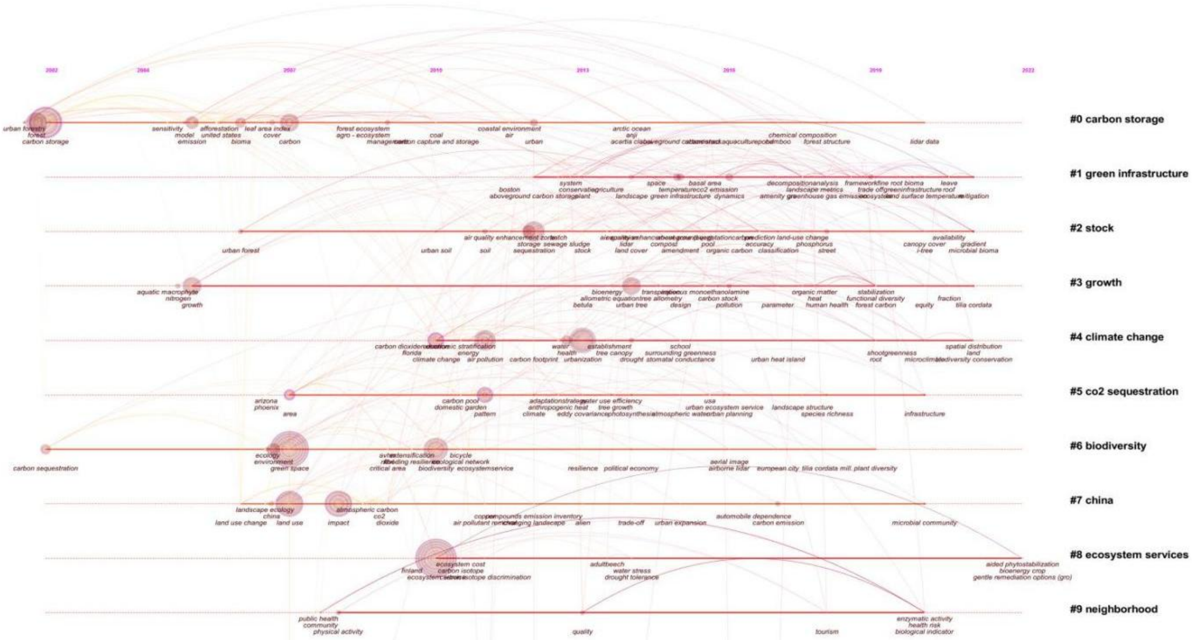


Fig. 1-7 Timing diagram for keyword co-occurrence. Source: by author

1.2.2. Current research status

1.2.2.1. Conceptual research

(1) Research on Key Influencing Factors

According to the existing research results, the reasons affecting carbon emissions are complex and numerous. Urbanization affects biodiversity and carbon dioxide emissions by changing land use types, reshaping landscape patterns, and changing ecological processes such as climate and hydrology. Research shows that cities have more impact on carbon emissions than rural areas, and that cities produce the majority of the world's carbon emissions. The larger the population, the higher the density of urbanization, the more carbon is emitted. The impact of urban green space systems on carbon sinks has been proven, including parks, production green space, protection green space, ancillary green space and other green space, as well as road greening and water, and important ecological landscape areas, and so on. If the original planning and design, scientific site selection and rational data analysis, unified planning and layout to form a large overall ecosystem. This will reduce a large amount of carbon emissions and also achieve carbon sequestration, which has a huge role in achieving carbon neutrality.

(2) Research on scientific assessment

The assessment of carbon sequestration capacity of urban green space system is also a method to achieve carbon neutrality. The plants that have the most influence on carbon sequestration in the green space system are plants, including trees, shrubs, ground covers and vines. Reasonable planning of plant group layout, and group matching, and selection of tree species with strong carbon sequestration capacity play an important role in achieving carbon neutrality. The study also includes methods such as the heterogeneous growth equation that can be used to measure the carbon storage capacity of plants, which can also be used to analyse the role of certain green systems in building a low-carbon city.

(3) Research on distribution pattern

The largest carbon sinks in the city are the green patches distributed in the city, which are also the only natural carbon sinks in the city. The largest carbon sinks in urban green spaces are trees and plants, so understanding the distribution pattern of plants and their influencing factors is the key to effectively achieving carbon neutrality. Research has found that the amount of carbon emissions reduced through rational planning and layout of urban green spaces may be more than the amount of carbon absorbed by the plants themselves. The carbon sequestration capacity of compound plant structure is higher than that of double-layer plant structure, double-layer plant structure is higher than that of single-layer plant structure, and the carbon sequestration benefit increases with the increase of plant level[8].

1.2.2.2. Applied research

(1) Research on planning strategies

Studies have shown that scientific and reasonable planning can change the morphology and spatial pattern of the whole city and form a green site from the fragmented patches, which can maximize the oxygen and carbon sequestration effects of urban green spaces[9]. International studies point out that the first principle of planning is to emphasize the priority of biodiversity, and that the key is to link green spaces into a network through the construction of green infrastructures at different spatial scales, including regional, urban and community scales. The most commonly recognized planning method is Systematic Conservation Planning (SCP). Research in China has mainly focused on the statutory planning system, focusing on four aspects: (1) urban and rural planning, which realizes the ideal of urban and rural planning for biodiversity conservation by optimising the urban and rural landscape pattern; (2) conservation planning, which includes plant mixes in urban green space systems and the creation of animal habitats, as well as conservation strategies and measures to improve the biodiversity of the city; (3) Restoration planning, which focuses on the fragmentation of sites and allows them to grow and recover on their own with minimal human intervention; (4) Ecological corridor planning, which focuses on linking existing green spaces to form a landscape protection network at different scales.

(2) Research on management strategies

In the past, urban policy makers have neglected later management and maintenance, focusing only on the early stages of planning and design, but the later management of urban green space systems has a huge influence. International studies have pointed out that the primary issue of management is to eliminate the gap between scientific research and policy making, and that scientific research should be transformed into clear, specific and detailed conservation goals and policies, and the most effective way to promote this change is for managers to promote and coordinate the actions of various stakeholders.

In addition, the management practices and intensity of urban green spaces can have a significant impact on carbon emissions, e.g. replanting trees in parks can lead to increased CO_2 emissions from urban green space systems due to relatively high maintenance management and death rates[10]. Higher growth rates and death rates mean higher emissions because more biomass needs to be cleared by fossil fuel maintenance equipment. According to research, there are multiple possible design alternatives for urban green space projects. For example, empty land can simply be designed as a lawn, and the intensity and frequency of maintenance may be different[11].

1.2.3. Shortcomings of the current research

Currently, research on low-carbon green space landscapes in China and internationally primarily focuses on exploring design concepts, application methods, and scientific verification. Utilizing RS and GIS technologies combined with studying urban carbon sequestration and oxygen release capacity in urban green space systems, applying scientific techniques to provide reasonable solutions for planning and construction has become a current research hotspot. China focuses more on the design concept of landscape green space, emphasizing "increasing carbon sinks" and "reducing carbon sources," and pays attention to the low-carbon aspects of landscape elements; while internationally, there is more emphasis on empirical research on landscape elements such as plants, soil, and water bodies, providing data support and formulating systematic low-carbon landscape design frameworks.

However, overall, there are still many shortcomings in the current research on achieving true low-carbon through the rational planning and design of urban green spaces: (1) Lack of comprehensive research, with many studies focusing only on specific areas and local landscape elements, without considering aesthetics and livability; (2) Research on the oxygen release and carbon sequestration of current urban green space plants is still in its early stages, mostly theoretical research, without sufficient long-term and accurate practical case data to support it; (3) The theoretical research on the oxygen release and carbon sequestration capacity of urban green spaces has not been well integrated with practical case studies.

Planning a low-carbon urban green space system that aligns with current carbon neutrality trends, meets the needs of residents, and promotes ecological sustainability has become the collective aspiration of humanity. The primary reason for researching the oxygen release and carbon sequestration capabilities of plants in urban green space systems and urban ecological land use is also driven by the current needs of urban development. Conducting detailed research on urban green space systems, establishing harmonious relationships between humans and nature, and seeking balanced development models will be the future research directions.

In summary, the expansion directions for future research on urban green space system planning in China may include the following aspects:

（1）Expansion of research subjects. Breaking through existing limitations, the scope of research extends from urban green space plant design to various activities within the green space system that may potentially release carbon dioxide. The research scale extends from the micro-level to the meso-level, exploring potential factors and subjects of carbon emissions from different types and activities. On one hand, it is necessary to expand research from within the green space system to activities outside the green space, including various behavioral activities within the surrounding area such as crowd activities and daily maintenance. On the other hand, it is necessary to expand from traditional urban green spaces to various areas with potential for greening, including rooftops, walls for vertical greening, as well as microspaces such as balconies, windowsills, building eaves, etc., to consider a series of methods for achieving carbon neutrality.

（2）Expansion of research content. In response to the current situation, future research should focus on enhancing the expansion of basic research, applied research, research scale, and research dimensions. In terms of basic research, there should be an emphasis on foundational data research such as investigation, evaluation, and understanding of impact mechanisms, which play a supportive role in the correct and rational planning, design, and management practices of urban green space systems to achieve carbon neutrality. To address specific practical needs, evaluations, feature analyses, impact assessments, and monitoring feedback should be conducted for different spatial scales and types of activity carriers. In the direction of applied research, attention should be given to China's urban conditions, development stages, and management systems. The development and application of new methods, technologies, and materials for planning and design should be pursued as secondary factors to achieve the goal of carbon neutrality.

1.3. Research Purpose and Significance

1.3.1. Research Purpose

Combining China's current carbon neutrality goals with the rapid urbanization process leading to issues in aging communities, this study aims to explore and propose the feasibility and effectiveness of using low-carbon green methods to renovate old communities in urban areas. The main objective is to address typical problems in two aging communities, namely inadequate infrastructure and energy intensity.

Firstly, this study plans to select a typical old neighborhood in the urban center of Jinshui District, Zhengzhou City, Henan Province, China. Through on-site surveys, satellite remote sensing data, and the i-tree model, relatively accurate maps of carbon storage and spatial distribution of green vegetation in this neighborhood will be obtained. The data on the green space structure and infrastructure in the neighborhood will be organized. Subsequently, by analyzing and evaluating different low-carbon green technologies, strategies, and implementation plans, a comprehensive set of renewal proposals will be formulated for low-carbon green updates to the neighborhood. This aims to improve the environmental quality of old neighborhoods, promote resource conservation and reuse, and minimize carbon emissions and environmental impacts. Finally, the characteristics of the designed green space structure model will be summarized, and the carbon sequestration data after design will be compared and evaluated against the pre-design data.

1.3.2. Research Significance

Based on existing carbon sequestration conditions and site conditions, implementing precise green space planning strategies and accurately calculating carbon sequestration data can effectively increase the green space area of the site, enhance the carbon fixation and storage capacity of the neighborhood ecosystem, and also contribute to more precise and effective green space planning and management. This promotes urban sustainable development and the timely achievement of carbon neutrality goals. Therefore, conducting research on this topic is of practical significance.

1.4. Relevant concepts and analytical methods

1.4.1. Relevant concepts

(1) Carbon Sink

A carbon sink is a natural or artificial reservoir capable of indefinitely accumulating and storing carbon compounds (especially carbon dioxide). These carbon sinks can be forests, soils, oceans, permafrost, etc. Specifically, there are two types of carbon sinks: natural carbon sinks and artificial carbon sinks[12].

Natural Carbon Sink: This includes ecosystems such as forests, wetlands, grasslands, oceans, and soils. In these ecosystems, plants absorb carbon dioxide from the atmosphere through photosynthesis and convert it into plant biomass (such as trees and vegetation).

Artificial Carbon Sink: Humans utilize measures such as afforestation, reforestation, forest management, and vegetation restoration to absorb carbon dioxide from the atmosphere through plant photosynthesis. This carbon dioxide is then sequestered in vegetation and soil, thereby reducing the concentration of greenhouse gases in the atmosphere. This contributes to mitigating global climate change. Carbon sinks play a crucial role in achieving carbon neutrality goals. Through various design strategies and methods, we can enhance the capacity of carbon sinks and reduce greenhouse gas emissions.

（2）Carbon Storage Capacity

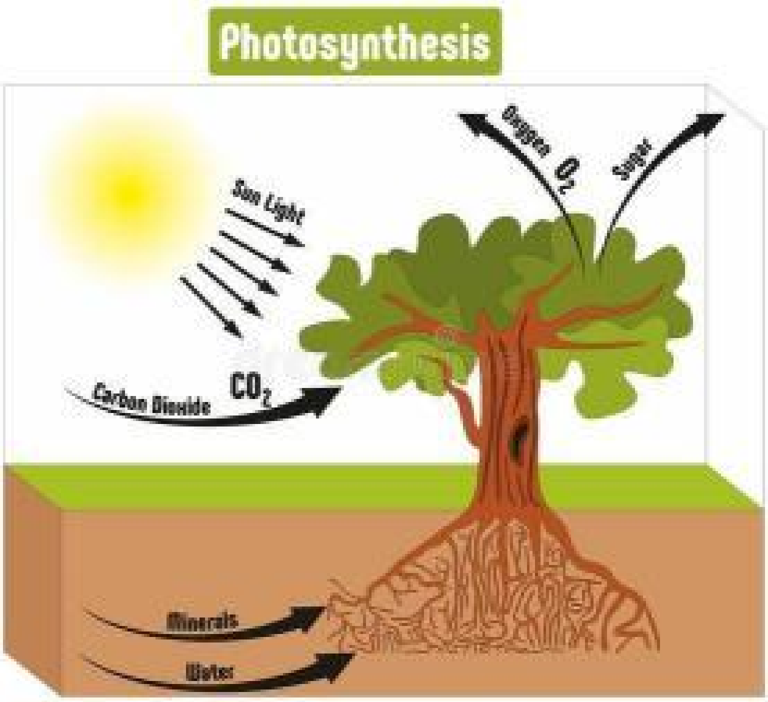


Fig. 1-8 Plant carbon sequestration diagram. Source: Internet

It refers to the amount of carbon that a system (such as a forest, wetland, soil, etc.) can store per unit area or unit volume. This term is commonly used to describe the amount of carbon elements that both living and non-living components of an ecosystem can absorb, fix, and store during the carbon cycle process. For instance, in a forest ecosystem, plants absorb carbon dioxide from the atmosphere through photosynthesis, convert it into organic matter, and store it in trees, trunks, leaves, and soil, thereby exhibiting high carbon storage capacity.

（3）Carbon Sequestration Capacity of Plants

It refers to the ability of plants to convert atmospheric carbon dioxide into organic carbon through photosynthesis and store it in plant tissues. This process is one of the crucial carbon cycling processes in ecosystems. Through carbon sequestration, plants not only absorb carbon dioxide from the atmosphere but also convert it into organic substances (such as glucose), thereby storing carbon in plant roots, stems, leaves, and other tissues[13]. This carbon storage not only promotes the growth and development of plants but also helps reduce carbon concentration in the atmosphere, playing a role in climate regulation. Therefore, the carbon sequestration capacity of plants plays a crucial role in carbon cycling and climate regulation within ecosystems.

（4）Carbon Neutrality

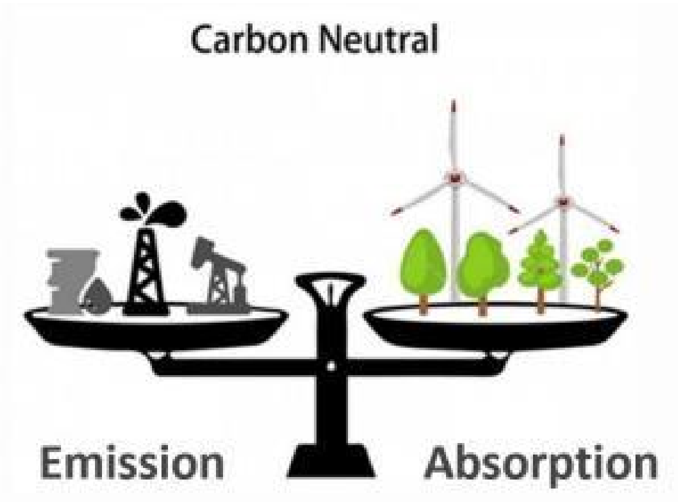


Fig. 1-9 Carbon neutral diagram. Source: Internet

Carbon neutrality refers to achieving a balance between carbon emissions and carbon absorption in the atmosphere through reduction, offsetting, or removal of carbon emissions. This means reducing carbon emissions to a level that matches the capacity of the environment to absorb and process them, thereby mitigating the impacts of climate change and global warming. Carbon neutrality can be achieved through various methods, including reducing carbon emissions and increasing carbon absorption (such as through afforestation).

（5）Low-carbon Green Renewal

Low-carbon green renewal refers to the use of green and low-carbon methods and technologies in urban or rural renewal processes with the aim of reducing carbon emissions, improving resource efficiency, and enhancing environmental quality. It involves the transformation and upgrading of urban buildings, infrastructure, transportation systems, etc., with the goal of achieving sustainable urban development, promoting harmonious coexistence between humans and nature, and providing a higher quality of life for the future. Specifically, low-carbon green renewal includes measures such as green buildings, green transportation, resource recycling, and ecosystem protection. By adopting energy-saving materials, optimizing energy use, promoting clean energy, improving transportation systems, and increasing green coverage, adverse environmental impacts can be reduced, residents' quality of life can be improved, and contributions can be made to global sustainable development.

（6）Low-carbon Community

A low-carbon community is a type of community developed in urban or rural areas that aims to build an efficient, energy-saving, and recycling system through the promotion of green buildings, innovative low-carbon technologies, and advocating green lifestyles. The goal is to achieve net-zero or negative carbon emissions at various stages of construction, renovation, and operation of the community through carbon emission reduction and carbon offset measures. This means that low-carbon communities are committed to reducing carbon emissions and achieving sustainable development goals by reducing energy and resource consumption, improving energy and water resource utilization efficiency, and enhancing waste disposal methods. Low-carbon communities emphasize community residents' participation and cooperation and aim to reduce greenhouse gas emissions, lower energy consumption, improve air quality, and protect the ecological environment through strategies such as energy conservation, emission reduction, and resource recycling. They serve as important demonstrations and practical foundations for building healthier, more livable, and sustainable cities.

1.4.2. Analytical methods

The following two methods and two software were used in this study to analyze and research:

（1）Literature review method

Collect, identify and organize a large number of relevant literature, including academic papers, journal articles, etc., and understand and study relevant policies and regulations. Get an insight into low carbon design in China and internationally, low carbon calculation methods and low carbon landscape design. Through studying theories and practical cases related to urban renewal, old communities and green renovation, I will gain a comprehensive understanding of the current situation in China and internationally regarding the low-carbon renewal and renovation of old communities. And i will study and summarize advanced experiences to provide effective ideas and methods for the low-carbon renovation and transformation of old communities in the city center.

（2）Field research method

Fig. 1-10 Site Photo. Source: by author

The following information can be obtained through research methods such as field surveys in the affiliated community of Henan Agricultural University, Jinshui District, Zhengzhou City, Henan Province. On the one hand, we can get the real and effective data of the current situation of the community in the functional space, traffic space, green space and other aspects; On the other hand, through the discussion with the residents can understand the real feelings and needs of the local residents, and the accurate plant data obtained from the research is helpful for analyzing and solving problems.

（3）I-Tree Eco Model software

i-Tree

Tools for Assessing and Managing

Forests & Community Trees

Fig. 1-11 Software name. Source: Internet

The I-Tree Eco Model software was utilized for carbon sequestration measurement in this study. Detailed information on plant diameter at breast height (DBH), crown width, and health condition was obtained through field surveys, and precise carbon sequestration data was computed by the software. The software was created by the U.S. Department of Agriculture Forest Service (USDA Forest Service) to assess the value of ecological services of cities and urban forests, which includes the evaluation of carbon storage and carbon sequestration. It utilizes tree inventory data and Geographic Information System (GIS) technology to help users estimate carbon storage, carbon absorption, and other ecological services of urban forests, such as climate regulation, air purification, and water resource protection.

In the study of carbon, i-Tree Eco Model provides a scientific approach to assessing the contribution of urban forests to the carbon cycle. By analyzing information such as tree species, quantity, size, distribution, as well as growth rates and survival rates of trees in urban forests, the software can estimate the carbon storage and annual carbon absorption in urban forests[14]. These data are important for offsetting urban carbon emissions, evaluating urban carbon balance, and formulating strategies for urban climate change adaptation.

This provides urban forest managers, urban planners and environmentalists with a powerful tool to help us better understand and assess the impact of urban forests on the carbon cycle and to promote the sustainable development of urban ecosystems.

（4）SPSS software

SPSS (Statistical Package for the Social Sciences) is a statistical analysis software used for data analysis and statistical modeling.It provides a wide range of statistical analysis functionalities, including descriptive statistics, inferential statistics, data visualization, data cleaning, and processing, making it suitable for research and applications in various disciplinary fields.

In carbon-related research, SPSS software can be used to analyze and process data related to carbon emissions, carbon storage, and carbon cycling.For example, SPSS can be used to compare and statistically analyze carbon emission data from different regions or time periods to understand trends and differences in carbon emissions.Additionally, SPSS can be used to analyze various factors affecting carbon emissions, such as economic development levels, energy consumption structures, industrial compositions, etc., to assist governments and decision-makers in formulating more effective carbon emission reduction policies and measures.

Furthermore, SPSS can also be utilized to establish carbon emission prediction models and carbon reduction scheme evaluation models. By modeling and analyzing carbon emission data and relevant influencing factors, it can predict future carbon emission trends and evaluate the impact of different emission reduction measures on carbon emissions. This provides a scientific basis for the formulation and implementation of carbon emission reduction policies.

