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Quality Improvement of Pedestrian Environment in Old Communities under the Guidance of Low Carbon—A Case Study of Shipai Creek Community in Guangzhou

A Dissertation Submitted for the Degree of Master

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Abstract

With the intensification of global climate change, construction of low-carbon cities and carbon neutrality have become a priority for the world. In the ranking of industrial carbon emissions, urban transportation remains high and has become the main target in battle with carbon emission. Walking is an integral part of urban transportation and is considered the most energy-saving way. Accordingly, the quality of pedestrian environment will directly affect people's inclination for travel methods. Therefore, it can be concluded that the construction of pedestrian environment has profound significance for the development of low-carbon transportation. Due to its early construction, the design of old communities can poorly coordinate the living needs in new era. The increasing traffic conflicts have aroused more concern for the pedestrian environment, which had led to a decrease in residents' desire to walk. Therefore, improving the pedestrian environment of old communities has become urgent. This article takes Shipai Creek Community on Tianhe North Street in Guangzhou as an example to explore strategies for improved pedestrian environment quality of old communities from a low-carbon perspective, and seeks to draw a plan for reference of practice.

Firstly, this article reviewed previous research on pedestrian and low-carbon practices both domestically and internationally, analyzed concepts such as pedestrian environment and old communities, and elaborated on the applicability between low-carbon concept and improve the quality of pedestrian environment in old communities. The article then revolved around two key issues: what kind of community is suitable for residents to walk in a low-carbon environment? How to guide the quality improvement of pedestrian environment in old communities?

The first research question is formulated based on the daily travel characteristics of residents and the Carbon peaking and carbon neutrality goals. The construction goals for walkable communities are divided into three dimensions: layout form for reducing carbon sources, transportation for reducing carbon sources, and landscape for increasing carbon sinks. The thesis then explored the relationship between elements of community construction and the walking behavior from evolution of community space development patterns, development of

Street patterns, and the impacts of the landscape on the walking experience. Then community construction goals that fit pedestrians were deduced. The goals of the layout form involve functional configuration and public facility layout, street system consist of non- motorized network, street classification, landscape coverage of green space and supporting facilities and so on.

The second question is to summarize the strategies for improving pedestrian environment quality of old communities under the low-carbon orientation from the three dimensions. It begins with two pedestrian friendly low-carbon community projects, combined with on-site research and problems analysis in Shipai Creek Community. The update of community pedestrian environment includes demolition of small idle buildings, organization of vitality centers based on the concept of "1+1+2", the reorganization of non-motorized networks based on existing streets, and the expansion and design of Shipai Creek promenade.

The innovation of this article is mainly reflected in three aspects. Firstly, innovative research perspectives was placed on reducing carbon emissions. From the material aspect of technological transformation and energy renewal in the past to the aspect of guiding residents' low-carbon living behaviors, the importance of individual residents in the low-carbon transformation of communities is highlighted; Secondly, this article combined the low-carbon concept with the renewal of old communities to promote the construction of low-carbon ones, develop and improve existing community practices; Thirdly, it is innovative from the perspective of improving pedestrian environment quality. The perspective of this research has expanded from a single spatial level to a community level, thinking about problems from its origin. In summary, this article aims to provide theoretical analysis and strategic guidance to create a high-quality pedestrian environment for Shipai Creek Community, while providing suggestions for low-carbon renewal of old communities.

Keywords: Low carbon; Old communities; Pedestrian environment; Walking; Low-carbon transportation