1.5. Outstanding cases and analysis of low-carbon community

1.5.1. Outstanding cases of low-carbon community

Beddington Zero Energy Development Community in the United Kingdom（BedZED）

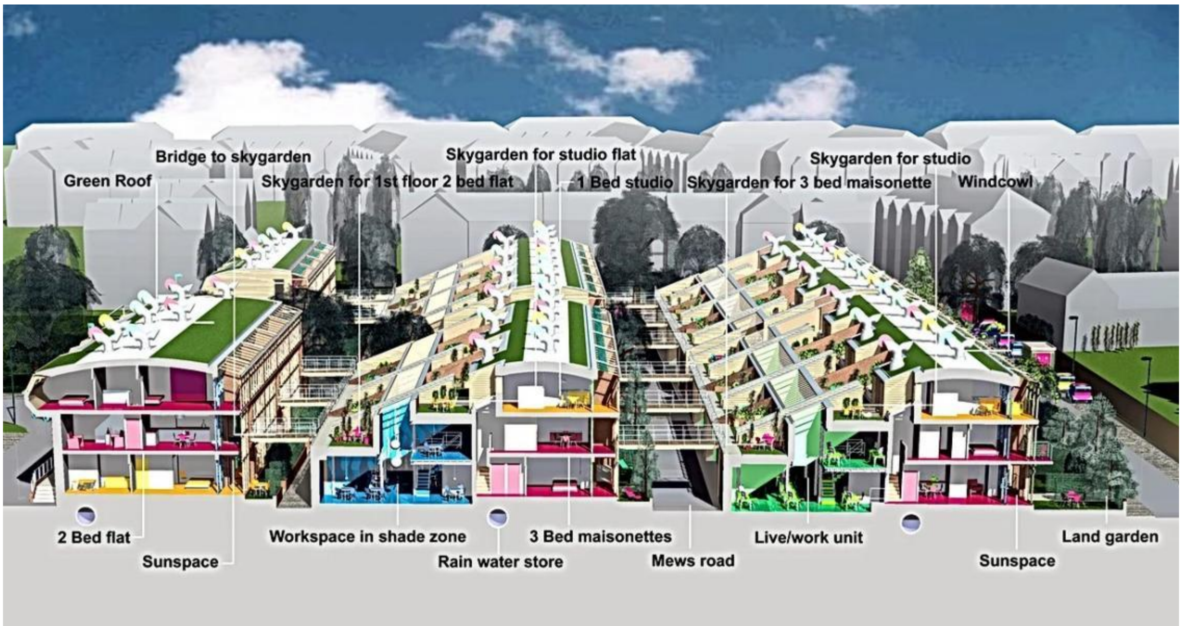


Fig. 1-12 Pattern picture of Beddington's zero-energy community. Source: Internet

The 1.65 hectare community was designed by famous low carbon architect Bill Dunster. It was completed in 2002 and is the largest low carbon sustainable community in the UK. The community includes 82 apartments and 2,500 square meters of office and commercial living space, and when completed will be a pioneer in the world of low carbon construction.

Beddington community is built on an abandoned site. The design focuses on the use of sustainable building materials that are "natural, reclaimed, and found within a 35-mile radius of the eco-village.

Furthermore, mixing office and residential buildings is aimed at alleviating transportation energy consumption.The design of multifunctional public spaces within the community, such as sports fields, vegetable gardens, bathing facilities, and entertainment centers, maximizes residents' ability to meet their daily needs within the community, thus reducing travel energy consumption.

Designed for clean energy, the Beddington community uses a cogeneration system to provide domestic electricity and hot water to the community.

In building design, architects take various measures to reduce building heat loss and make full use of the sun's thermal energy to achieve the goal of not using traditional heating systems.

In the utilization of resources, recycling is achieved through rainwater harvesting devices and "organic treatment of domestic wastewater".

Create green transportation. The community has an excellent public transportation network, including two train platforms to London and community bus routes. The developer has also built bike parking and bike paths, following a "pedestrian first" policy.

Installation of home energy saving equipment. All homes are installed with refrigerators, refrigeration equipment and cooking equipment that are the least harmful to the environment; there is a wide range of energy-saving equipment in the homes.

As a typical green eco-community, Beddington's "zero-energy" concept has always been present in the community's planning, design, construction, environmental protection and other hardware. It is also reflected in the green culture it promotes and the establishment of a comprehensive environmental management system.

（1）Sun and Wind Community in Beder, Denmark

Fig. 1-13 Photo of the Sun and Wind Community. Source: Internet

The Sun and Wind community was built in 1980.This low-carbon community is entirely self-organized and built by residents. A group of 30 local residents volunteered to discuss and discuss low-carbon ideas, develop a plan for the community, and participate in the entire process of planning, designing, and building the community from start to finish. Such a community is not just a house, but truly a home built with the hearts and minds of the residents of the community. Such a community is full of warmth.

In low-carbon design, the following main methods are used:

Use of solar energy:The community was designed with a 45 degree roof angle to facilitate the installation of solar panels to maximize the absorption of sunlight. The community has a total of 600 square meters of solar panels installed. Based on the energy source, solar energy provides 30% of the community's energy supply.

Use of wind energy: A 20m high wind tower has been placed by residents on a hillside 2km away from the community. The wind tower operates under the action of the wind, generating a continual power supply that meets some of the community's electricity needs. Wind energy generated by wind towers contributes about 10% of total community energy consumption.

Public Green Spaces and Gardens: The community has public vegetable gardens and public green spaces. A large number of plants can enhance the circulation of materials within the community, and on the other hand, can increase the productive function of the natural landscape, reducing the dependence on external resources and the overall energy consumption due to transportation.

Public Housing Design: Public housing provides an ideal place for people to communicate with each other. The public housing area is divided into adult and children's areas, with places for children to play and for adults to talk.

1.5.2. Case study of low-carbon community

Based on two previous success cases, we can get some inspiration:

（1）Beddington Zero Energy Development Community in the United Kingdom（Bed ZED）

A large number of fast-growing forests have been planted around the community, making it possible to utilize this renewable energy source for electricity and heating, thereby saving on the use of fossil fuels. On the other hand, the community takes full advantage of the British weather conditions and cleverly uses solar and water resources to facilitate energy use in the community. It is worthwhile to learn from the different and effective low-carbon measures that have been taken in different aspects of buildings and transportation, as well as energy.

（2）Sun and Wind Community in Beder, Denmark

The most important experience of the Sun and Wind community is in utilizing the natural advantages of the community's location. Denmark is located at the northwestern edge of the European continent and has very rich solar and wind energy resources. The community chose to use the most abundant wind and solar energy in the location, fully embodying the principle of building according to local conditions. With the government's preferential policies and the joint efforts of local residents, the Sun and Wind community has been built into a low-carbon eco-demonstration community. Another aspect of the Sun and Wind community building experience is in creating a public space that creates a space for people to communicate. In addition, people in the community create new interpersonal relationships within the community by participating in public garden labor and management.

1.6. Research contents and Workflow

1.6.1. Research contents

The research is based on four main points:

First, research and study Chinese and international cases of low-carbon community renewal and renovation, as well as international low-carbon eco-design practices. Combining the theories and principles of low-carbon renewal and transformation of old communities, I will summarize the same experiences and differences between China and the international community, which will be the basis of the research on low-carbon renewal and reconstruction strategies for old communities in urban centers.

Secondly, based on the common points summarized in the previous part, the factors and objectives affecting the low-carbon renewal and reconstruction of this community are obtained by combining the characteristics of Zhengzhou City in Henan Province. Then I will study the strategies that can be adopted for low-carbon renewal and reconstruction from the building, transportation and energy levels respectively. And I also summarize the experiences of successful cases to provide ideas and directions for low-carbon renewal and renovation in this study.

Third, select the typical old community in the central urban area of Jinshui District, Zhengzhou City, Henan Province as the design objects, and conduct in-depth research on the current spatial characteristics of this community. And also investigating the issues related to low-carbon living, encompassing aspects such as architecture, transportation, energy, and human needs. The main focus is on analyzing and proposing solutions in several aspects, such as people's needs and the current infrastructure, as well as the over-intensive use of energy.

Fourth, based on the strategy of low-carbon renewal and renovation of old communities summarized in the previous case study, combined with the plant data from the field research, the carbon sink results calculated by the i-tree eco model, and the site's own design issues. I will make targeted renovation in this community, mainly to reduce emissions and increase carbon sinks to establish effective renovation measures.

1.6.2. Workflow

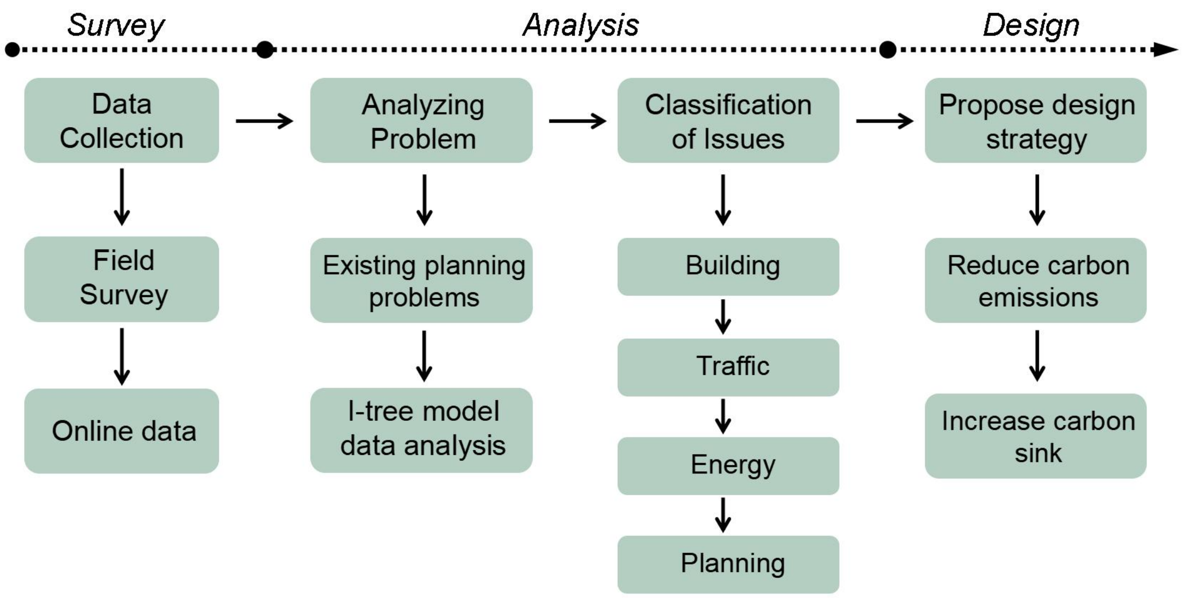


Fig. 1-14 Flow of the study. Source: by author

1.7. Research Innovation Points

Based on the current case studies and the weaknesses or problems of the existing studies, I will focus on the following points in my research:

（1）Comprehensive research. Combine the three aspects of site aesthetics, people's living needs and low-carbon green renewal, and propose a precise and reasonable approach to low-carbon green development.

（2）Accurate data support. The basic information of the site and the data of each plant are investigated in the field, and then the I-tree model is used to calculate to get the actual carbon sinks of the site, and the carbon sinks of the site are calculated again and compared after the design is completed. It increases the credibility and practicality of the study.

（3）Combine theory with practical examples. Using proven theoretical research for low-carbon green renewal and renovation of older community. The final research results may inspire or contribute to the theory, practice or policy in the field.

This is of great help and practical significance for achieving true low-carbon.

2. Site Introduction

2.1 City overview

The design site is located in the center of China, in Zhengzhou City, Henan Province. Zhengzhou City is located in the north-central part of Henan Province, on the downstream of the Yellow River, between longitude 112° 42′ ~114° 14′ E and latitude 34° 16′ ~34° 58′ N. It is the capital of Henan Province, the core city of the Central Plains Urban Agglomeration, as well as an important central city in central China and an important comprehensive transportation pivot of the country. The total area of the city is 7,567 square kilometers. It was known as the Shangdu in ancient times and is now called the Green City.

The total area of the city is about 7,567 square kilometers, with the central urban built-up area covering 744.15 square kilometers and the urban built-up area of the city region covering 1,342.11 square kilometers.As of the end of 2023, the permanent population of Zhengzhou City, Henan Province, was 13.08 million, with the urban population accounting for 80%, and the urbanization rate relatively stable.

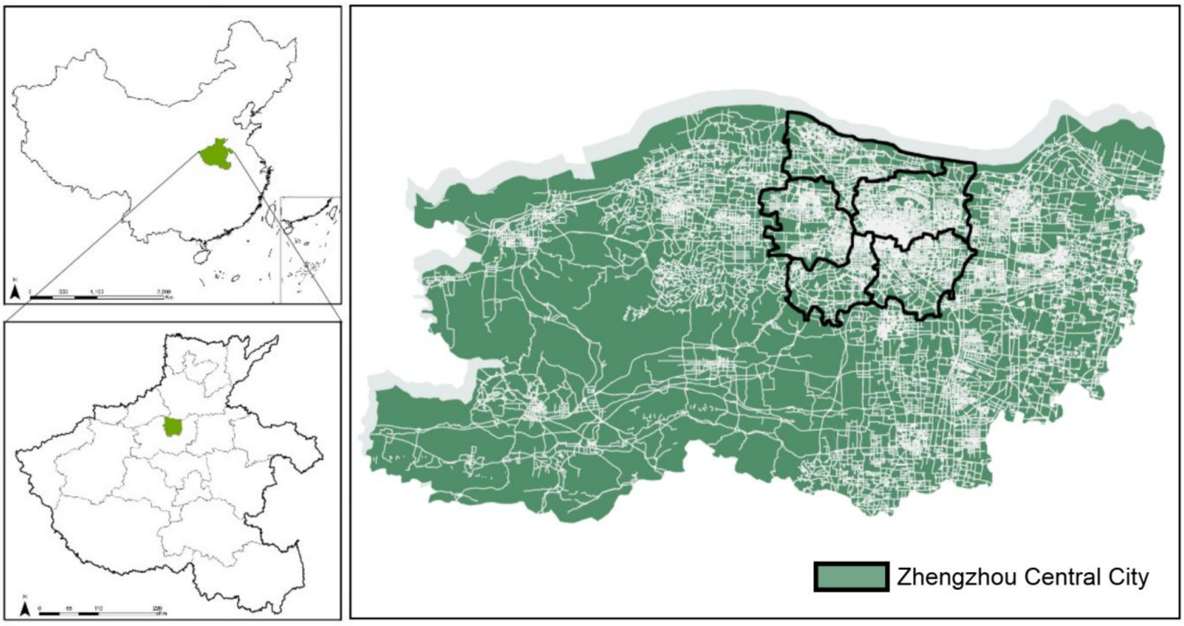


Fig. 1-15 Geographic location of the study site. Source: by author

2.1.1. Overview of the physical and geographical environment

（1）Topography

The topography of Zhengzhou City is relatively complex, with the general trend being high in the southwest and low in the northeast.The altitude of the central low mountainous and hilly area generally ranges from 150 to 300 meters, while the eastern region is relatively flat with altitudes generally less than 100 meters, and the lowest point is only 72 meters. The altitude difference within the territory is 1440 meters. Zhengzhou's mountainous area covers 2375.4 square kilometers, accounting for 31.6% of the total area. The area of hilly regions is 2256.2 square kilometers, representing 30.0% of the total area, while the plain area covers 2879.7 square kilometers, accounting for 38.4%.

The mountainous terrain is less undulating and is of the low mountain type. The city's mountainous area is 2,377 square kilometers, accounting for 31.9% of the total area.

Secondly, the city's hills cover an area of 2,255 square kilometers, accounting for 30.3% of the total area. And the total area of plains in the city is 2815 square kilometers, accounting for 37.8% of the total area. In the eastern plains, the altitude ranges between 75 and 100 meters, with a relative elevation of 10.30 meters. With flat terrain, deep soil and ample water supply, the Plain District is the main crop area of Zhengzhou City.

（2）Climate

Zhengzhou City belongs to a temperate continental monsoon climate, characterized by distinct four seasons. Spring is characterized by dryness, little rainfall, and frequent strong winds; summer is relatively hot with concentrated precipitation; autumn is cool with a short duration; winter is dry and cold with sparse rainfall and snow.

The average temperature over the 30-year period was 14.7°C, with an average of 0.5°C in January; and 27.1°C in July. The lowest monthly average temperature was -1.71°C in January 2000, while the highest monthly average temperature was 28.8°C in June 2009 and July 2010.The average annual sunshine hours are 1,564.3 hours and the total annual radiation is 452.6 kcal/cm2. The duration of temperatures above 0° C lasts for 306.7 days, with an annual average precipitation of 632.4 millimeters and an average of 78 precipitation days per year.Rainfall is concentrated from June to August each year, with the highest amount in August.

（3）Hydrology

Zhengzhou City has 124 large and small rivers, mainly in the two major basins of the Yellow River and Huaihe River.The Yellow River Basin covers an area of 2011.8 square kilometers, accounting for 27% of the city's total area; the Huaihe River Basin covers an area of 5,499.5 square kilometers, accounting for 73% of the city's total area.There are 29 rivers with large basin areas (≥100 square kilometers) in the city, including 6 in the Yellow River basin and 23 in the Huai River basin.

（4）Vegetation

Zhengzhou City is located in the warm temperate deciduous broad-leaved forest vegetation zone.In the central urban area, there are a total of 1965 species belonging to 734 genera and 165 families of seed plants.Among them, there are 502 species of trees, including 103 evergreen and 399 deciduous species. There are 461 species of shrubs, including 104 evergreen and 357 deciduous species. There are 57 species of climbers, including 9 evergreen and 48 deciduous species. Additionally, there are 945 species of herbaceous plants, 45 species of aquatic plants, and 40 species of bamboo.The different topography of the landscape has produced a rich and varied resource of biological species, and the biodiversity of the entire city is rich and complex.

Out of the 882 species of woody plants cultivated, 180 are native to Zhengzhou, accounting for 20.4% of the total. This indicates a shortage of native plants in Zhengzhou's green spaces, highlighting the need to strengthen efforts to plant native species.

The ratio of deciduous trees to evergreen trees is 3:1, and the ratio of broad-leaved trees to conifers is 7:1, which also reflects that the application of evergreen trees and needles should be strengthened to enrich the landscape of the main urban area.

2.1.2. Socio-economic overview

Zhengzhou, as the capital city of Henan Province, has shown strong economic development in recent years.In 2023, the economic aggregate of Zhengzhou City surpassed 1.36 trillion yuan, marking a growth of 7.4% compared to the previous year.Zhengzhou's industry is the mainstay of its economy. According to the 2022 statistics from the Zhengzhou Municipal Government, the city's economy primarily relies on the first, second, and third industries.Primary Industry: Including agriculture, forestry, fisheries, etc.Secondary Industry: Including industry, manufacturing, construction, etc.Tertiary Industry: Including services, finance, information technology, etc.

Zhengzhou's economic growth is mainly supported by the secondary industry, but the tertiary industry is also continuing to develop.

2.1.3. Overview of the green space

By the end of 2021, the built-up area of Zhengzhou City will have 1,603 parks and gardens, with a total green space of 246.17 million square meters.The green space rate, green coverage rate and per capita park green space area reached 36.74%, 41.63% and 15.26 square meters respectively.Zhengzhou plans to build the main center of the city around two themes: an ecological new city and a central park.

And according to the planning of Zhengzhou Municipal Government, in 2024, Zhengzhou City will continue to increase urban landscaping.Here is some key information about urban landscaping in Zhengzhou City in 2024:Zhengzhou City plans to build more than 3 million square meters of new green space, including parks, playgrounds, greenways, river greening and street green space; including more than 30 new open parks and playgrounds will be built, more than 50 micro-parks and small playgrounds, and more than 50 roads (greenways) will be greened, in order to further enrich the city's green resources and optimize the layout of parks and green spaces.It also plans to build 2,000 square meters of new green roofs in different areas to increase the green coverage of the city.

Functional upgrading of the city's green spaces in order to further improve their service functions.

2.2. Study area overview

2.2.1. Location analysis

Fig. 2-1 Basic information of the study site. Source: by author

Henan Agricultural University Affiliated Community is located in the old city center of Jinshui District, Zhengzhou City, built about 30 years ago, with a total area of about 5.06 hectares.The area is surrounded by developed areas with thriving businesses and relatively good infrastructure.The community is across the street from Henan Agricultural University, and convenient bus stops are at the entrance, providing residents with convenient travel conditions.In addition,within 500 meters of the community, there are large supermarkets, food markets, pharmacies, and metro stations, offering convenient transportation and easy living. This makes the community a very ideal residential area in Zhengzhou, attracting many people to choose to settle here.

2.2.2. Analysis of external road environment

The community is located between several urban roads, bordered by a primary city road (Agriculture Road) to the north and another primary city road (Culture Road) to the west.The north side is the secondary entrance to the community, which is only accessible to non-motorized vehicles and pedestrians. On the west side is the main entrance to the community, facing Henan Agricultural University. On the east side is another residential area. There are many schools in the vicinity of the community, such as Henan Agricultural University, Zhengzhou University, Zhengzhou No. 9 Middle School, Henan Experimental Middle School, etc. Moreover, it is just a ten-minute walk to the Youth Park and Zhengzhou Zoo.

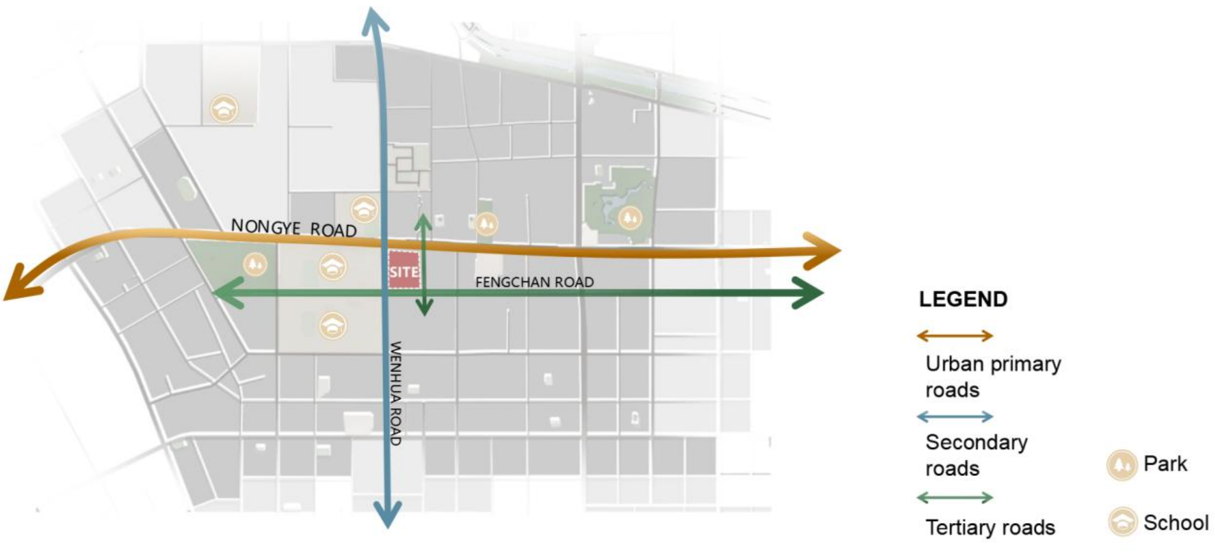


Fig. 2-2 Transportation location of the study site. Source: by author

2.2.3. Internal environment analysis

The community has two entrances, with the main entrance on the west side leading to a small garden, followed by some fitness facilities at the back of the garden.The basic living facilities in the community are well-established, including small shops, cafeterias, psychological service centers, activity centers, etc. These buildings are primarily concentrated in the central area of the community.

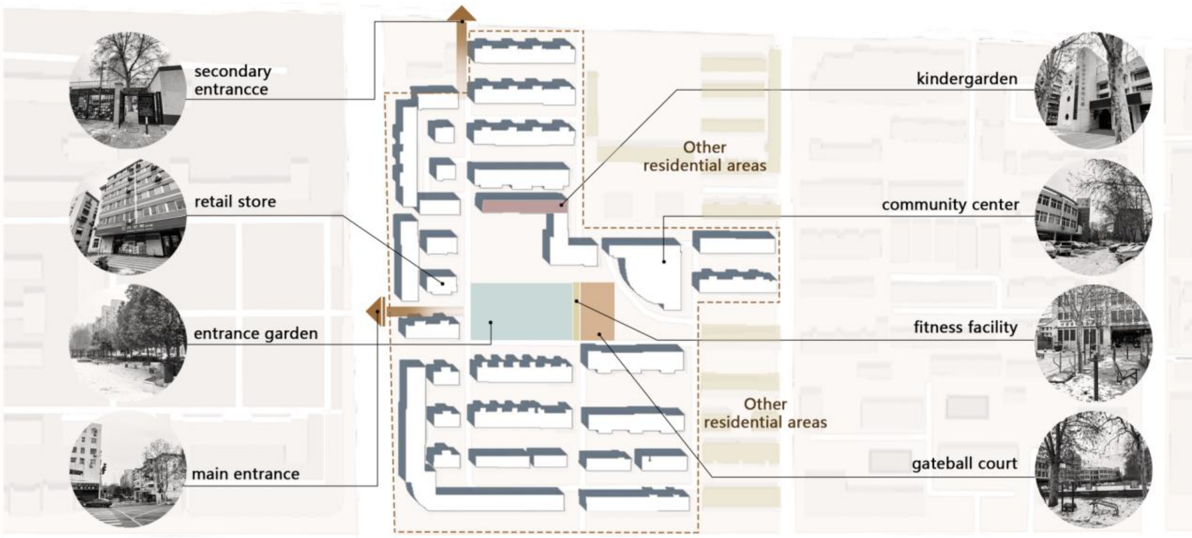


Fig. 2-3 Interior environment of the community. Source: by author

2.2.4. Analysis of the population structure of households

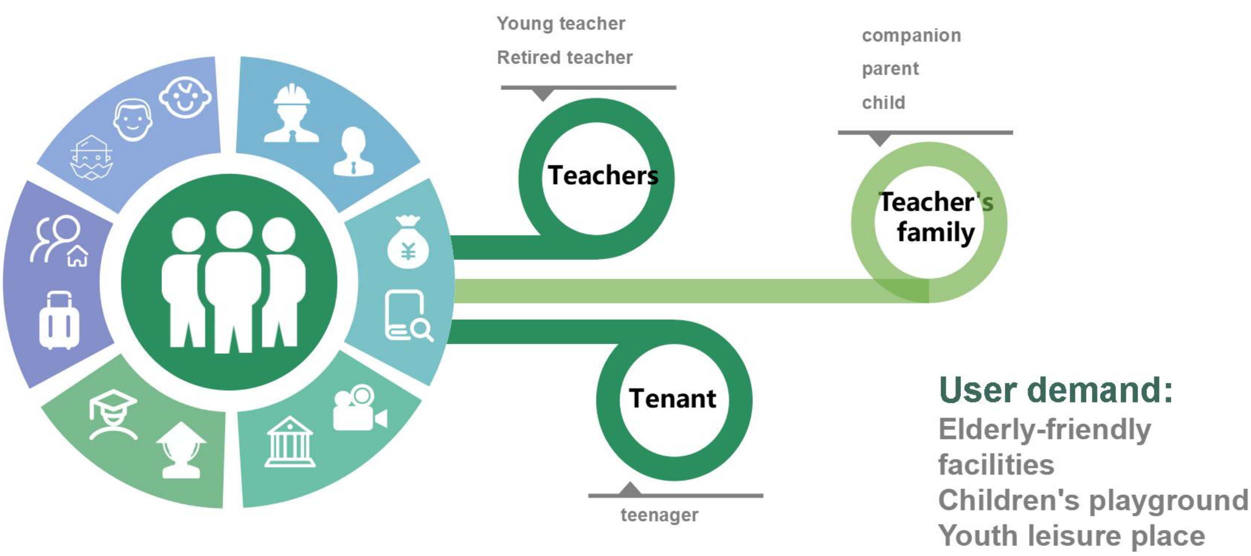


Fig. 2-4 Main population of the community. Source: by author

Since this affiliated community, was originally constructed some 25-30 years ago, a large portion of the community's residents were teachers who worked at Henan Agricultural University at the time.Therefore, the community exhibits clear signs of an aging population, and after undergoing multiple renovations, the residential area has a mixed population with high mobility.

The residents of the community mainly include current school teachers, retired teachers, private business owners, students, freelancers, and others.The high proportion of retired individuals underscores the need to fully consider their requirements in the community's renovation process. This also presents new challenges for the renovation and redevelopment efforts.

2.2.5. Analysis of existing roads

The road traffic conditions in residential areas directly impact the daily lives of residents. Roads serve as the fundamental framework of a community, connecting various spatial areas throughout the area.The internal road hierarchy of the community affiliated with Henan Agricultural University is divided into the main roads of the community and the paths between the houses.

（1）Character of road use

Residential area roads are categorized by their usage nature into pedestrian-only paths, vehicle-only roads, separate paths for pedestrians and vehicles, and mixed-use paths for both pedestrians and vehicles.The community affiliated with Henan Agricultural University is a closed residential area. It is densely populated and enclosed by fences and walls.The main roads and secondary roads are planned for mixed pedestrian and vehicular use. The residential area is densely populated, with buildings constructed long ago, and the current design no longer meets people's pursuit of a better life.

（2）Road accessibility

Road accessibility has a strong relationship with residents' daily travel and interaction with their neighbors.The affiliated community of Henan Agricultural University has a weak road system hierarchy due to the lack of unified planning.The roads in the residential areas are basically mixed with people and vehicles, and the accessibility of the roads is good, but it has also resulted in uncivilized behaviors such as motor vehicles being parked everywhere and private buildings, thus affecting the accessibility of the roads and even obstructing normal traffic.

2.2.6. Analysis of existing buildings

The building area of the community affiliated with Henan Agricultural University is 1.57 hectares, accounting for 31 percent of the total area.The earliest houses were built in 1998, followed by several renovations, and the buildings in the community were constructed in different years, from 1998 to 2005, thus making renovation very difficult.

（1）Building quality

The evaluation of building quality primarily considers the degree of damage to the building facade and its appendages, the aging of hallway spaces, the overall condition and internal structure of the building, building height, building orientation, and other factors. It is divided into three levels: "good quality," "average quality," and "poor quality," for the comprehensive assessment of building quality in the residential area affiliated with Henan Agricultural University. Through on-site visits and photography, we can see that the residential buildings in the area affiliated with Henan Agricultural University are primarily 5-6 stories high. Intermingled among these buildings are older 4-story structures, along with scattered instances of high-rise buildings ranging from 6 to 10 stories in height.

Fig. 2-5 Building photo of the community. Source: by author

The older residential buildings in the community, which are six stories and below, have deteriorated significantly in terms of building conditions. Their exteriors appear aged and gloomy, while the hallways are dark and cluttered. The indoor environment is poor, with very dim lighting.

And there are more illegal constructions in the community, which to a certain extent reflects the residents' practical needs for use. During the renovation process, if these makeshift buildings are not addressed, they will continue to affect the overall aesthetics of the community. However, completely removing these structures may seem inhumane. Therefore, illegal buildings should be dealt with differently. Buildings built privately by residents to meet their personal needs should be removed and encouraged to be planted in the same place for greening. For makeshift structures that have been utilized as public activity spaces, if they do not impede the daylighting and sunshine of surrounding residents, they should be retained and their materials replaced to allow for continued use while harmonizing with the community environment.

（2）Building ownership

Since the residential area affiliated with Henan Agricultural University was established as a supporting living area for solving the housing issues of university staff during the construction of Henan Agricultural University by the government at that time,the property rights of the initially constructed buildings still belong to the university.

After the renovation, the houses built belong to individuals. Some are sold to non -local residents or rented out to migrant workers, leading to a complex ownership structure of the buildings. Investigations have shown that building ownership throughout the community is divided into three main forms: unit public housing, individual property, and rental.

2.2.7. Analysis of existing green spaces

（1）Green environment

The green environment in the residential area mainly includes front-yard greenery, public green spaces, and environmental hygiene. Evaluating the quality of the residential green environment typically involves quantitative analysis based on the green coverage rate of the area. During the research process, it was found that the green environment in the community affiliated with Henan Agricultural University is generally bad. Residents have privately built vegetable plots at the entrances to their homes, the landscaping relies only on a small garden in the center of the main entrance, and there is no vegetation covering the tree planting pools on both sides of the road. The community has very little green coverage and the environment is extremely dirty.

（2）Public activity space

The public activity space in residential areas is mainly to provide residents with places for neighborhood interaction, recreation and other activities. Public activity spaces can increase residents' sense of well-being and community cohesion. Therefore, a comprehensive evaluation was conducted through three main indicators: the number of public activity space activity places, the configuration of leisure and recreation facilities within the activity places, and the frequency of use in the old residential areas.

The public activity space in the neighborhood affiliated with Henan Agricultural University is small, with only a small garden in the center. Recreational facilities are also old and dilapidated, with limited variety. Residents prefer to exercise at nearby universities and parks due to poorer sanitation and less open space in the surrounding area. Only a small number of elderly people are active here, resulting in an extreme waste of resources.

2.3. Field survey of plant data

2.3.1. Investigation steps

Field surveys of plant data are crucial for low-carbon design; they can provide critical information to help me better understand the site and devise the most appropriate solutions, minimizing carbon emissions and promoting ecosystem development to the fullest extent.

So in order to better consider the impacts of ecosystems and vegetation in the design, I conducted a field survey in January 2024 in a neighborhood attached to Henan Agricultural University in the urban center of Zhengzhou City, Henan

Province.The survey focused on basic information about the green spaces on the site and detailed data on the plants.

This fieldwork not only provided me with an in-depth understanding of the species and distribution of vegetation within the neighborhood, but also a more comprehensive base of information, which will help me design a more targeted low-carbon design.

Investigation time: January 15-January 22, 2024

Investigation data: site base information and plant species, diameter at breast height (DBH), tree height, vertical height of trees from the ground surface to the lowest branching point of the crown, tree crowns, and health status.

Investigation steps: First, print out a map of the site, then divide the site into 5 zones named A, B, C, D, E, and F for the zoning survey. Then, after the survey is completed, mark the ID of the trees in the map as well as fill out the basic plant information in the form.

Fig. 2-6 Plant investigation form. Source: by author

2.3.2. Investigation results

（1）Plant species

After an investigation, the community's plantings include 520 trees with a tree cover of *Toona sinensis*. The three most common species are *Toona sinensis* (18.3 percent), *Platanus orientalis* (9.0 percent), and *Paulownia fortunei* (8.7 percent).Then *Koelreuteria paniculata*、*Fraxinus chinensis*、*Populus tomentosa*、*Ligustrum lucidum*、*Bischofia polycarpa*、*Ficus carica*、*Punica granatum* and others. The shrubs are only 1,000 square meters and the overall planting structure is predominantly single-layered.

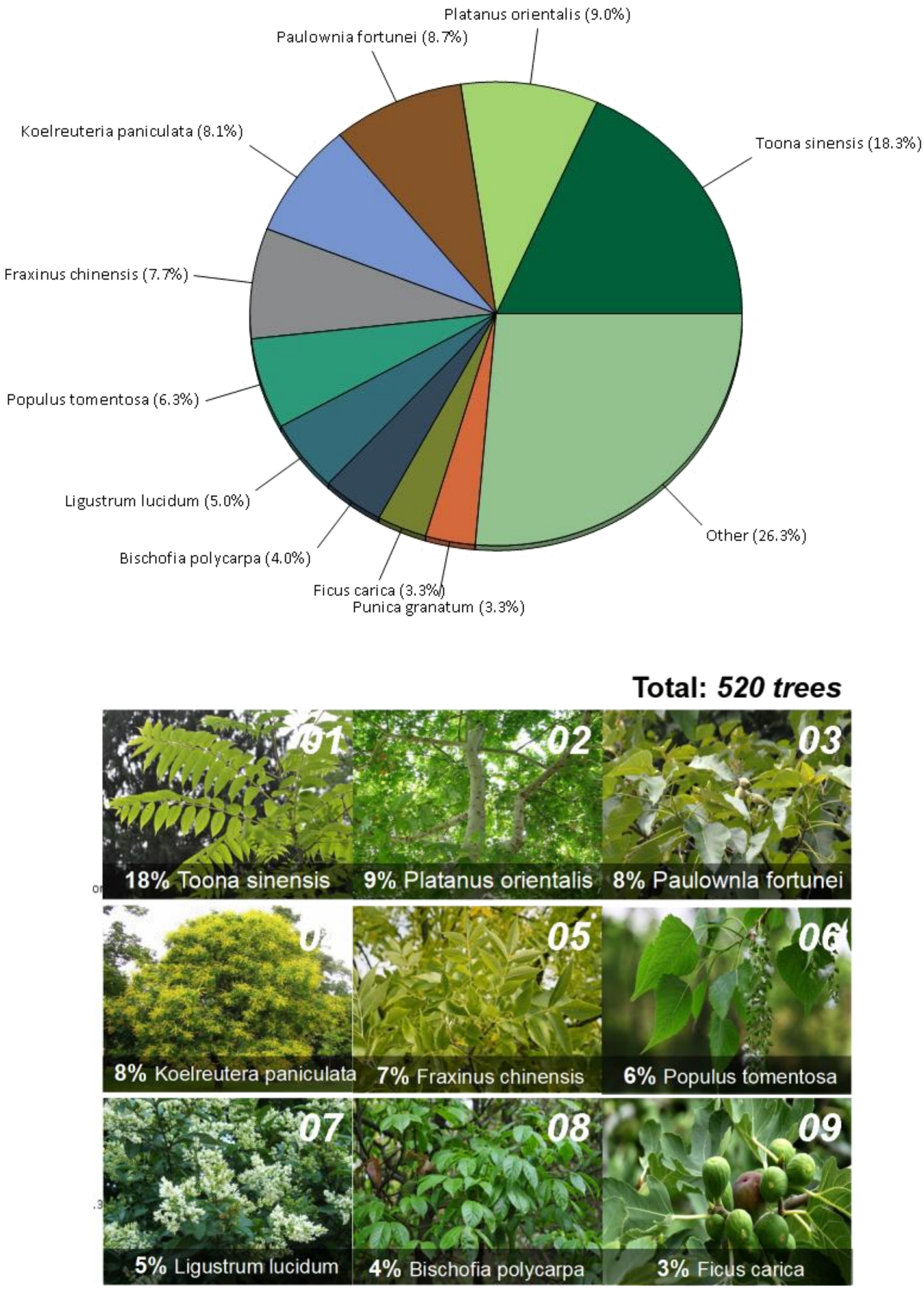


Fig. 2-7 Existing tree species composition. Source: by author

Most of the trees on the site have a diameter at breast height (DBH) ranging from 15.2 cm to 30.5 cm.

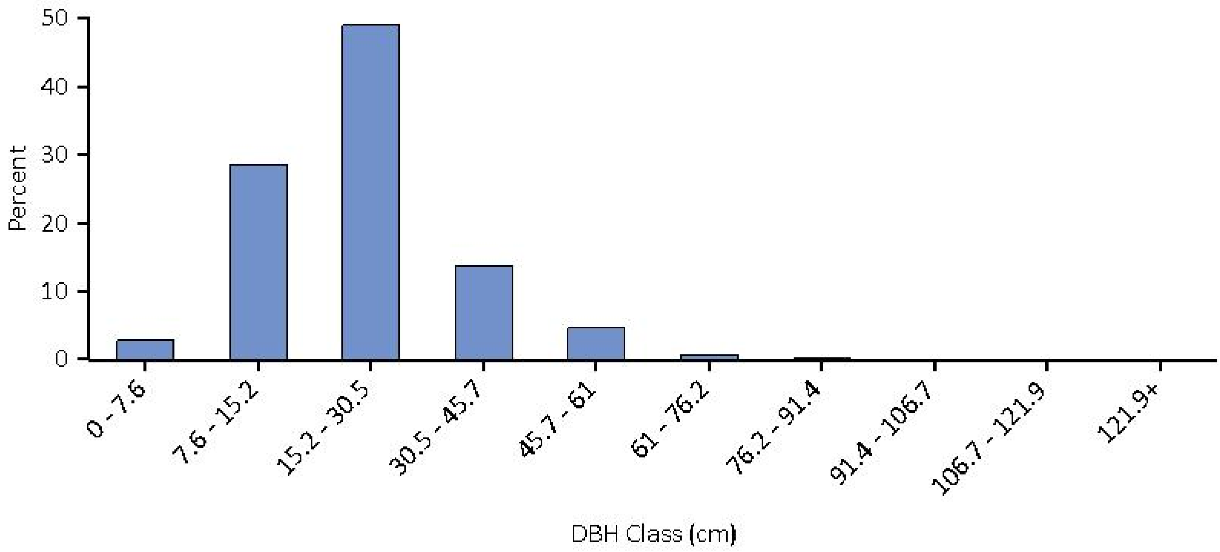


Fig. 2-8 Range of diameter at breast height (DBH) of existing trees. Source: by author

（2） Carbon Storage and Sequestration

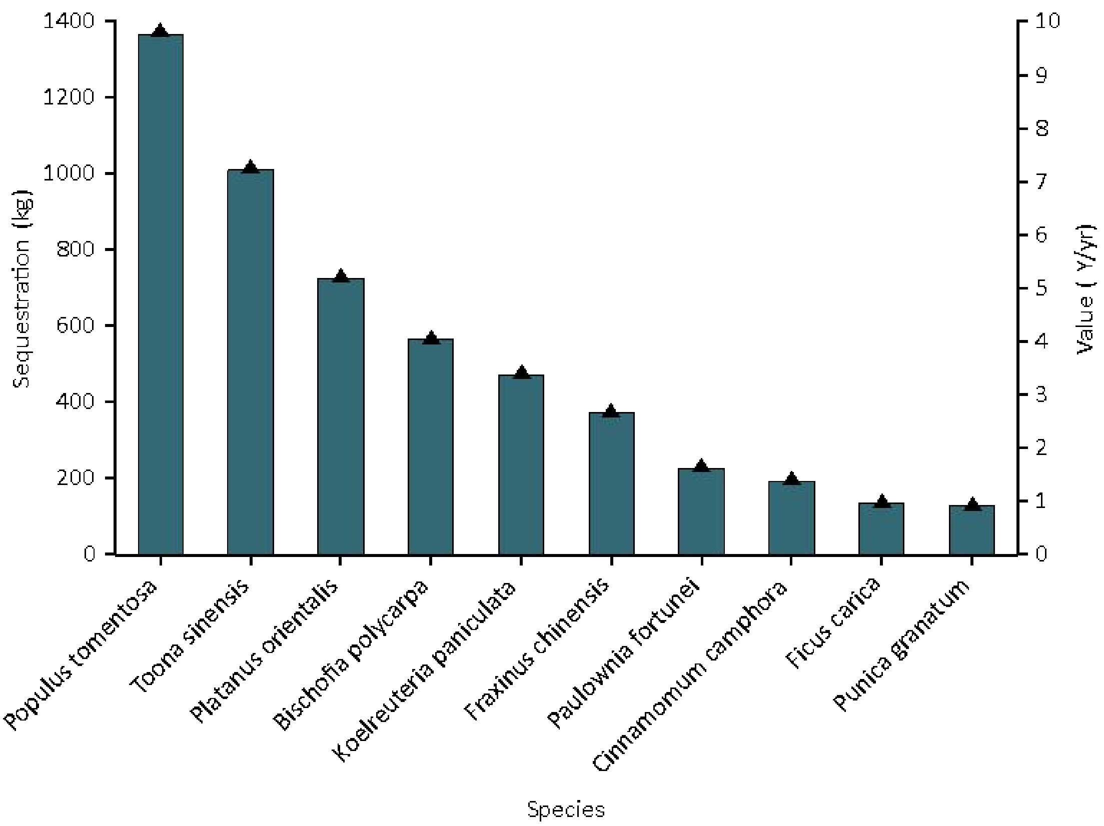


Fig. 2-9 Carbon storage in different tree species. Source: by author

Trees reduce the amount of carbon in the atmosphere by sequestering carbon in new growth every year. The amount of carbon annually sequestered is increased with the size and health of the trees. The gross sequestration of community trees is about 6.2 metric tons of carbon per year with an associated value of Y44.1.