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Chapter 1 Introduction

1.1 Background

1.1.1 Tackling Climate Change through Low-Carbon Transportation

It has become increasingly apparent in recent years that global warming is no longer just an academic conjecture due to extreme weather events, sea level rises, abnormal ocean currents, and other problems around the globe. Global warming has gradually become a reality that human beings must confront as an objective environmental reality. The world has gradually reached a consensus on the need to curb global warming by promoting human production and lifestyle changes to curb the various types of disasters caused by global warming. The measures range from agreements between countries, greenhouse gas emission targets for local governments, to carbon trading programs designed to slow down global warming[1]. On December 12, 2015, the Paris Climate Change Conference adopted the Paris Agreement (PA), which prescribed arrangements for global action on climate change after 2020. As an active participant in the Paris Agreement, China proposed in September, 2020 to "strive for peak CO_2 emissions by 2030 and to achieve carbon neutrality by 2060". However, of over 120 countries and regions that have recognized carbon neutrality in legislation and policymaking to PA, the majority have stated that they will achieve carbon neutrality by 2050. Compared to this, China, as the world's largest source of carbon emissions, faces a number of challenges in achieving its carbon neutrality targets[2].

As the central areas for human production and energy consumption, cities play a crucial role in the major strategic development tasks of nations. Despite covering only 2.4% of the global land area, cities bear approximately 70% of the world's carbon emissions[3].

In China, the carbon emissions contributed by urban areas account for over 73% of the country's total carbon emissions, and this proportion continues to rise steadily[4]. Among various industries and sectors, urban transportation contributes significantly to CO_2 emissions, making it one of the three major carbon sources in cities[5]. The main reasons behind this phenomenon are the continuous expansion of urban areas, the increasing transportation demands from

residents, and the rising per capita vehicle ownership. In this regard, addressing carbon emissions at the transportation level has become a critical component of the carbon peaking and carbon neutrality goals and the collaborative construction of low-carbon cities in practice.

1.1.2 Focus on Walking Behavior of Residents in Communities

Promoting a low-carbon mindset and incorporating innovative energy-saving technologies are essential steps toward curbing carbon emissions in transportation. However, the most impactful approach to reducing these emissions is to inspire residents to shift away from their habitual reliance on car travel[6]. Alternatively, public transportation, non-motorized traffic, and other low-carbon modes of transport should be encouraged. For carbon neutrality, Zhao Yixin, Director of the Urban Planning and Design Institute's Transportation Research Branch, stressed the importance of changing the travel structure. The individual who switches from driving a car to riding a bicycle can reduce carbon emissions by one ton per year, which is equivalent to achieving carbon neutrality from an individual's perspective. Clearly, human activities produce greenhouse gases that lead to climate change, so reducing emissions of greenhouse gases in daily life is an important step toward carbon neutrality.

Communities serve as the starting and ending points for residents' daily travels, as well as playing a significant role in the fight against climate change. An ideal foundation for the promotion of low-carbon concepts, technological developments, and the building of low-carbon cities is provided by communities. Residents of the community engage in a variety of travel-related activities on a daily basis, thereby contributing to the accumulation of carbon emissions within the community. As a result, creating a low-carbon, pedestrian-friendly environment and providing convenient conditions for walking are crucial measures to encourage the general public to adopt low-carbon ideas and practices.

1.1.3 Improving the Pedestrian Environment Quality in Old Communities

In China, the current urban development has shifted from incremental planning and construction to inventory planning and construction. The focus has transitioned from prioritizing speed to embracing a humanistic approach, with an emphasis on enhancing quality and adopting a people-oriented ideology. Despite the fact that urbanization and industrialization

have accelerated rapidly, there is a marked contrast between the proliferation of motorized vehicles and the development of low-emission modes of travel such as walking, cycling, and public transportation as the old communities have become the main carriers of inventory over time. Several issues have led to an imbalance in street space allocation, including mixed traffic patterns, the encroachment of motorized and non-motorized modes on pedestrian walkways and public spaces, and the prevalent practice of prioritizing vehicle mobility over pedestrian needs. Consequently, the old community often suffers from deteriorating pedestrian environments, diminished liveliness, and a gradual decline in residents' motivation for walking. Therefore, it is imperative to implement a comprehensive set of measures intended to improve pedestrian safety and promote walking as a viable means of transportation.