Trees in community are estimated to store 88.6 metric tons of carbon (Y630). Of the species sampled, *Populus tomentosa* stores and sequesters the most carbon (approximately 33.2% of the total carbon stored and 22.2% of all sequestered carbon.)

Carbon Storage of Trees by Species

Location: Zhengzhou, Henan, China
Project: Jiashuyuan2024itree, Series: Jiashuyuan2024itreeseries, Year: 2024
Generated: 2024/2/8

i-Tree Eco

Species	Carbon Storage (metric ton)	Carbon Storage (%)	CO_2 Equivalent (metric ton)
Acer buergerianum	0.8	0.9%	3.1
Acer pictum ssp. Mono	0.1	0.1%	0.3
Acer palmatum	0.1	0.1%	0.2
Aesculus chinensis	0.1	0.1%	0.4
Albizia julibrissin	0.2	0.2%	0.6
Bischofia polycarpa	6.4	7.2%	23.4
Broussonetia papyrifera	0.2	0.2%	0.6
Toona sinensis	10.8	12.1%	39.4
Celtis sinensis	0.2	0.2%	0.6
Chimonanthus praecox	0.1	0.1%	0.3
Cinnamomum camphora	1.6	1.8%	6.0
Cotinus coggygria	0.1	0.2%	0.5
Crataegus pinnatifida	0.1	0.1%	0.2
Diospyros kaki	0.1	0.1%	0.4
Ficus carica	0.9	1.0%	3.4
Firmiana simplex	0.0	0.0%	0.1
Fraxinus chinensis	3.5	4.0%	12.8
Ginkgo biloba	0.4	0.5%	1.5
Juglans mandshurica	0.1	0.1%	0.3
Juglans regia	0.1	0.1%	0.5
Koelreuteria paniculata	9.7	10.9%	35.6
Lagerstroemia indica	0.1	0.1%	0.3
Ligustrum lucidum	1.0	1.1%	3.6
Magnolia grandiflora	0.1	0.1%	0.3
Malus pumila	0.3	0.3%	1.0
Melia azedarach	0.3	0.4%	1.2
Nerium oleander	0.1	0.1%	0.2
Osmanthus fragrans	0.1	0.1%	0.4
Paulownia fortunei	2.4	2.8%	9.0
Photinia serrulata	0.4	0.4%	1.3
Platanus orientalis	12.1	13.6%	44.2
Populus davidiana	0.9	1.0%	3.2
Populus tomentosa	29.4	33.2%	108.0
Prunus cerasifera	0.4	0.5%	1.6
Prunus persica	0.1	0.1%	0.4
Pseudocydonia sinensis	0.1	0.1%	0.3
Pterocarya stenoptera	0.6	0.7%	2.4
Punica granatum	1.0	1.1%	3.6
Robinia pseudoacacia	0.1	0.1%	0.3
Styphnolobium japonicum	2.1	2.4%	7.7
Trachycarpus fortunei	0.2	0.2%	0.7
Ulmus pumila	0.7	0.8%	2.5
Yulania	0.7	0.8%	2.5
Total	**88.6**	**100%**	**324.8**

Fig. 2-10 Total carbon storage in existing trees. Source: by author

After investigation and calculation, it was found that the total area of the site is 5.06 hectares, but the green space only accounts for 8 percent of the area, which is about 0.37 hectares. Due to the early design, residents may lack awareness and involvement in the green space, making it difficult to manage and maintain the green space effectively. Over time, some of the green space may be used for other purposes or damaged, resulting in the greening ratio failing to meet the standard and a serious shortage of green space per person.

It has been proven that an increase in the area of green space can increase carbon sinks. In addition, green spaces have multiple effects such as improving air quality, reducing the concentration of pollutants in the air, creating a cold island effect that lowers temperatures, and absorbing carbon dioxide from the air[15]. Therefore, the lack of sufficient green space will lead to a serious decline in the quality of life of the residents and a lower sense of well-being. Air quality will decline and the ecological balance will be disturbed, among other things.

So there is still a lot of potential to improve the size and quality of the green space built throughout the neighborhood, as well as the carbon sinks.

2.4. Main problems and characteristics of the site

This chapter provides a detailed investigation of the social structure, including population composition, housing patterns, and length of residence, of the residential area affiliated with Henan Agricultural University in Jinshui District, Zhengzhou City, from a material perspective. It also examines the property rights, age, quality, and provision of public facilities of the buildings, as well as environmental elements such as the green landscape, public spaces, and road systems within the community. And statistical analysis was conducted on the survey data to provide a basis for the renovation of the material space of the urban old residential areas.

Since the beginning of its construction, the neighborhood attached to Henan Agricultural University has undergone many local updates, renovations, demolitions and reconstructions. However, each update has not been guided by a comprehensive plan. Therefore, spatial, environmental, and social problems continue to worsen, with local environmental conditions deteriorating to the extreme; public service facilities are lacking in variety, dispersed in location, and too small in scale; open space facilities are rudimentary, with extremely poor quality; green spaces are either occupied for private cultivation or converted into private car parking; road space is heavily occupied by motor vehicles, and there is disorderly unauthorized construction.

Through the analysis and study of the field research and interview data of the community, the main problems and characteristics existing in the old residential area are summarized as follows:

Fig. 2-11 Existing problems at the sit. Source: by author

（1）Older residential areas have obvious locational advantages. These old residential areas are generally located in the core area or sub-center area of the entire city, surrounded by well-developed commercial, office, medical, educational, transportation, leisure, entertainment and other infrastructures and supporting service facilities.

（2）Complex diversification of functions and interests. Old residential areas in their old and new functions in the continuous renewal alternation, combined with through the different times, different cultures, different functions, different biological and other factors of renewal superposition, so that the internal function of the residence is complex, but also makes the main stakeholders in the renewal of the interests of the diversified. These phenomena make it impossible to use traditional overall planning methods for the renewal of residential areas.

（3）Population is aging, and there is high mobility. The construction lifespan of old residential areas is generally long. Even though the living conditions are poor and their children could provide them with a better environment, these elderly individuals are unwilling to leave due to the strong sense of belonging to the community, neighborhood relationships, and physical factors associated with aging. For young adults in the early stages of entrepreneurship or recent graduates, they may temporarily rent due to the advantageous location and relatively affordable rent. However, once they have acquired sufficient ability, they are likely to leave, resulting in high mobility.

（4）Lack of public space. Since the requirements for public infrastructure, service facilities and parking facilities are low in the early stages of planning for old residential areas. With the increase in population, structural changes, new needs of residents on the material and spiritual levels, and the lack of specialized management and maintenance, the original public space has been appropriated or destroyed, and there is an extreme lack of public space.

（5）Energy use intensive. Due to their construction long ago, old neighborhoods have not implemented green planning and management schemes, resulting in significant energy consumption from traditional sources. The overall carbon emissions of the community are relatively high.

Based on the above analysis of the problems, they can be summarized in two main points: inadequate community infrastructure and intensive energy use. This is also a classic problem in older communities.

3. Design Conception

3.1. Design concept

After investigating and analyzing the community affiliated with Henan Agricultural University, my design concept aims to create a livable and low-carbon community environment through a series of sustainable strategies and innovative technologies. In order to meet people's living needs as well as improve the site's energy intensity and other issues.

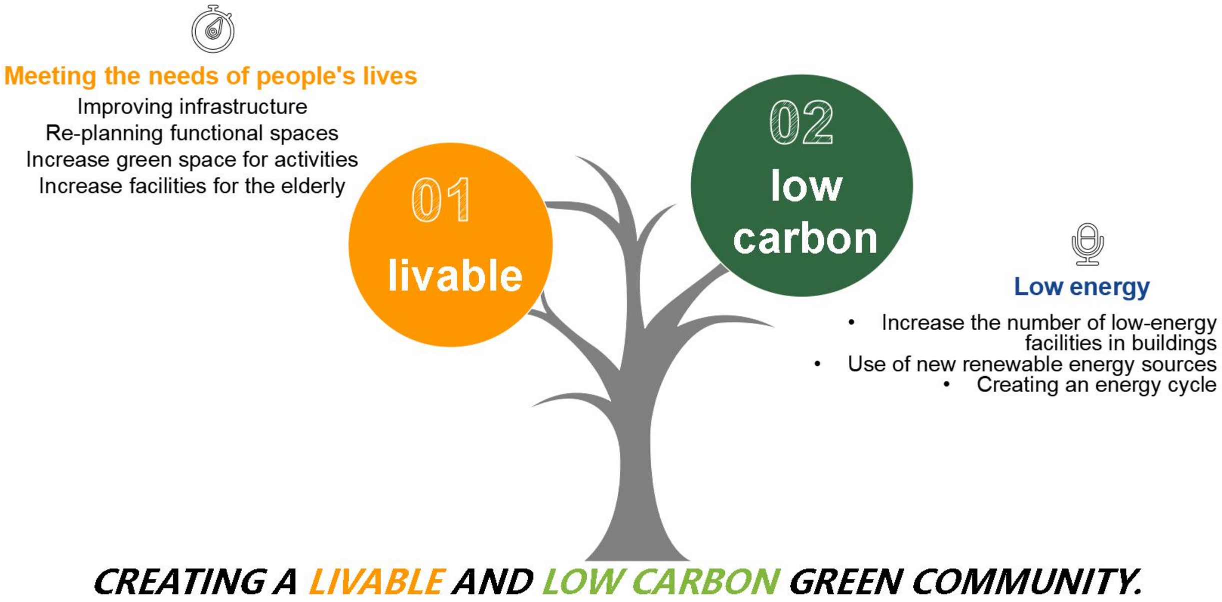


Fig. 3-1 Design concept. Source: by author

3.2. Overall design framework

Following is a diagram of the overall design framework. It is divided into three main sections: problem summary, solution strategy, and design concepts.

（1）Summary of issues: four main issues that need to be addressed in the community update.

The first is the lack of architectural consistency, followed by traffic and parking chaos, then the lack of infrastructure and drainage, and the lack of space for public events and greenery four issues.

（2）Problem solving strategy: provides solutions for each problem, which are divided into two parts.

First part is to reduce carbon emissions: the main strategies are to increase natural ventilation systems, renovate building facades, increase rainwater collection systems, separate and recycle household waste, and increase the use of renewable energy.

Second part is to increase carbon sinks: the main strategies are to expand green space and change the vegetation structure.

（3）Design concepts: meeting livability and low-carbon needs.

Livability part: mainly through wind cowl design and vertical green shading, as well as designing rain gardens and using wet waste as fertilizer.

Low-carbon part: first of all, adding photovoltaic solar energy systems to the roofs of buildings and encouraging residents to plant plants on balconies, as well as planting high carbon sequestering trees and enriching plant communities, reducing the size of lawns, etc.

The entire framework diagram clearly shows the logical flow from problem to strategy to design concept.

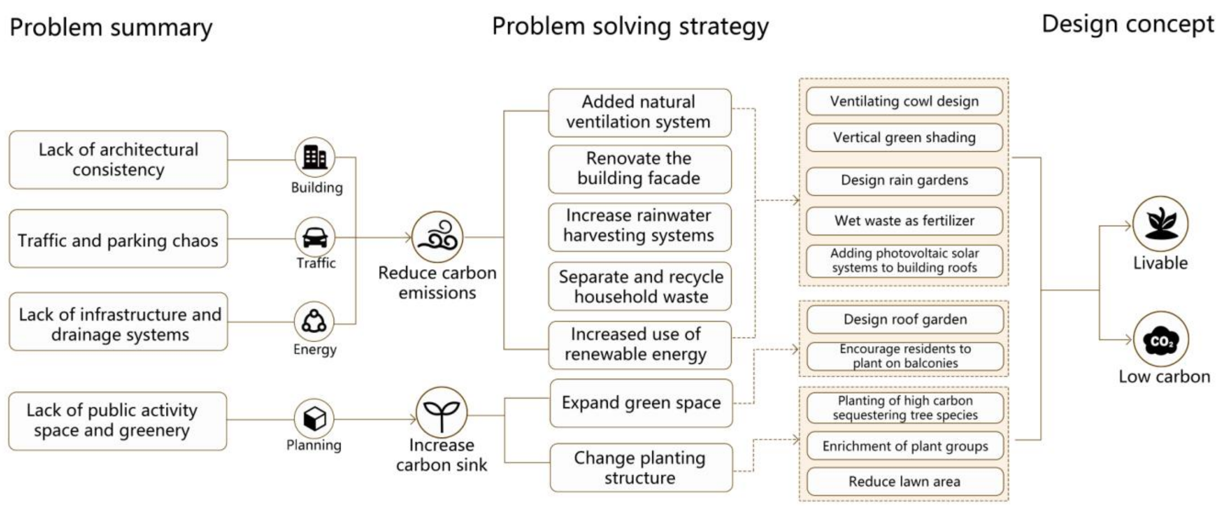


Fig. 3-2 Overall design framework. Source: by author

3.3. Design strategy

Specific design strategies for low-carbon renovation of older communities aimed at reducing carbon emissions and increasing carbon sinks.

（1）Carbon reduction strategies include:

Ventilating cowl design: This design reduces energy consumption by utilizing wind power to increase natural ventilation in the room and reduce reliance on air conditioning.

Vertical green shading: adding vertically growing green plants to the building facade.This type of green wall is not only aesthetically pleasing but also provides natural shading, reduces indoor temperatures, and further decreases the demand for cooling energy.

Design rain gardens: on green spaces between houses, using native vegetation and natural topography to collect rainwater and reduce rainwater runoff, while providing a greening effect, which also helps to reduce the urban heat island effect.

Wet waste as fertilizer: Turning organic wet waste into fertilizer. This practice reduces landfill waste while providing nutrients for community greenery.

Adding photovoltaic solar systems to building roofs: Installing photovoltaic panels on building roofs is a renewable energy technology. The ability to convert solar energy into electricity for use in buildings reduces dependence on fossil fuels.

（2）Increasing carbon sink strategies include:

Design roof garden: Creating shared gardens on the roofs of buildings provides additional green space, helps to absorb carbon dioxide from the air, and provides a habitat for urban biodiversity[16] .

Encourage residents to plant on balconies: Encourage residents to participate in the greening of the community by planting in private spaces to increase the overall green area of the community.

Planting of high carbon sequestering tree species: Planting trees that have a high carbon sequestering capacity allows for more efficient absorption of carbon dioxide from the atmosphere.

Enrichment of plant groups：Planting a variety of plants not only enhances the aesthetic appeal and biodiversity of the community but also helps create a more stable carbon sink.

Reduce lawn area：Reducing reliance on maintenance-intensive lawns to decrease water and fertilizer use. This reduces the environmental footprint while increasing the area of other types of vegetation.

These strategies not only reduce the carbon emissions of the community, but also increase the coverage of green vegetation in the community, enhance its carbon absorption capacity and the ecological function of the community, beautify the environment, and create an eco-friendly and livable community together.

4. Design Outcomes

4.1. Updated planning of the general layout

The planning object of the renewal of old residential areas is residents, and the service object is even more residents.The renewal of old residential areas is not only about the sustainable development of the area, but also about maximizing the satisfaction of the residents' living needs. Regarding the problems of the community affiliated to Henan Agricultural University, the goals of renewal are proposed: optimizing the spatial environment, perfecting the service network, diversifying the functions of the residential area, care for the neighborhood, and creating a low-carbon community.

General Layout Renewal Focus for the Henan Agricultural University Affiliated Community:First, the illegal buildings in residential areas will be demolished, and the demolished vacant land will be fully utilized to build more green areas and squares, and the public space and public service facilities in residential areas will be improved. Secondly, to solve the problem of shortage of parking spaces in residential areas.

This master plan shows a design plan for a low-carbon renewal of the Henan Agricultural University Affiliated Community. The plan includes the following key parts:

The entire design basically retains the functional zoning structure of the original site, but adds more functional space.

A sunken green space was designed in the center of the community to create a multi-functional activity space. The sunken green space collects and filters rainwater, reducing surface runoff and pressure on the drainage system. It adds a sense of hierarchy and interest to the design and enhances biodiversity.

A resting pavilion on the east side of the sunken green space provides a shady place for residents to rest and interact. On the east side of the resting pavilion, there is a multi-purpose sports ground to cater for residents of different ages and interests to engage in sports activities.

As well as between the 16th residential building and the activity center building, a tree formation plaza was designed to help reduce noise in the activity area and create a more peaceful environment. and can provide natural shade during the hot summer months, as well as reduce surface and air temperatures. This can greatly improve the comfort of residents and reduce the urban heat island effect.

Small rain gardens have been designed in the green spaces between residential buildings. Rainwater gardens are used to collect and purify rainwater while serving as an aesthetically pleasing landscape element for the community. It also enhances biodiversity by providing habitat and food sources for a variety of native wildlife. This is essential for maintaining ecological balance and promoting a healthy ecosystem.

In addition, solar photovoltaic panels have been installed on the roofs of some buildings in the community. By utilizing sunlight to convert into electricity, it helps to reduce dependence on and consumption of fossil fuels, thereby reducing carbon emissions. This is very beneficial in mitigating climate change and improving air quality.

Fig. 4-1 Master plan. Source: by author

Fig. 4-2 Inspiration. Source: Internet

Secondly on the roof of the activity center, I designed a relaxing roof garden. It provides valuable outdoor space for residents, especially in high-density residential environments, and such space can serve as a quiet place for rest and relaxation. And the roof garden helps to insulate and retain heat, reducing the need for heating in winter and the frequency and intensity of air-conditioning use in summer, thus decreasing energy consumption and reducing carbon emissions.

Most importantly, this plan redesigns the width of the roadway to separate sidewalks from driveways. And in order to promote outdoor exercise and healthy lifestyles for residents, a running path was designed to run through the community. This greatly enhances the well-being of the residents.

The entire design enhances the living environment through a combination of green infrastructure and renewable energy, promoting ecological sustainability and encouraging community activities in the hope of achieving the goal of low-carbon living. With thoughtful consideration of space utilization and functional zoning, the program aims to create a harmonious and sustainable living environment for residents[17] .

4.1.1. Functional analysis of the master plan

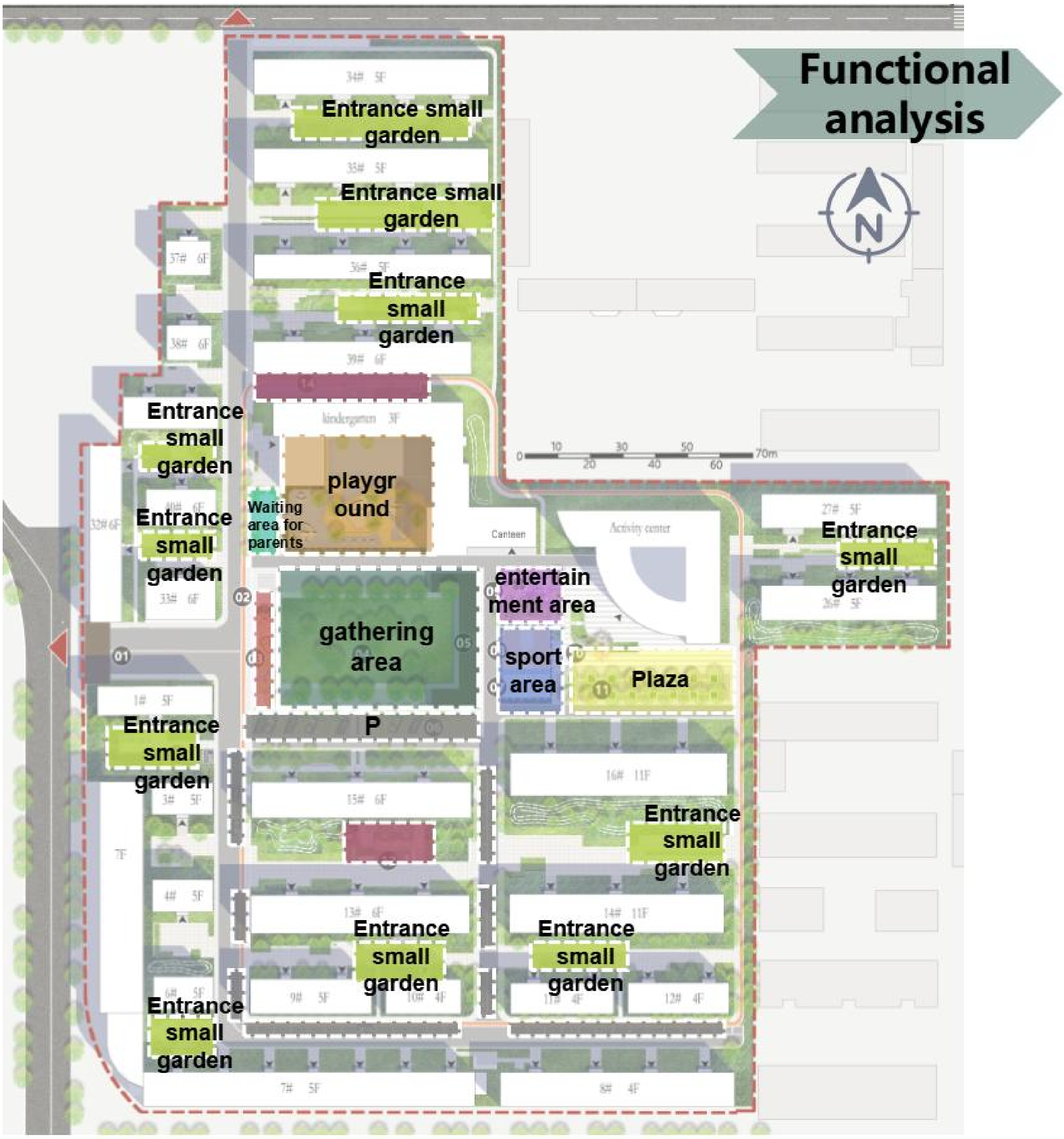


Fig. 4-3 Functional zone. Source: by author

This plan is the functional layout of the floor plan after careful design. Based on the deep study and detailed analysis of the site, I have divided the diversified use space and functional areas. In the design, I pay special attention to the scientific division of functions and the integration of green ecological space, and aim to create a low-carbon and environmentally friendly living environment.

Around the residential buildings in the community, there are a number of small, well-built entrance gardens. These gardens not only add greenery to the community, but also act as buffer zones, beautifying the environment while welcoming every returning resident and visiting guest.

Turning to the center of the community, you will find a series of functional activity areas, including a “playground” for children to play, a “gathering area” for residents to interact，“entertainment area” provides recreation and entertainment, the “sports area” meets people's sports needs, and the “Plaza” serves as the center of the community. These areas provide residents with a variety of activity options, from playgrounds for children to waiting areas for parents, from open gathering spaces to recreational areas to specialized sports areas, all of which take into consideration the needs of the residents.

It is worth mentioning that in the design of the “playground” area, I especially considered the needs of parents and provided a special waiting area.This special design aims to provide parents with a comfortable resting space when picking up and dropping off their children.

As a whole, the entire design fully embodies the concept of low-carbon living. By increasing the area of green space, optimizing the layout of public activity areas and providing convenient community services, it aims to create an environmentally friendly and dynamic community that promotes the sustainable development of the community and enhances social interaction between residents[18]. Such a plan will not only help reduce the carbon emissions of the entire community and improve the quality of life of the residents, but also enhance the cohesion and centripetal force of the community.

4.1.2. Dynamic and static zoning of the master plan

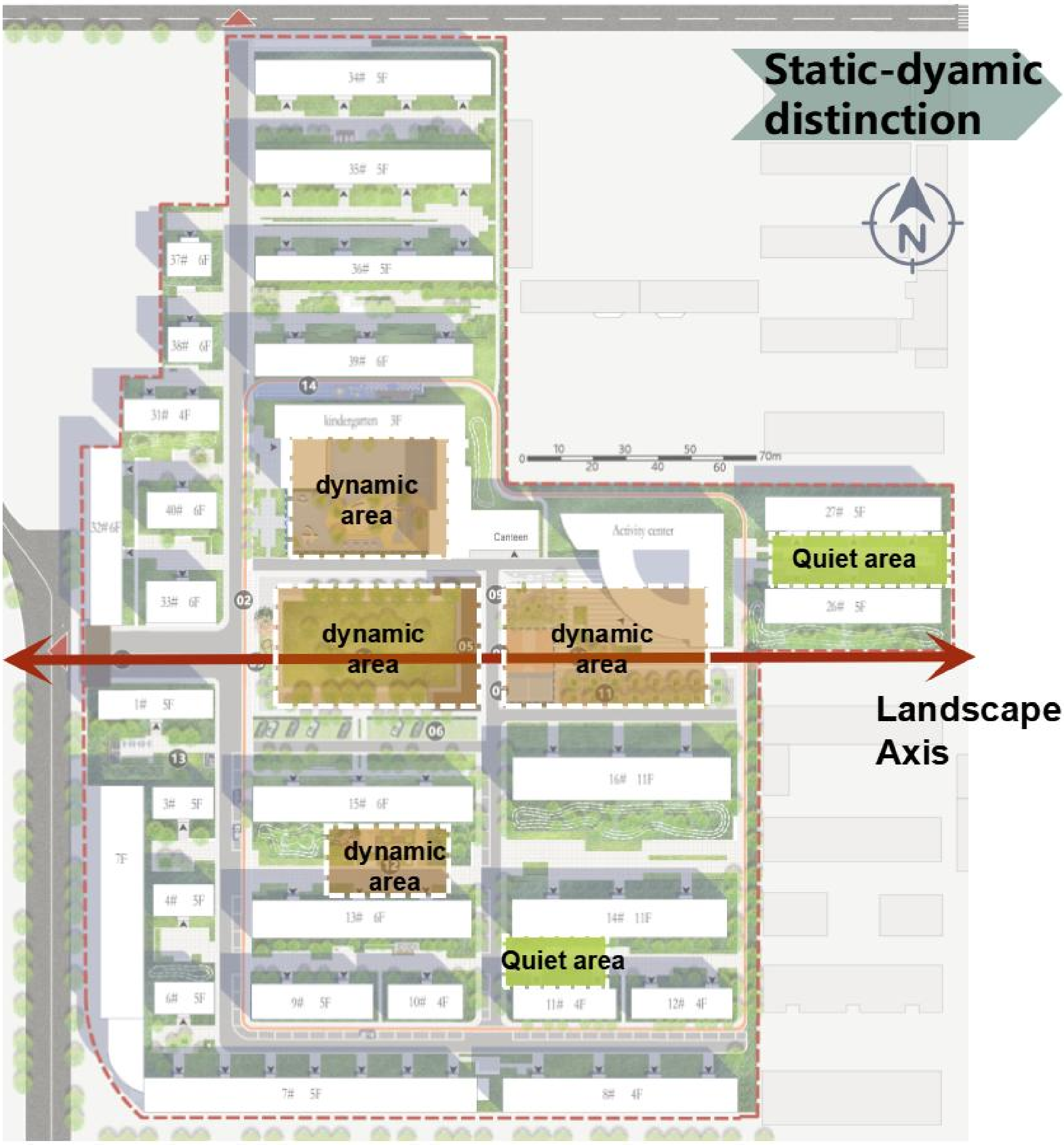


Fig. 4-4 Static-dynamic zone. Source: by author

This diagram shows in detail the dynamic and static zoning layout of the neighborhood, clearly divided into "dynamic activity area" and "static rest area", and through a well-designed "landscape axis", the whole community is linked together. Dynamic activity zones are mainly located in the center of the community, adjacent to the community activity center. These zones include children's playgrounds, community activity plazas, and a variety of sports facilities, which are designed to meet the residents' needs for active social and sports activities.

In contrast, the Static Rest Areas are cleverly located between the residential buildings, providing a private space for residents to get away from the noise and provide peace and relaxation. With its elegant environment and peaceful atmosphere, it is an ideal place for residents to read and study, rest and relax, or enjoy some solitude.

The landscape axis that extends through the entire community serves not only as a visual focal point, but also as the center of activity. This axis skillfully connects the main entrance with the main activity areas, guiding the flow of people and forming a fluent spatial sequence. Through this design, I have fully considered the mobility of activities and the quietness of static areas, so that residents can enjoy the lively and energetic community life in the dynamic areas, but also find inner peace and tranquility in the static areas.

The planning strategy of static and dynamic zoning not only meets the diverse needs of residents for community activities, but also ensures the privacy and quietness of personal space. This humanized design effectively improves the quality of life of the residents and at the same time meets the core concept of a low-carbon community. By rationalizing the spatial layout, it aims to reduce unnecessary energy consumption, promote sustainable lifestyles, and create a vibrant and livable community environment for residents.

4.2. Detailed plan

4.2.1. Entrance center-sunken garden detailed plan

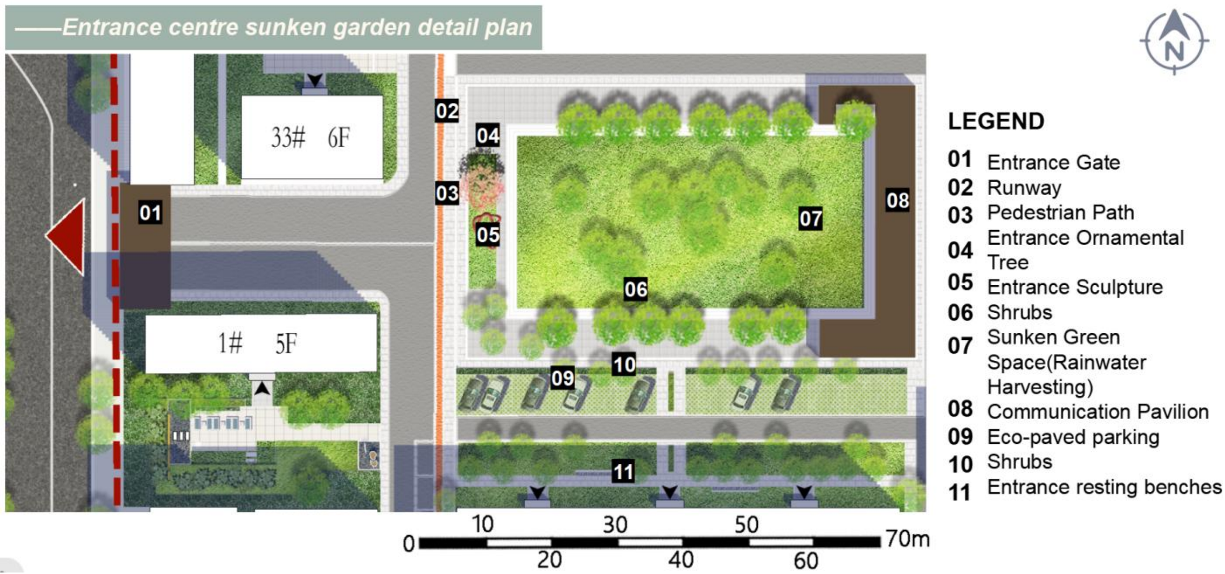


Fig. 4-5 Entrance center-sunken garden detailed plan. Source: by author

This diagram shows the detailed layout of the main entrance to the community. The first thing you see when you enter the community is the entrance numbered 01 on the left, which serves as the community's identity and plays the double role of guidance and welcome. Immediately adjacent to the entrance is the runway numbered 02, which is not only a good place for fitness and leisure for residents, but also plays a role in dividing the space and guiding the flow.

Entering the community, a wide walkway (no. 03) leads the way into the interior of the community. On both sides of the walkway, decorative trees (No. 04) and the entrance sculpture (No. 05) are integrated to create a welcoming space full of artistic flavor and warmth. These elements not only beautify the environment, but also inadvertently enhance the culture of the community.

The central part of the picture is a green open space. The bushes (No. 06) and the sunken green space (No. 07) form the main part of the garden, which not only provide a place for recreational activities for the residents, but also play an important role in ecological functions. The sunken green space serves as a rainwater harvesting area that can effectively manage rainwater and reduce runoff, thus realizing ecologically sustainable development.

Around the green space, the eco-paved parking area, number 09, embodies the concept of environmental protection. Adopting permeable paving technology, it reduces rainwater runoff and helps maintain the balance of groundwater. The neat shrubs of No. 10 further enhance the ecological effect of the green space, adding life and vitality to the community.

In addition, the resting pavilion (No. 08) and resting bench (No. 11) at the entrance provide a comfortable space for residents and visitors to rest and communicate. These facilities are set up with full consideration of humanitarian needs, so that people can enjoy the natural scenery and at the same time feel the warmth and tranquility of the community.

Through the use of eco-friendly materials and an innovative rainwater management system, this community entrance design successfully creates a welcoming space that is both aesthetically pleasing and functional.

Perspective "A" - Entrance landscape

Perspective "B" - Sunken green space

Perspective "C" - Sunken green space

Fig. 4-6 Entrance visualization. Source: by author

4.2.2. Sport area detailed plan

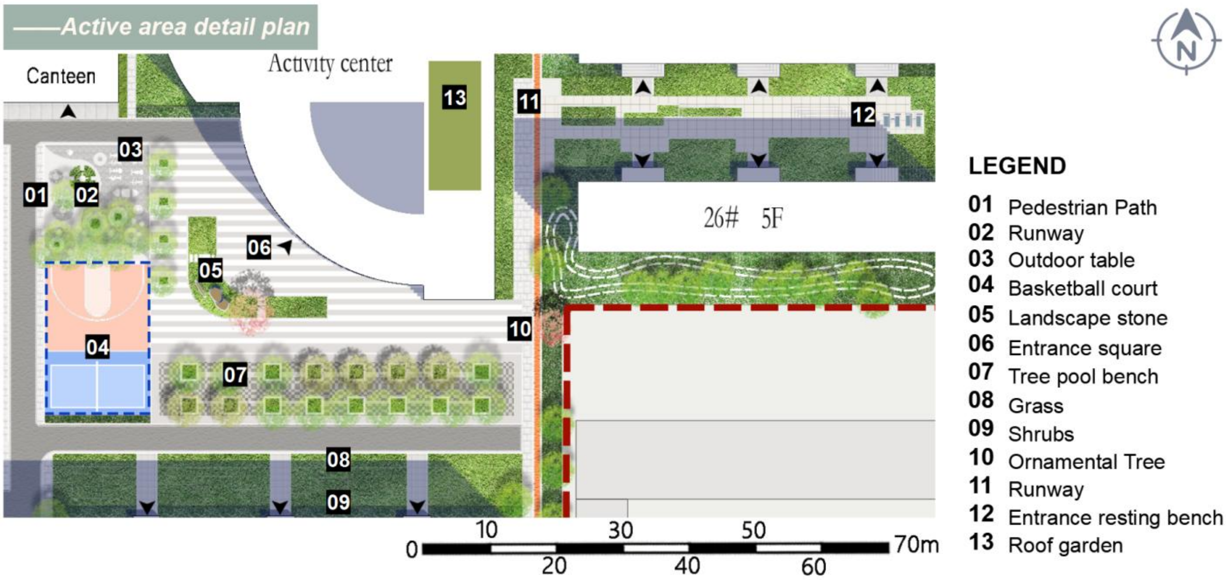


Fig. 4-7 Sport area detailed plan. Source: by author

In the main activity area of the community, the pedestrian walkway (number 01) provides a peaceful place for residents to walk. Next to the walkway is a vibrant basketball court (No. 04), which is an excellent place for residents to enjoy sports.

Adjacent to the basketball court, there are several outdoor tables (No. 03), which provide a convenient place for residents to meet and communicate, as well as for leisure and entertainment. Whether it's for a cup of tea or a game of cards, these tables meet the different needs of the residents.

On the other side of the activity area, a landscape stone (No. 05) and a tree bench (No. 07) are designed. These design elements not only enhance the overall aesthetics of the community, but also provide a peaceful resting space where residents can enjoy the surrounding scenery and feel the charm of nature.

As the entrance to the activity center, the plaza (No. 06) plays the double role of reception and gathering. Whenever residents enter the activity area, this bright and open plaza is the first thing they see, and it has become an important place for gathering.

The green areas are also not to be overlooked. Grass (No. 08) and shrubs (No. 09) together form this green ecological space. They not only beautify the environment of the community, but also bring fresh air and a peaceful atmosphere to the residents. At the same time, the green vegetation can effectively mitigate the noise from the activity area, creating a comfortable and livable living environment for the residents.

In addition, the rooftop garden (No. 13), a highlight of the community, provides more space for community residents to interact with each other. Here, residents can appreciate the beautiful botanical landscape while enjoying close interaction with their neighbors, and it also increases the green area. The resting bench at the entrance (No. 12) provides a convenient resting place for residents entering and exiting the community, allowing them to take a break from their busy schedules and feel the beauty of life.

Through careful planning and design, the main activity area of this community not only provides a rich variety of outdoor activity spaces, but also focuses on the needs of residents for rest and gathering. The entire area is both environmentally friendly and vibrant, creating a livable and enjoyable community environment for residents.

Perspective "A" - Communication area

Perspective "B" - Activity center entrance square

Perspective "C" - Tree array square

Fig. 4-8 Active area visualization. Source: by author

4.2.3. House entrance small garden detailed plan

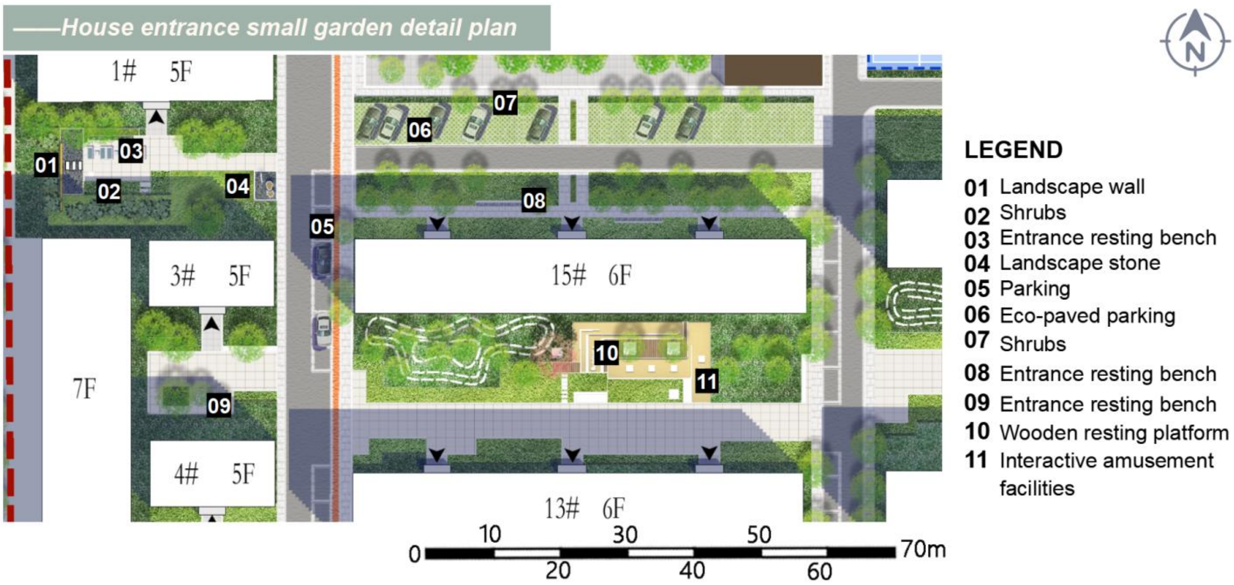


Fig. 4-9 House entrance small garden detailed plan. Source: by author

This is a detail plan of the small garden at the entrance of the building in the community. The core concepts of environmental protection and livability are present throughout the small gardens at the entrances of the buildings in the community. The whole layout is carefully planned to meet the living needs of the residents while focusing on low-carbon green development.

At the left edge of the garden, a landscape wall (No. 01) and a dense bush (No. 02) create a natural barrier that not only enhances the privacy of the space, but also provides a sense of security for the residents. In addition, multiple entrance benches (numbered 03, 08, and 09) are cleverly distributed throughout the small garden, providing a convenient resting place for residents as they enter and exit.

At the entrance of the small garden, an attractive landscape stone (No. 04) is designed, which serves as a decorative element and adds a natural rhythm to the small garden. The parking space next to it (number 06), on the other hand, uses advanced ecological paving technology, which effectively promotes rainwater management and reduces water surface runoff, reflecting the practical application of environmentally friendly concepts.

In addition, the shrubs in the small garden (No. 07) not only enrich the green layer, but also provide a fresh air environment for residents and help to enhance biodiversity. On the right side of the floor plan, a wooden resting platform (No. 10) and interactive recreational facilities (No. 11) are designed. It provides a space for residents who are far away from the central activity area to move around and communicate with each other.

The small garden at the entrance of the building fully demonstrates the design concept of sustainable development and the quality of life of the residents at the same time through well-designed rest spaces and beautification elements. At the same time, it has become a unique green space within the community, providing a pleasant living environment for the residents and increasing the carbon sink capacity of the site, making a positive contribution to the green renewal of the community.

Fig. 4-10 Visualization of small garden at residential entrance. Source: by author

4.3. Main road section

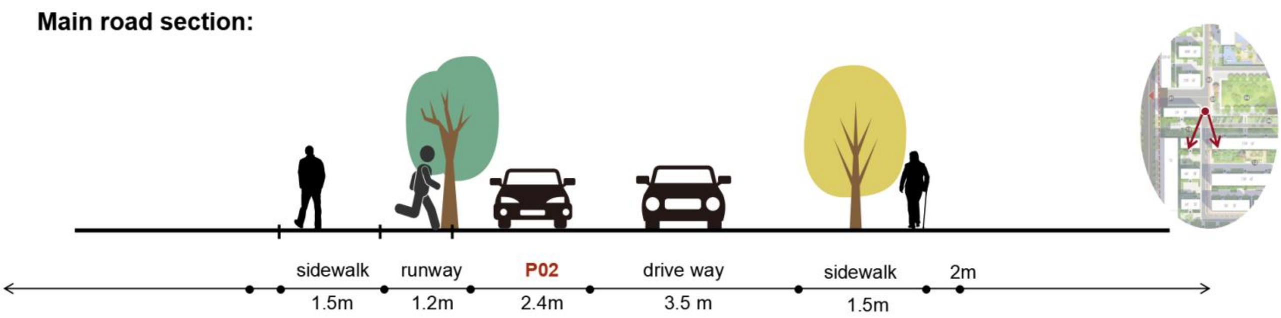


Fig. 4-11 Main road section. Source: by author

In this elevation of the main road, the renewed structure and layout of the community road can be clearly seen. From one side to the other, the road has been skillfully divided into five core zones, the width of each of which has been carefully designed to ensure its functionality and safety.

First, there is the Sidewalk, which is 1.5 meters wide and located on each side of the driveway. This wide walking space provides a safe and comfortable environment for pedestrians and gives residents a sense of security when walking in the community.

This is followed by the Runway, which is 1.2 meters wide and is located adjacent to the sidewalk on one side. This area is designed to encourage fitness activities, such as running or brisk walking, to promote health and wellness.

On the inside of the runway is an area of parking spaces 2.4 meters wide. This design effectively increases the parking capacity of the community, alleviating the problem of parking difficulties and providing residents with more convenient parking services.

Located in the center of the road is Drive way, which is 3.5 meters wide. This width is sufficient to meet the needs of the vehicles in the area and ensures the accessibility and safety of the road traffic.

Finally, trees and vegetation have been skillfully planted between the sidewalks and runways of the roads, as well as next to the parking spaces. These green elements not only beautify the road environment and enhance the overall landscape effect of the community, but also help purify the air, moderate the climate and provide a pleasant walking environment for pedestrians.