The focus of this study, the old community, is located in the Peri-Wushan Innovation Area of Tianhe District, Guangzhou. It serves as a crucial platform for Guangzhou City to promote the development of innovation alliances, accelerate the high-quality development of both Guangzhou City and provincial-level scientific institutions. According to the "Fourteenth Five-Year Plan for Ecological Environment Protection in Tianhe District, Guangzhou," Tianhe District is committed to accelerating green and low-carbon development and promoting the transformation towards a low-carbon lifestyle. In 2023, the Housing and Urban-Rural Development Bureau of Guangzhou emphasized the need to focus on the renovation and improvement of the old communities in the Peri-Wushan Innovation Area. Therefore, as a carrier for high-quality development in Tianhe District and even in Guangzhou City, discussing the improvement of pedestrian environments in old communities within the Peri-Wushan Innovation Area in line with low-carbon principles aligns with policy guidance and can guide the region towards steady progress of the carbon peaking and carbon neutrality goals.

1.2 Literature Review

1.2.1 Research on low-carbon community

Due to the early beginnings and robust economies, advanced Western nations have gathered substantial expertise in establishing low-carbon urban communities. Notably, countries such as the United Kingdom, Germany, and Sweden stand out as prime examples in

this regard. According to incomplete statistics, more than ten countries, including the United Kingdom, the United States, Germany, Denmark, Singapore, and the United Arab Emirates, have carried out low-carbon community practices. Cases include BedZED in the UK, Vauban District in Germany, Bahnstadt Heidelberg in Germany, Halifax in Australia, Southside Park in the US, Ecovillage in New York, Menlo Park Low-Carbon Emission Town in California, Malmö Western Harbor in Sweden, Singapore Building and Construction Authority Office Building, Ecolonia in the Netherlands, Masdar Low-Carbon City in Abu Dhabi, and the "Solar Wind" community in Denmark, all of which have a positive guiding role in low-carbon community and city construction.

Furthermore, in 2010, the UK Department of Energy and Climate Change launched the Low Carbon Community Challenge project in 22 communities, testing different low-carbon development models in 22 existing communities and providing different strategies for different types of communities. After two years, 18 communities completed the specified tasks.

The inception of low-carbon communities in China occurred belatedly, with practical expertise in this domain still in its infancy. Most of them are driven by local governments or developers, using experimental projects as carriers to find low-carbon development planning and construction models that can be implemented and promoted[7], such as Changxingdian Low-Carbon Ecological City in Beijing and Sino-Singapore Tianjin Eco-City.

The application of low-carbon construction techniques in aging communities is still at an early phase, primarily concentrating on the revitalization and modernization of outdated infrastructure. For instance, in the Shunde Neighborhood of New Taipei City, carbon reduction objectives are achieved through improvements in environmental greening, upgrading lighting fixtures, and replacing insulation materials[8]. The Zhongshan Xiaolan Town Low-Carbon Community undertakes low-carbon renewal through enhanced waste sorting and recycling practices, as well as the installation of photovoltaic power generation facilities[9].

In 2015, the National Development and Reform Commission issued the "Guidelines for the Construction of Low-carbon Community Pilot Projects" with the aim of promoting low-carbon urban development and controlling carbon emissions from residents' lives. In this construction guide, "existing communities" have become one of the three major pilot projects for low-carbon communities, thus advocating low-carbon lifestyles and improving the livable

environment in existing communities will become an inevitable choice. Meanwhile, governments at various levels have also introduced a series of incentive policies and promotion initiatives regarding walking and cycling. In January 2020, the Ministry of Housing and Urban-Rural Development deployed efforts to purify pedestrian walkways and construct dedicated bicycle lanes. In July 2020, the Ministry of Transport issued the "Green Travel Creation Action Plan." Furthermore, in April 2021, the Ministry of Housing and Urban-Rural Development released the "Urban Walking and Cycling Transportation System Planning Standards."