During the planning process, I focused on incorporating low-carbon concepts by establishing special running tracks and vegetated areas. Residents are encouraged to use low-carbon means of transportation such as walking and running to reduce their reliance on motor vehicles. This not only helps to improve the quality of life of residents, but also actively promotes the popularization of a healthy lifestyle.

4.3.1. Two types of parking

Two types of parking:

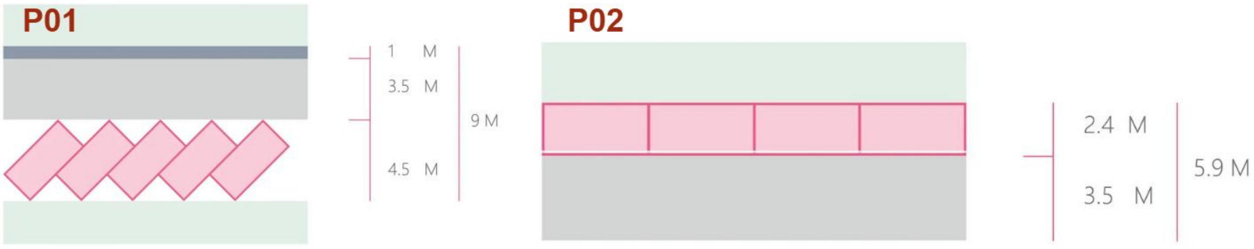


Fig. 4-12 Two types of parking. Source: by author

Henan Agricultural University affiliated community, due to historical reasons, there is no unified planning of parking spaces. With the progress of the times, the number of private cars has increased dramatically, and the problems of difficult parking and parking space tension have become more and more obvious. To address this challenge, I designed two parking types with their own distinctive features, aiming to improve the efficiency of parking in the community and alleviate the parking pressure.

First of all, the P01-type parking area uses a diagonal parking space layout. This design not only optimizes the use of space, allowing the width and length of each parking space to be optimally proportioned to ensure that vehicles can enter and exit easily, but also increases the density of parking spaces in the parking lot. Through the efficient and compact design, we were able to add more parking spaces within the limited space to meet the parking needs of the residents. In addition, the P01 type parking lot also focuses on the concept of environmental protection by using grass tiles as the pavement material, which not only enhances the green area, but also meets the requirements of low-carbon and green development.

In contrast, the P02 type of parking lot uses a parallel parking space layout. The width of each parking space is moderate, and although it requires more space for vehicle operation than diagonal parking spaces, it has the advantage of being more direct and convenient for vehicle entry and exit. This design not only facilitates parking for residents, but also improves the efficiency of the parking lot. At the same time, the P02 type parking lot is located on the side of the driveway, which adds additional parking spaces to the community and effectively alleviates the problem of parking difficulties.

Both parking types are designed with full consideration of maximizing the use of space on the site. The diagonal parking spaces (P01) maximize the use of parking spaces by optimizing the spatial layout, while the parallel parking spaces (P02) focus on the convenience and management of vehicle access.

Through the implementation of these designs, a more convenient and comfortable parking environment can be provided to the residents of the community, promoting the harmonious and sustainable development of the community.

4.4. Paving material

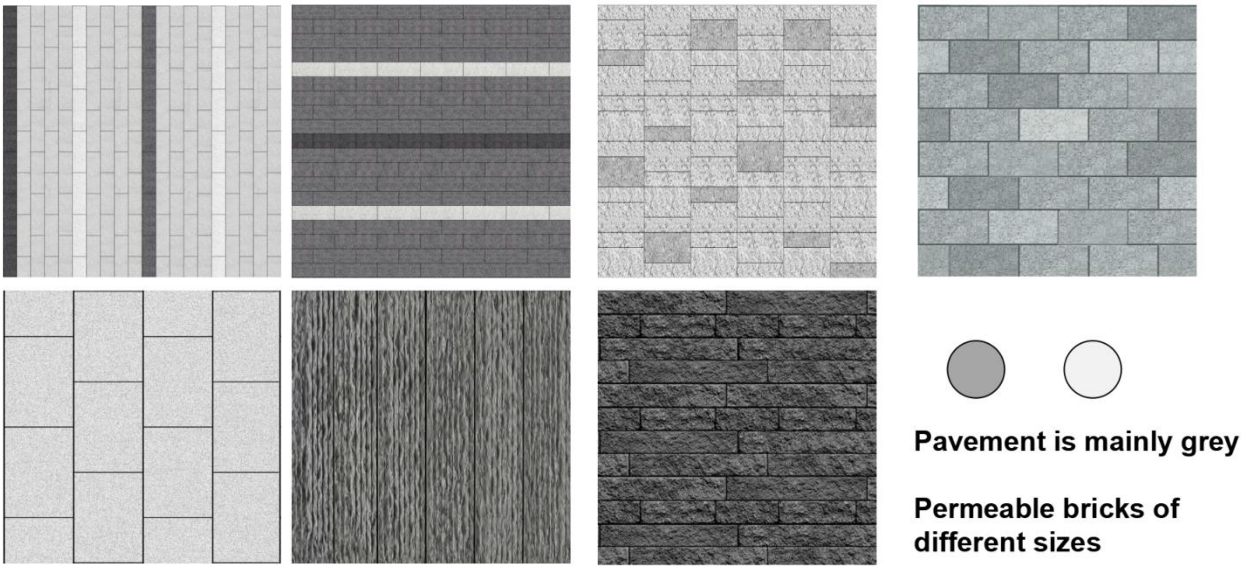


Fig. 4-13 Photographs of paving materials. Source: Internet

The material used for the pavement throughout the district is permeable bricks of various sizes, predominantly gray. Permeable bricks allow for water infiltration, which aids in groundwater recharge and reduces runoff.

The first is a slender arrangement of paving blocks, a design often used for pedestrian paths, showing a clean and modern look.

The second type is a wide strip of paving tiles alternating with thin strips of tiles. This design provides good visual guidance and is suitable for main sidewalks.

The third is a random patterned brick paving style. This adds texture to the surface and can be used to differentiate between areas or as a decorative focal point.

The fourth type is a regular matrix arrangement of paving blocks. It can be used in areas that require more sturdy support, such as building entrances.

The fifth type of material is an arrangement of large square paving bricks. This simple geometric design is suitable for plazas or public gathering places.

The sixth type is a rougher textured pavement that can be paved on the edges of two roads in order to increase friction and reduce the risk of slipping.

The last is a texture similar to that of aged wood, a design that aims to provide a natural visual feel and can be paved in small gardens to create a natural atmosphere.

The choice of these materials is based on factors such as low carbon, sustainability, and functionality, while also focusing on aesthetics and safety.

5. Research results

5.1. Landscape pattern strategy

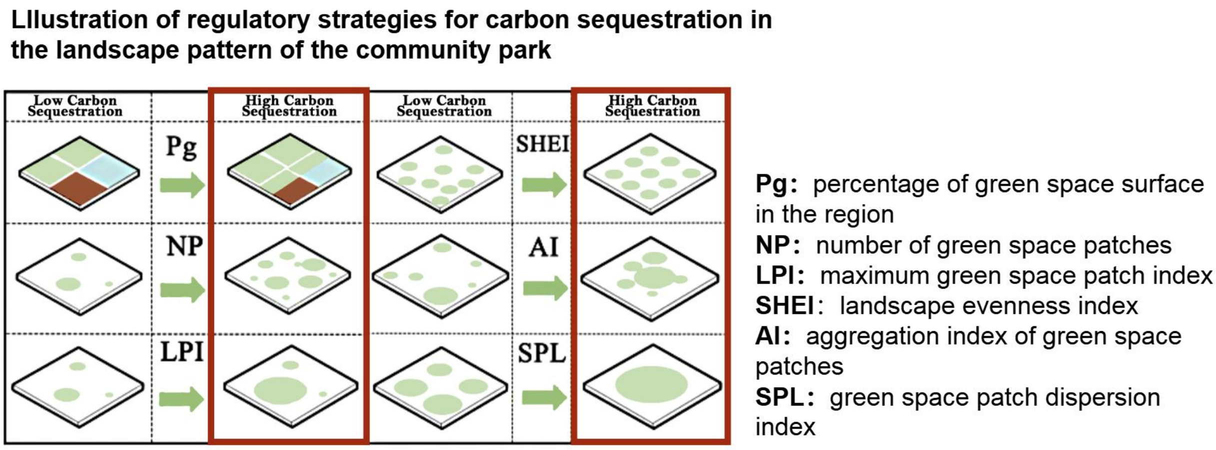


Fig. 5-1 Landscape pattern strategy. Source: Literature

Research has confirmed that carbon sequestration in community landscapes can be significantly enhanced by implementing the strategy in the graph above. This strategy focuses on several key landscape indicators, including Percentage of Green Space (Pg), Number of Green Space Patches (NP), Largest Green Space Patches Index (LPI), Aggregation Index (AI), and Spread of Green Space Patches (SPL). These indices are closely related to the carbon sequestration capacity of green space and provide a scientific basis for optimizing green space design.

Among them, the percentage of green space (Pg) is an important indicator of the proportion of green space in the region. Theoretically, as Pg increases, the carbon sequestration capacity of green space will increase accordingly. The number of green space patches (NP) reflects the spatial distribution of green space, with more green space patches implying wider coverage and higher carbon sequestration potential. The largest greenfield patch index (LPI) reflects the size of the largest individual greenfield patch, with larger LPI values contributing to greater biodiversity and carbon sequestration efficiency.

In addition, the landscape homogeneity index (SHEI) and green space patch aggregation index (AI) further characterize the spatial distribution of green space patches and their interrelationships. Uniformly distributed green space contributes to the balanced provision of ecosystem services, while a higher green space patch aggregation index implies a more continuous green space structure, which is conducive to ecological mobility and carbon sequestration efficiency[19] .

I have fully utilized these research results in the renewal design of the affiliated community of Henan Agricultural University. By increasing the area of green space and optimizing the distribution and aggregation of green space patches, I aim to maximize the carbon sequestration capacity of the green space and enhance other ecosystem services at the same time. Such as providing habitats for creatures, enhancing biodiversity and improving the urban microclimate. The implementation of these measures not only helps to increase the carbon sink capacity of the community, but is also an important step in creating a sustainable and environmentally friendly community.

So, through scientific planning and design of green space landscape, we can effectively enhance the carbon sequestration capacity of the community landscape, contributing to the fight against climate change and the promotion of sustainable urban development. The renewal design of Henan Agricultural University's affiliated community is a specific practice of this concept, demonstrating the possibility of improving carbon sequestration capacity by optimizing green space indicators.

5.2. Pavement and plant details

5.2.1. Before design

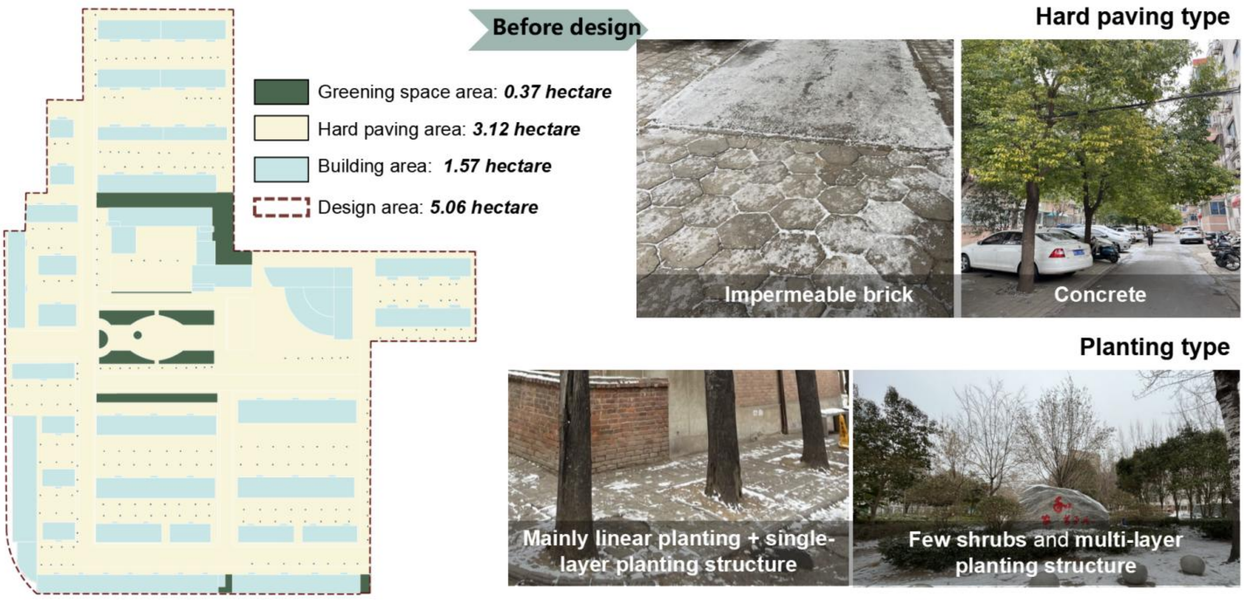


Fig. 5-2 Paving and planting type before design. Source: by author

The total design area of the community affiliated to Henan Agricultural University is 5.06 hectares, of which the area of green space is only 0.37 hectares, compared with 3.12 hectares of hard-paved areas and 1.57 hectares of built-up areas. This data clearly reveals a problem in the utilization of space in the district, i.e. the obvious lack of green space.

Currently, pavement materials in the community are dominated by impermeable bricks and concrete. This hard pavement not only leads to the impenetrable of water and the formation of water accumulation problems. Moreover, the production of concrete occupies about 8% of global carbon emissions, further aggravating the carbon emission problem [20]. Therefore, this material choice is clearly unfavorable from a carbon sequestration and ecological perspective.

In regard to planting, the existing vegetation structure in the community is dominated by linear planting and single-layered vegetation, which appears to be monotonous and lacking in diversity. Although there are also some shrubs and multi-layered planting structures, on the whole, the diversity and layering of vegetation still needs to be improved. This single vegetation structure not only affects the landscape effect of the community, but also is not beneficial to the conservation of biodiversity and the enhancement of ecological value.

So the Henan Agricultural University affiliated community, the original choice of materials is not favorable to carbon sequestration and ecosystem development. The hard impermeable pavement material limits the natural permeability of water and creates a challenge for rainwater management, while the single vegetation structure restricts the development of biodiversity and reduces the ecological value.

5.2.2. After redesign

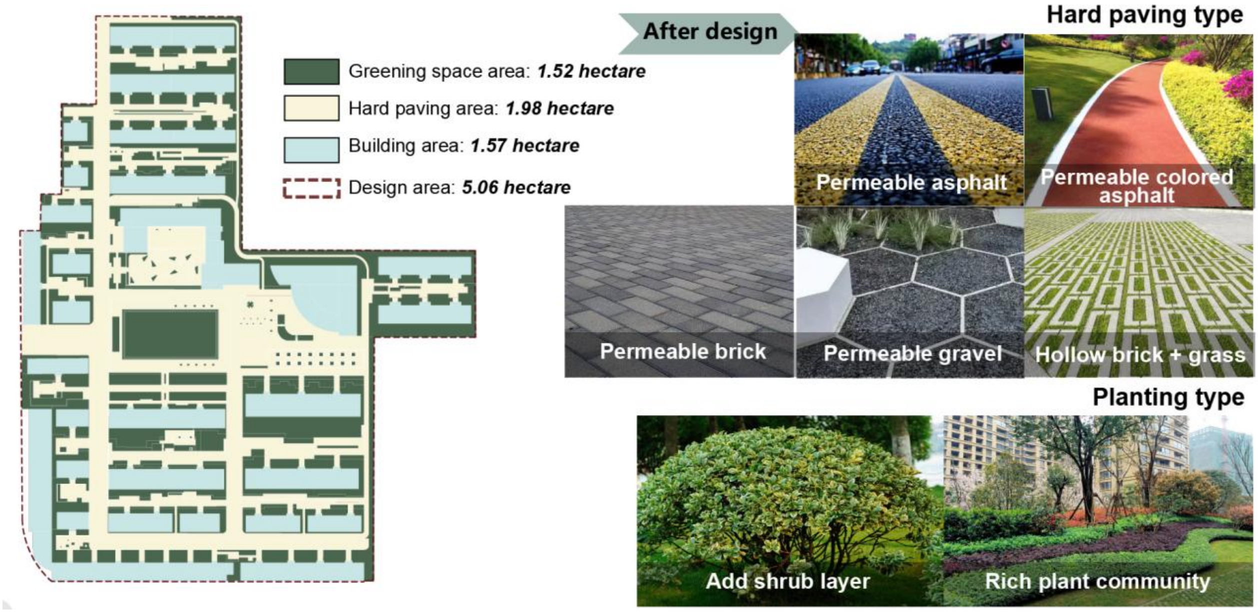


Fig. 5-3 Paving and planting type after design. Source: by author

This is the designed plan with the selected community paving and planting materials. For the hard surfaces, a variety of materials were skillfully used in the design to enhance the permeability of the ground and to improve its aesthetics. The choice of permeable asphalt and permeable colored asphalt not only meets the needs of ground drainage, but also adds a bright color to the community. The design of permeable bricks and hollow bricks with grass is a perfect combination of practicality and aesthetics. It not only enhances the ground's water permeability but also brings rich visual effects to the community through its unique textures and colors.

In the plant matching, the design emphasizes the creation of biodiversity and layering. By adding shrub layers, the density and three-dimensionality of the vegetation have been significantly improved, adding more greenery and vitality to the neighborhood. At the same time, the rich plant community is designed with a wide selection of different types of plants. A hierarchical green space is created, providing an ideal habitat for a variety of small animals. This design not only improves the single plant hierarchy of the original site, but also enriches the natural landscape of the community so that residents can live in a more harmonious and natural environment.

The design aims to provide a pleasant natural environment for the residents of the community, fully integrating ecological concepts and aesthetic principles, as well as playing a positive role in the urban ecosystem.

5.3. Renewal Design of Landscape Greening

5.3.1. Comparison before and after renewal

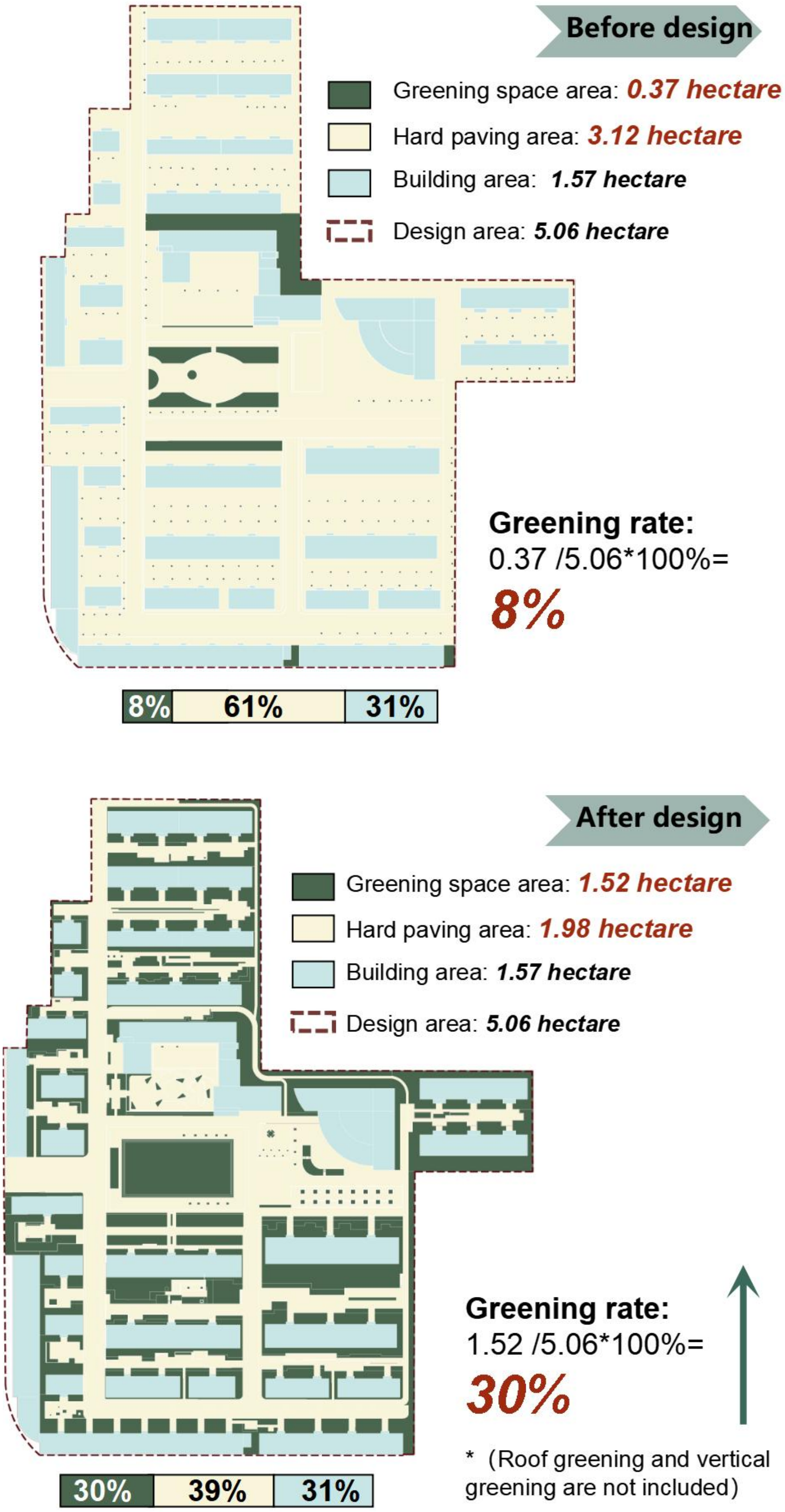


Fig. 5-4 Renewal Design of Landscape Greening. Source: by author

After redesigning the site, we can observe that the green space area has been significantly enhanced.

The site totals 5.06 hectares, and before design, the green space area was small at 0.37 hectares, while the hard paving area was larger at 3.12 hectares, and the building area was 1.57 hectares. According to the formula for calculating the greening rate, the greening area is divided by the total design area, and its greening rate is only 8%. The proportion of each type of area is 8% for greening, 61% for hard paving and 31% for building, with hard paving dominating the entire space layout.

After design optimization, the area of green space was significantly increased to 1.52 hectares, the area of hard paving was correspondingly reduced to 1.98 hectares, and the building area remained unchanged. With a newly calculated greening rate of up to 30%, this plan has had a significant effect in enhancing the greening level. The distribution of the area ratio has also been adjusted accordingly to 30% for greening, 39% for hard pavement as well as 31% for buildings.

Moreover, the calculation of the greening rate after design does not include rooftop greening and vertical greening, and if they are included in the calculation, the greening rate will be further enhanced. In addition, the design not only increases the area of green space, but also optimizes the distribution and aggregation of green space patches. The balanced distribution of green space contributes to the balanced provision of ecosystem services, while the high aggregation of green space patches means the continuity of green space structure is enhanced, which is important for the enhancement of ecological mobility and carbon sequestration efficiency. Together, these design strategies enhance the carbon sink capacity of the affiliated community of Henan Agricultural University, further reflecting the ecological value of the design.

By adopting a low-carbon green renewal approach, the design significantly increases the green space and reduces the area of hard paving while maintaining the same building area, thus enhancing the overall greening rate of the community.This change not only enhances the quality of the community's living environment, making it more livable and comfortable, but also complies with the concept of low-carbon and green development, which helps to promote the enhancement of the community's carbon sink capacity.

5.3.2. Greening standards

China Building Climate Zone Map

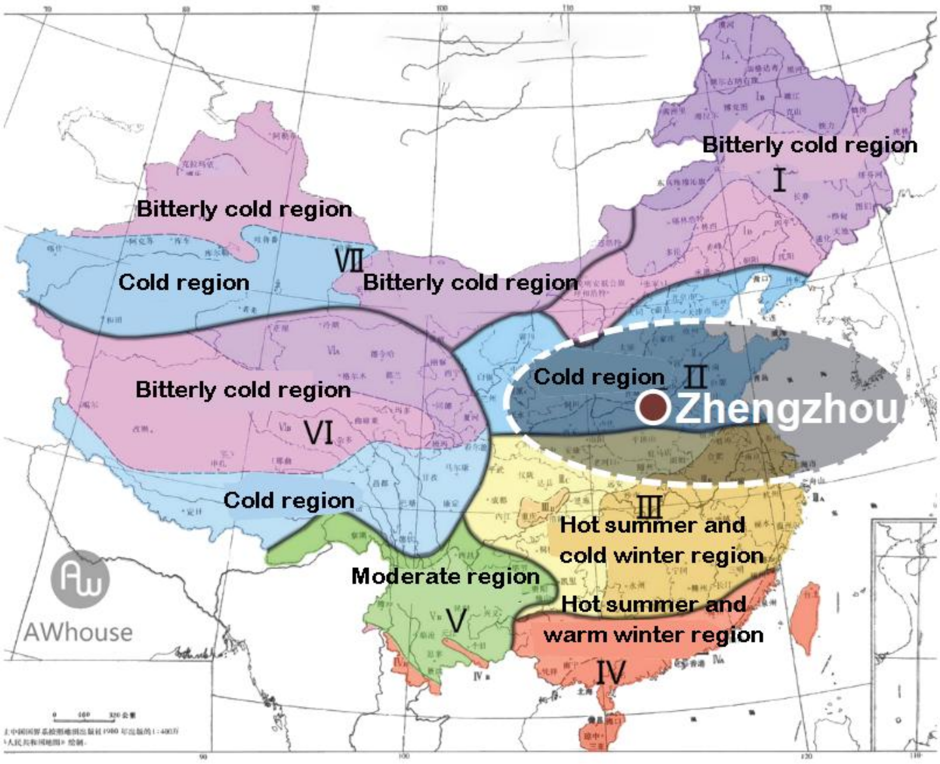


Fig. 5-5 China building climate zone map. Source:Internet

Residential Land and Building Control Standards Document

Building climate zoning	Category of average number of floors in residential buildings	Residential land plot ratio	Maximum building density	Minimum green area ratio (%)	Maximum residential building height control (m)	Maximum residential land area per capita
Ⅰ、Ⅶ	低层（1层~3层）	1.0	35	30	18	36
	多层Ⅰ类（4层~6层）	1.1~1.4	28	30	27	32
	多层Ⅱ类（7层~9层）	1.5~1.7	25	30	36	22
	高层Ⅰ类（10层~18层）	1.8~2.4	20	35	54	19
	高层Ⅱ类（19层~26层）	2.5~2.8	20	35	80	13
Ⅱ、Ⅵ	低层（1层~3层）	1.0~1.1	40	Greening rate		36
	Multi-storey Ⅰ类（4层~6层）	1.2~1.5	30	30	27	30
	Multi-storey Ⅱ类（7层~9层）	1.6~1.9	28	30	36	21
	高层Ⅰ类（10层~18层）	2.0~2.6	20	35	54	17
	高层Ⅱ类（19层~26层）	2.7~2.9	20	35	80	13

Fig. 5-6 Residential land and building control standards. Source:Internet

Zhengzhou is located in a Class II climate zone, and the government standard for greening rates in such residential areas is 30%. The design therefore follows the latest guidelines for the renovation of old communities and complies with this regulation.

In summary, this design not only meets the government's requirements for the renovation of old communities, but also optimizes the community living environment of the affiliated community of Henan Agricultural University in a comprehensive and in-depth way, making it an excellent low-carbon and green living community, and showing a new style of the old community.

5.4. Renewed design of planting

5.4.1. Steps in Plant Renewal Design

The plant renewal program for the community affiliated with Henan Agricultural University is divided into three main steps:

Step 1: “Try to keep most of the trees” and add plants to the original bare soil planting beds, partially adding planting beds. And combine these planting pools with some outdoor designs, such as using tree trunks to design outdoor tables, and combining planting pools to design circular seating, which are both ecologically significant and practical.

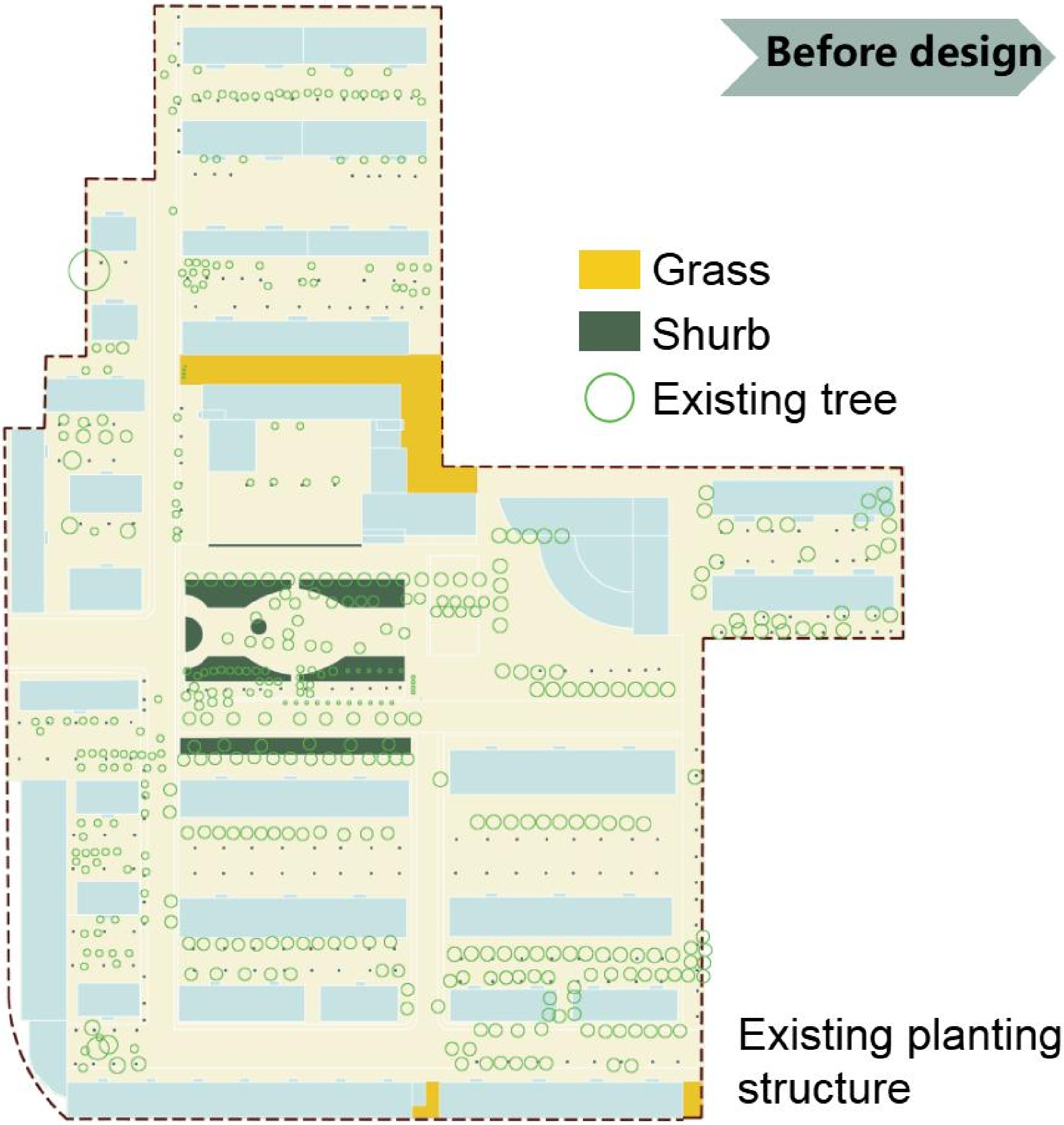
Step 2: “Remove some healthy plants that obstruct traffic” also recommends cutting down unhealthy plants. Retain older trees, which have higher ecological value and sequester more carbon.

Step 3: “Add new plant groups with high carbon sequestration capacity” to supplement the missing shrub layer and prioritize those plants with high carbon sequestration capacity and unique characteristics to create a rich vegetated landscape. Examples include *Ulmus pumila, Lonicera japonica* and *Pyracantha fortuneana*.

This comprehensive plant renewal plan begins by reinforcing the natural atmosphere of the community by preserving most of the trees and innovatively using them as design elements. Retaining the site's original carbon sink base is being renewed. Secondly, the accessibility and environmental health of the neighborhood is then enhanced by removing plants that impede traffic and are unhealthy. Finally, the carbon sink of the site is increased by introducing plants with high carbon sequestration capacity.

This design plan not only enhances the greening function of the community affiliated with Henan Agricultural University, but also enriches the biodiversity. This plan is an optimization of the existing plant ecology and an environmentally responsible expression for the future.

5.4.2. Planting structure before and after renewal



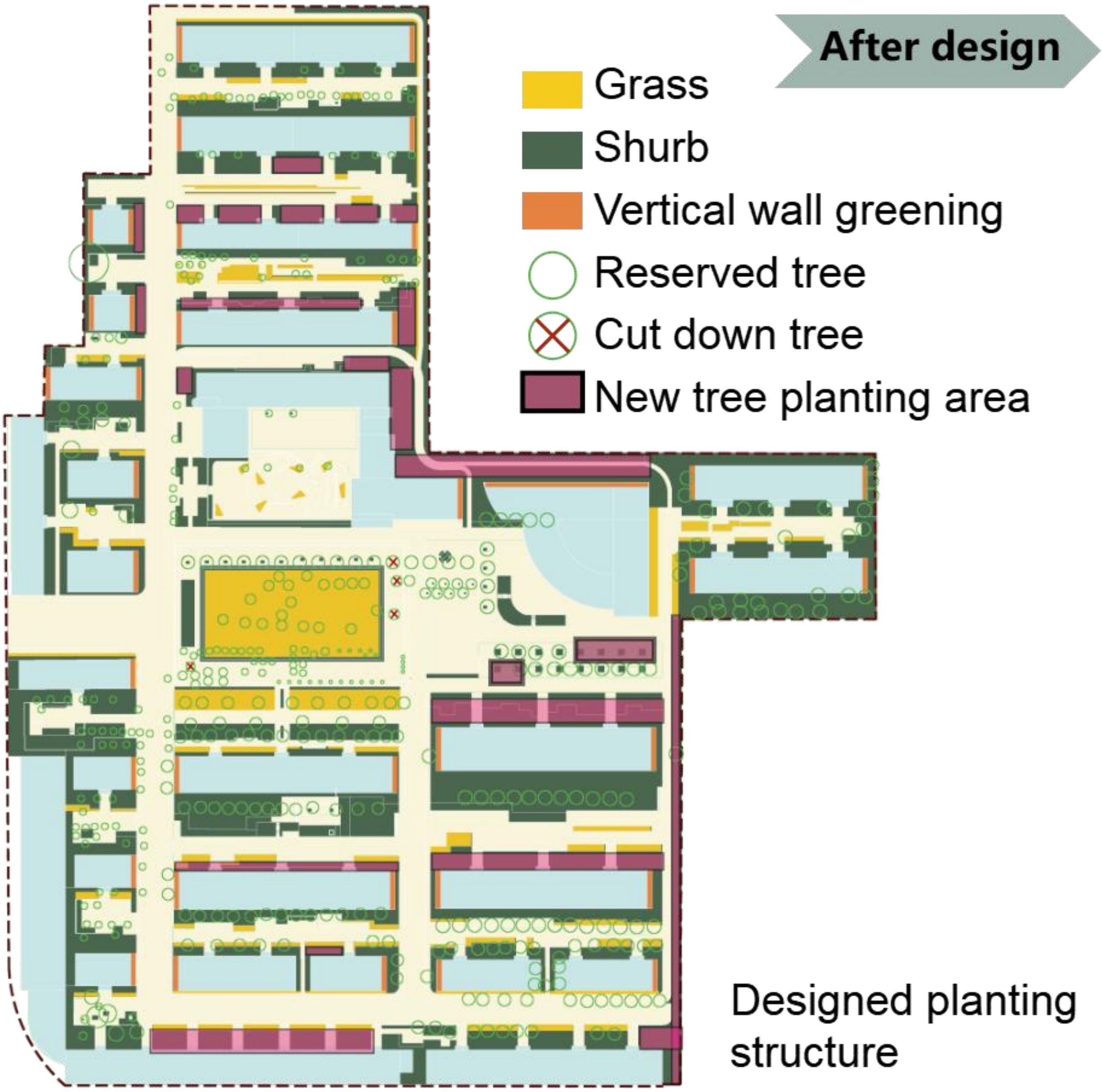


Fig. 5-7 Planting structure before and after renewal. Source: by author

This is a comparative picture of the design of the planting structure in the plot attached to Henan Agricultural University.

The planting structure before the design shows us a relatively homogeneous planting area consisting mainly of grass (yellow area), shrubs (green area) and existing trees (marked with circles). The planting structure is relatively fragmented, with grass as the dominant vegetation type, and trees and shrubs scattered throughout.

After the design, the planting structure became more diverse and organized. Vertical green walls (orange areas) and new tree planting areas have been added to this design, all of which may contribute to the site's carbon sink capacity. Vertical green walls can provide additional areas for plant growth on limited floor space, and these plants can absorb carbon dioxide from the atmosphere through photosynthesis. The added area for new tree plantings also facilitates carbon sequestration, as trees can store large amounts of carbon as they grow. This is especially the case for long-growing tree species, whose carbon stores usually increase over time[21].

Retained trees (marked with circles and forks), and cut trees (marked with forks). New tree planting areas (marked with dark red areas) have been added to increase biodiversity, provide shade, and improve the overall aesthetics of the community.

Overall, the redesigned planting structure presents a more detailed and strategic planning. Consideration has been given not only to aesthetics and biodiversity, but also to environmental benefits and the needs of the community for their use. And while the plan ensures adequate plant cover and healthy plant growth, it also increases the use of native plants, which are critical to maintaining and enhancing the site's carbon sink potential.

By creating multi-level green environments within a limited space, not only has the ecological environment of the community been improved, but also the comfort and quality of life for residents have been enhanced.

5.5. Plants with high carbon sequestration

Before proceeding with the selection of suitable high carbon sequestering tree species, a list of urban greening plantings was obtained from the official website of the Zhengzhou Municipal Government, and then the software was used to analyze and screen among these trees suitable for growing in Zhengzhou. Ensure that these trees are suitable for survival in Zhengzhou City, followed by prioritizing high carbon sequestration plants.

After the study and analysis, plant lists were screened for three main categories: trees, shrubs, and climbing and mulching plants. They all performed well in carbon sequestration capacity.

In the tree category are the following plants: Platanus orientalis, Acer truncatum Bunge, Salix matsudana, Ulmus pumila, Paulownia fortunei.

The tree categories cover a wide range of sizes and adaptations, from the large Platanus orientalis to the small and tough Ulmus pumila. this shows the diversity of tree species that can be selected to suit different spatial and environmental requirements when designing a neighborhood green. For example, Platanus orientalis is often suitable for planting next to a spacious street, while Ulmus pumila may be better suited to small gardens or narrow spaces.

In the shrub category are the following plants: Forsythia suspensa, Forsythia viridissima, Cercis chinensis, Hibiscus syriacus, Cornus alba, Photinia serratifolia, Pittosporum tobira, Chimonanthus praecox, etc. These plants can be used to create landscapes, barriers or borders. For example, Forsythia suspensa has yellow flowers in the spring, which not only add visual appeal, but also absorbs a lot of carbon dioxide through its leaves. In addition, shrubs such as Cercis chinensis and Hibiscus syriacus provide seasonal aesthetics while also contributing to carbon sequestration.

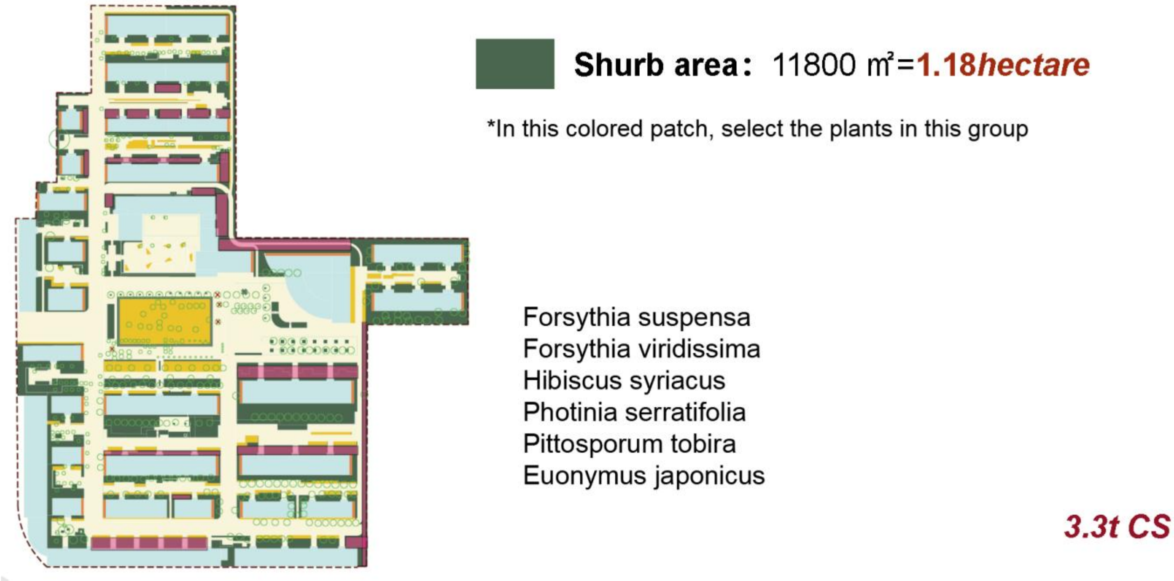
Plants in the Climbing and Covering Plants category: Lonicera japonica.This type of plant can cover walls and fences, not only helping with energy conservation and insulation but also absorbing a significant amount of carbon dioxide. Additionally, its flowers are highly decorative.

These plants were chosen based on their high carbon sequestration capacity. Carbon sequestration is the process by which plants absorb carbon dioxide from the atmosphere through photosynthesis and store it as biomass.This characteristic is important for mitigating greenhouse gas emissions in cities. These plants can be adapted to local growing conditions and also play an active role in reducing carbon dioxide concentrations in the atmosphere. It is possible to ensure that plant growth is both ecologically friendly and contributes to carbon reduction, thus striking a balance between environmental protection and urban greening.

5.6. Carbon sinks after redesign

5.6.1. Shrub carbon sink

Fig. 5-8 Shrub carbon sink. Source: by author



The shrub area was calculated to be 11,800 square meters, equivalent to 1.18 hectares.

Shrubs to be planted in the part of the map marked in dark green: Forsythia suspensa, Forsythia viridissima, Hibiscus syriacus, Photinia serratifolia, Pittosporum tobira, Euonymus japonicus. These plants are usually used for landscaping, which can beautify the environment as well as absorb carbon dioxide through photosynthesis, providing a certain carbon sink effect.

The calculated plants in this area are expected to store 3.3 tons of carbon over a certain period of time.

5.6.2. Grass carbon sink

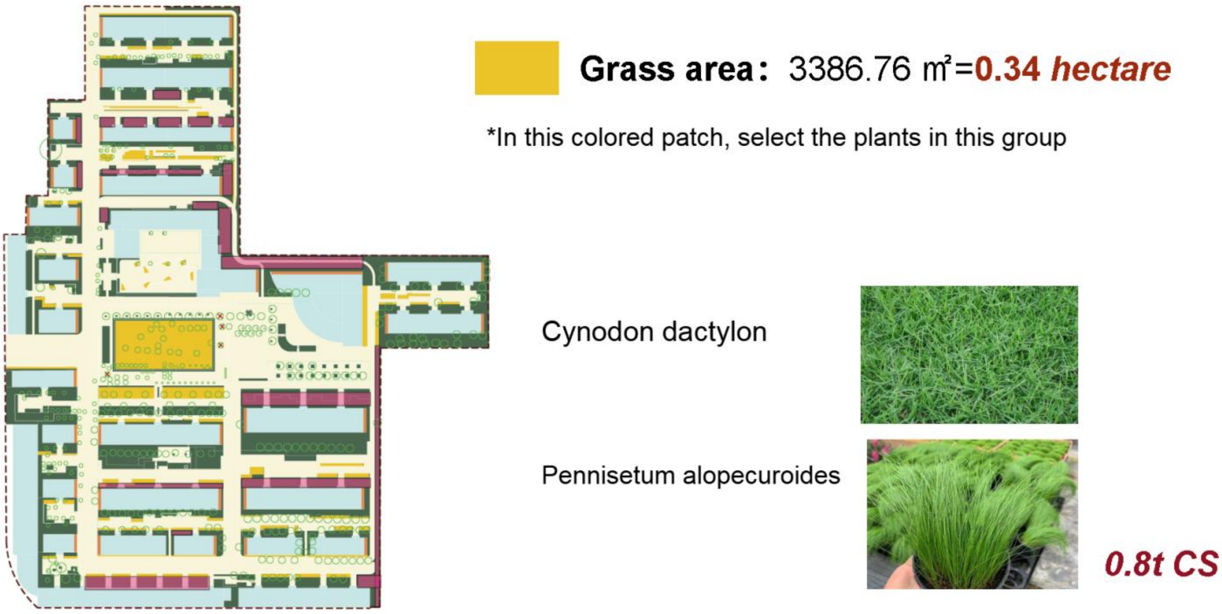


Fig. 5-9 Grass carbon sink. Source: by author

The calculated grass area is 3,386.76 square meters or approximately 0.34 hectares. In the picture, the grass area is highlighted in yellow. On the lawn, two plants are planned: Cynodon dactylon and Pennisetum alopecuroides.

Cynodon dactylon is a drought-tolerant grass commonly used in lawns, while Pennisetum alopecuroides is famous for its decorative flower spikes. Both grasses are known to be cold and drought tolerant, and easy to maintain, making them suitable for keeping green spaces stable and aesthetically pleasing in changing climates.

Calculations have shown that this lawn area is expected to absorb 0.8 tons of carbon.

5.6.3. Vertical green carbon sink

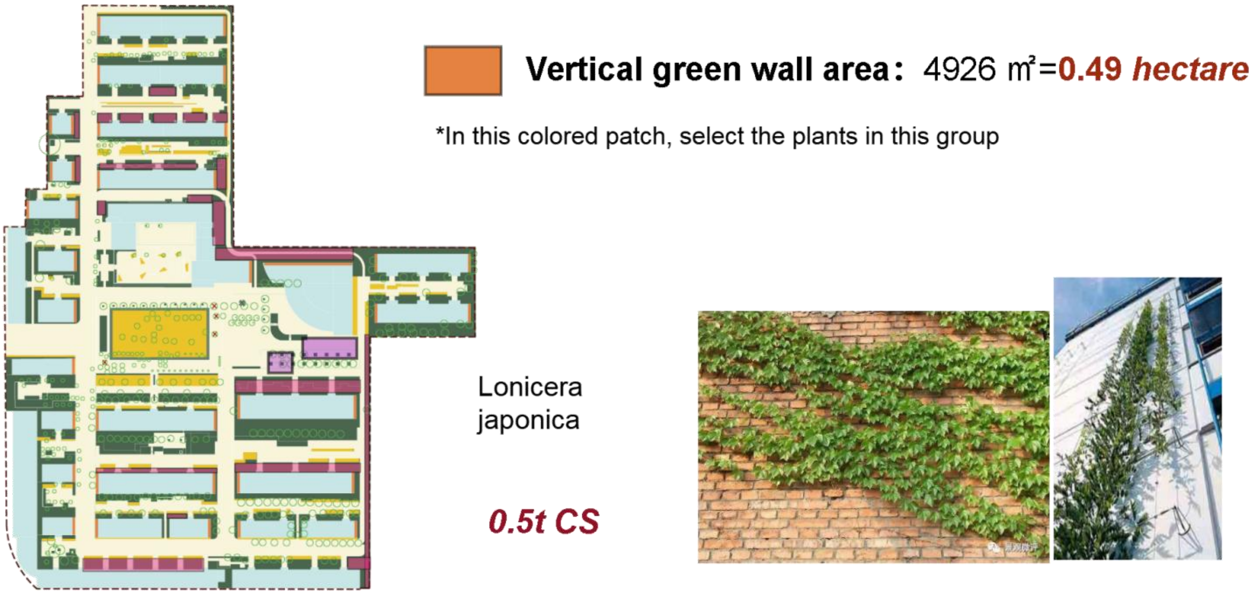


Fig. 5-10 Vertical green carbon sink. Source: by author

The designed vertical greening area of the building is 4,926 square meters, which is approximately 0.49 hectares. The area of vertical greening is marked in orange. Vertical greening usually refers to planting plants vertically on the facade of a building as a way to increase green space and improve the microclimate of the city, as well as to increase the aesthetics of the building.

In this plan, the vertical greening plant chosen is Lonicera japonica. Lonicera japonica is a vine commonly used for vertical greening and is widely used because it is fast growing and easy to maintain. It adapts to a variety of environments and helps absorb carbon dioxide from the air through its leaves and stems.

It is estimated that the amount of carbon that can be absorbed by this vertical greening area is 0.5 tons. Vertical greening is not only useful in landscaping and improving urban ecology, but also in its potential contribution to reducing carbon dioxide concentrations in the atmosphere.

Sustainable community development and reduction of carbon emissions through efficient use of limited spatial resources.

5.6.4. High carbon sequestration capacity tree

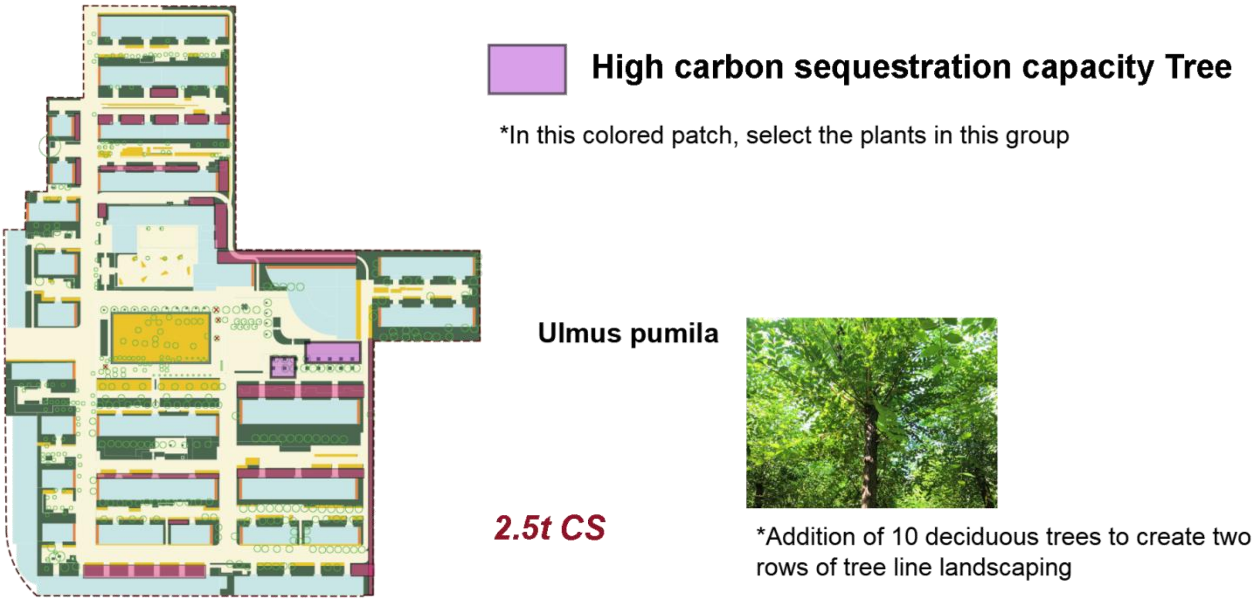


Fig. 5-11 High carbon sequestration capacity tree. Source: by author

The areas marked in purple on the picture represent sites where trees with high carbon fixing capacity are planned to be planted. The species to be planted is Ulmus pumila, a fast-growing, cold- and drought-tolerant tree that is often used in urban greening to improve air quality and provide shade.

Ten deciduous trees were added to create two tree lined landscaping rows between the activity area and the residential building. The tree lined landscape will provide a comfortable understory space for shade in the summer and a place where people can enjoy the sun after the leaves fall in the winter. It is not only about carbon sequestration, but also about beautifying the landscape of the community through an orderly tree planting initiative.

These Ulmus pumila were calculated to be expected to absorb 2.5 tons of carbon. Tree species with high carbon fixing capacity were selected to reduce the amount of carbon dioxide in the atmosphere and to enhance the aesthetic value of the community and the quality of life of the inhabitants through a well-planned layout of tree planting.

5.6.5. High carbon sequestration plant groups

（1）Type 01

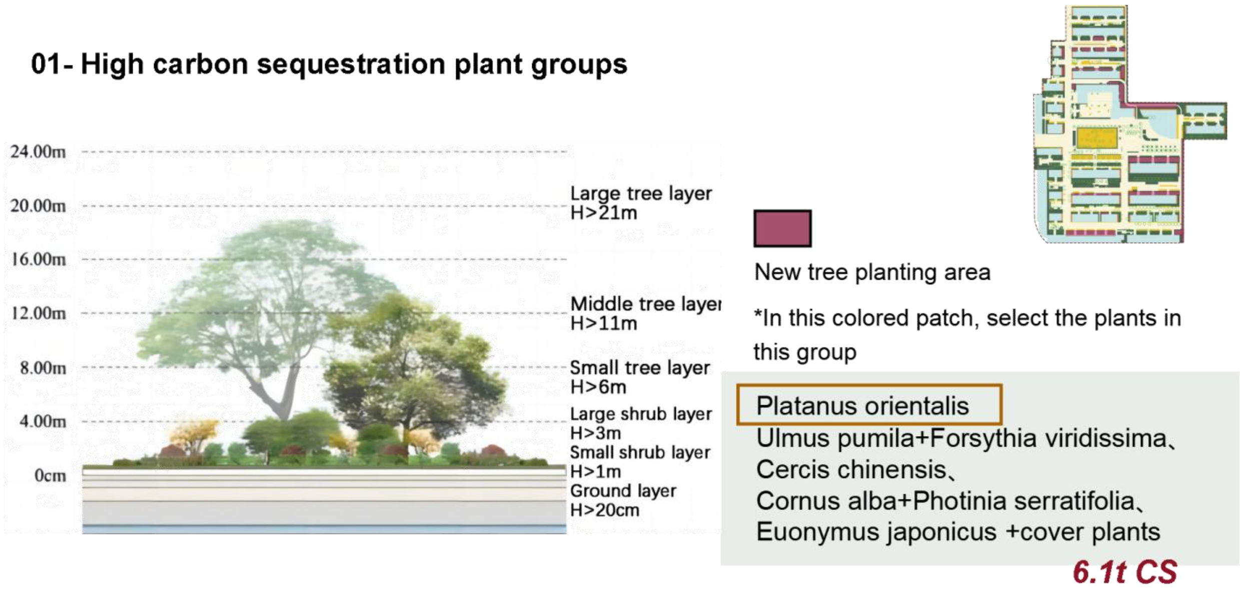


Fig. 5-12 High carbon sequestration plant groups—Type 01. Source: literature + author

This is the first type of plant groupings in the plan and their carbon sink potential. The vertical structure of the plant distribution is presented in a hierarchical diagram, from the ground level up to the layer of large trees no more than 20 meters high.

Starting from the ground level, there is a ground level (about 20 cm in height), followed by a small shrub level (up to 1 m in height), and then a large shrub level (more than 3 m in height) above that. The tree layer is divided into three levels: the small tree layer (up to 6 meters in height), the medium tree layer (up to 11 meters in height), and the large tree layer (over 21 meters in height). This hierarchical greening design creates a rich ecological environment and is important for enhancing urban biodiversity and ecosystem services.

In areas marked in purple, selected plants include Platanus orientalis, Ulmus pumila + Forsythia viridissima, Cercis chinensis, Cornus alba + Photinia serratifolia, Euonymus japonicus and cover plants[22].These proposed plantings are visually and ecologically diverse and include both tall trees and small to medium sized shrubs and groundcovers.

Calculations anticipate that this plant grouping is expected to be able to absorb 6 tons of carbon dioxide by the time it grows to a certain point. This further highlights the role of community greening in environmental protection and climate change mitigation.

（2）Type 02

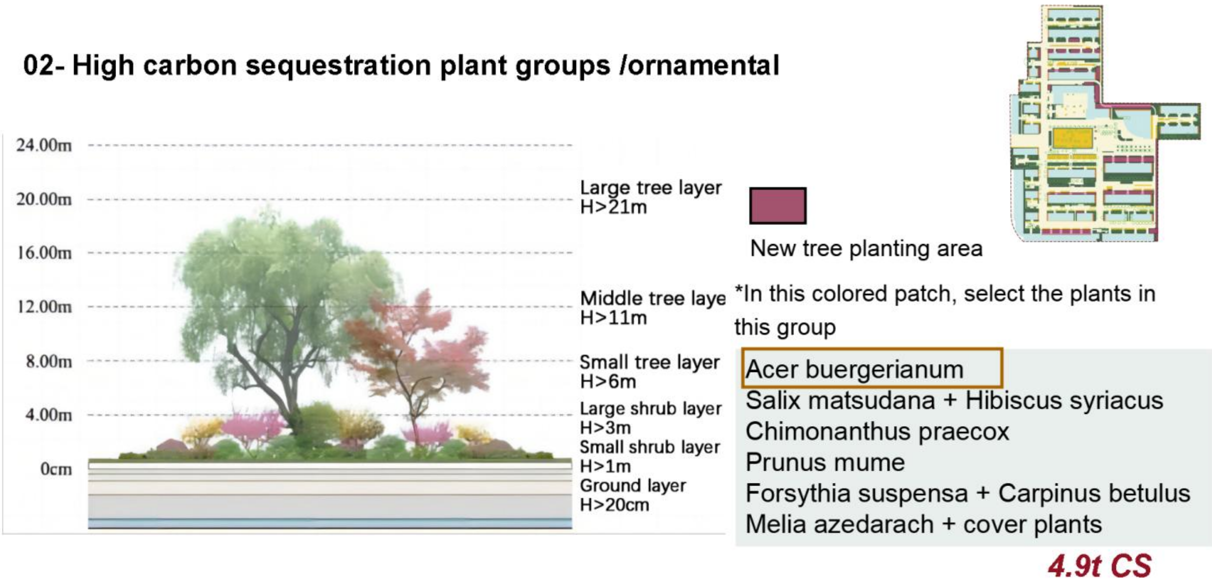


Fig. 5-13 High carbon sequestration plant groups—Type 02. Source: literature + author

This is the second type of high carbon sequestering plant grouping and emphasizes the decorative nature of these plants. Areas of planting are marked in purple and illustrate the vertical hierarchy of plant distribution, from the ground level to the large tree level above 21 meters.

Each layer of the plant distribution contains different types of plants including: large tree layer, medium tree layer, small tree layer, large shrub layer, small shrub layer, and ground layer.

The following plants have been selected for this plant group: Acer buergerianum, Salix matsudana and Hibiscus syriacus, Chimonanthus praecox, Prunus mume, Forsythia suspensa and Carpinus betulus ,as well as Melia azedarach and other cover plants. These plants were calculated to have a high carbon sequestration capacity and were selected for their ornamental qualities[22].

And it is expected that this plant grouping will absorb 4.9 tons of carbon dioxide. Overall, through careful selection of tree species and other plants with high carbon fixation potential, we can create a community environment that is both beautiful and conducive to mitigating climate change. This multi-layered greening strategy can effectively increase biodiversity, improve the urban microclimate, and enhance the quality of life for residents[23] .

5.7. Results summary

Before the design, the original carbon sink of the community was 88.58 tons. However, after a series of deliberate designs, i added more grasses, shrubs, vertical greenery, trees, and special plant groups in order to increase the carbon sink capacity of the community through these greening measures. It is predicted that when these plants mature, they will be able to directly store up to 61.11 tons of carbon. This valuation is calculated based on the maturity and carbon sink potential of the plants and directly reflects the expected effects of my greening strategy.

It is important to notice that this figure is still a preliminary estimate at this point in time. In order to obtain more accurate data, further information on plant growth status needs to be collected and analyzed for a more accurate assessment of carbon sinks. Moreover, apart from its direct carbon sink effect, low carbon green renewal design may also bring about indirect emission reduction benefits. For example, by installing solar panels on the roof, it can effectively reduce the building's reliance on external electricity, thereby reducing electricity consumption and the corresponding carbon emissions. This emission reduction effect has not yet been included in my current calculation of carbon sinks, but its contribution to the overall carbon reduction of the community in the future should not be overlooked.

Therefore, the quantification of these indirect emission reduction benefits needs to be further explored in depth in subsequent studies and incorporated into the overall carbon reduction strategy. Through these efforts, I expect to be able to contribute more to the realization of sustainable development and low-carbon living in the community.

6. Conclusion

6.1. Main findings

Based on the actual carbon sink conditions of the community and information on the current status of the site, this study thoroughly explores the feasibility and effectiveness of enhancing the carbon sink capacity of the community through precise green space planning strategies.After the final research results, we can conclude a series of important conclusions.

First of all, through the low-carbon green renewal design approach, the implementation of precise green space planning strategies can significantly increase the green space area, the optimization of plant layout, and the use of renewable energy sources, such as solar energy, in the community affiliated with Henan Agricultural University, thus significantly increasing the carbon fixation and storage capacity of the community ecosystem. This result shows that we can create a more livable, beautiful and low-carbon ecological environment for the community, and at the same time directly and significantly increase the carbon sink.

Second, this study provides strong data support for green space planning and management by calculating accurate carbon sink data. These data not only help us better understand the current status and potential of carbon sinks in the community, but also provide a basis for us to develop a more scientific and rational green space planning strategy. At the same time, it also provides an important reference and reference for the sustainable development of the city and the realization of the carbon neutrality goal.

In addition, this study also combines theory and practice, successfully applying the proven theoretical research to the low-carbon green renewal and renovation of old community. This practice not only verifies the feasibility and validity of the theory, but also accumulates a wealth of experience and insights for us. By applying the methods and models of this study, urban planners can more accurately calculate the carbon sink capacity of urban green space, and then fully consider the distribution and layout of green space in the urban planning process, optimize the spatial structure of the city, and enhance the carbon sink capacity of the city[24] .

In summary, this study provides strong support and guarantee for the low-carbon green development of the community through accurate green space planning strategies and carbon sink data calculation. I expect that this research result can attract more people's concern and attention, and jointly promote the sustainable development of the city and the early realization of the goal of carbon neutrality. At the same time, I also hope that future research can further deepen and expand on this basis and make greater contributions to low-carbon green living.

6.2. Limitations and suggested future research

Although this study has achieved some results in exploring the enhancement of the carbon sink capacity of the community through low carbon green renewal methods, there are still some limitations as follows:

(1) The collection and analysis of research data may be limited. Due to the complexity and time-consuming nature of field surveys and data collection, there may be cases of incomplete data or errors. This may lead to an imprecise calculation of carbon sinks in the community, which in turn affects the formulation and implementation effects of green space planning strategies.

(2) This study focuses on green space planning and carbon sink capacity enhancement at the community scale, and may lack generalizability and applicability to a larger scale or different types of cities. Factors such as climate, environment and socio-economic conditions in different cities or regions may have different impacts on green space planning and carbon sink management, so the results of this study may not be directly applicable to other cities. However, reference can be made to this methodology.

(3) The theoretical framework and modeling assumptions of this study may have some limitations. Although I have tried my best to adopt proven theoretical studies as support, no theory can fully and accurately describe and predict complex natural and social phenomena. Therefore, the conclusions of this study may be affected in some ways and need to be further verified and adjusted in practical applications.

(4) This study mainly focuses on the technical aspects of green space planning and carbon sink management, which may lack comprehensive consideration of policy, economic and social aspects. In practical application, green space planning and carbon sink management need to be combined with various factors such as policy

formulation, financial investment and public participation to achieve better results. Therefore, future research can further expand and deepen the exploration of these aspects.

In conclusion, although this study has achieved certain results in the low-carbon green development of communities, there are still some limitations. In future studies, we will further improve the data collection and analysis methods, expand the coverage and depth of the study, and comprehensively consider more relevant factors, so as to promote sustainable urban development and early realization of the carbon neutrality goal.

Acknowledgement

This is the end of my thesis, which means that my two years of postgraduate life in Hungary are coming to an end! Looking back on these two years, I have so many emotions about the wonderful time I had at the Hungarian University of Agricultural and Life Sciences. These memories are colorful; staying up late with classmates to do homework, going out to investigate sites together, going on trips together, and so on. These moments make up the person I am now.

First of all, I would like to thank all the teachers of Hungarian Agricultural University for your guidance and teaching, your seriousness and rigor. Let me learn a lot of things in school. I am also very grateful to my tutor, Gabriel Silva Dantas, for giving me a lot of guidance and advice on my graduation project.

Secondly, I am very grateful to my Chinese supervisor, Ge Shidong, who opened the door of academic research to me. Thank you for your patience in teaching me and care in my life.

Finally, I would like to thank Henan Agricultural University, the Hungarian government and the Chinese government for giving me such a learning opportunity.

It's because of the support of everyone that I've gotten this far. Also, thanks to myself, who faced the pain of a family member's departure a few days before the green light, and insisted on completing the task while crying.

What ended was the time spent learning in school, and my life was just beginning.

Lists of Figures

Fig. 5-13 High carbon sequestration plant groups—Type 02. Source: literature + author

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