1.2.2 Research on the Impact of Built Environment on Walking

Moughtin[10] studied European traditional urban living blocks and argued that smaller living blocks lead to stronger urban life permeability, which is more conducive to creating pleasant street spaces. Small-scale, mixed-function, and street-friendly living blocks can provide vibrant and pleasant scales for cities, encouraging residents to choose low-carbon travel. Regarding the specific living block scale, he believes that the ideal living block size is within the range of 70m x 70m to 100m x 100m based on the European traditional urban living block cases he studied.

In addition, Jacobs[11] advocated for humanized small-scale living blocks and emphasized the importance of increasing urban functional diversity. Gehl[12] pointed out that the once vibrant small-scale living blocks have been replaced by large-scale living blocks of modernist cities, making street life scenes monotonous and uninteresting.

Lee and Moudon[13] explored the impact of the built environment on residents' walking trips through empirical research. They conducted a descriptive analysis of the basic environmental characteristics and conditions of walkable communities by reviewing existing research on walkable communities. Combining social demographic survey information, walking behavior research, and community built environment measurements, they used multiple linear regression analysis to quantitatively analyze the impact of increased residential density on promoting residents' choice of walking for both commuting and leisure trips.

Pan[14] conducted data analysis on the travel behavior characteristics and urban morphology of residents in four living blocks in Shanghai, and conducted empirical research on the relationship between living block morphology and residents' travel. They pointed out

that China's large-scale residential development model is far from the green transportation development model, and the traditional living block morphology is conducive to residents' short-distance travel and the choice of low-carbon travel modes.

Jiang[15] believed that the study of the relationship between urban morphology and residents' travel energy consumption is particularly urgent in the new stage of China's urbanization development. Nine different types of residential areas in Jinan City were selected to compare the impact of different residential morphologies on residents' travel energy consumption from the perspectives of plot ratio, density, mixed use, and street width. The data shows that the plot ratio and population density of super-large living blocks are the highest, and their residents' travel energy consumption is 2-5 times higher than that of other types of residential areas. Therefore, China should not blindly pursue high-density urban construction, and future residential areas should have the characteristics of functional mixing, appropriate scale, and pedestrian and non-motorized vehicle-friendly.

Qin and Shao[16] discovered a significant correlation between land use morphology, building density, public transport accessibility, employment accessibility, and residents' direct carbon emissions in their study of five communities in Beijing. Their findings suggest that a well-planned and reasonable residential morphology plays a crucial role in the construction of low-carbon cities.

Zhou and Qian[17] argued that the functional structure and layout of residential areas are closely related to residents' low-carbon travel. Through a comprehensive analysis of relevant norms and existing research, they argue that the mixed and compact functional layout of residential areas has a significant impact on promoting low-carbon travel.

Chen[18] emphasized the key role of walking in building a green transportation system in large cities. To study the living block spatial morphology related to residents' walking activities, 21 living block in the central area of Shanghai were selected as research objects, and the factors that have a significant impact on walking in the built environment of the living block were studied. Finally, based on the analysis results, suggestions for friendly living block construction that reduce walking distance and improve the quality of the pedestrian environment are proposed.

In conclusion, the consideration of reducing carbon emissions has become a common

practice in urban planning both domestically and internationally. In China, the attention to low-carbon community construction has been increasing, accompanied by the formulation of corresponding policies and regulations. Efforts to promote pedestrian activities have also been effectively publicized. However, it is worth noting that overseas research on low-carbon communities has a longer history, with numerous successful newly built community. In China, the focus on low-carbon communities is primarily in the theoretical research stage, and practical cases mostly involve newly built communities, often on a larger scale than those found overseas. There is relatively limited research on reducing community transportation carbon emissions from the perspective of residents' travel behavior, particularly in improving the pedestrian environment of aging communities. Therefore, this paper aims to derive strategies for enhancing the quality of pedestrian environments that are conducive to promoting walking activities, drawing upon successful case studies from abroad and considering the spatial characteristics of aging communities in China.

1.3 Explanation of Related Concepts

1.3.1 Low Carbon

Narrowly defined, "low carbon" refers to lower greenhouse gas (primarily carbon dioxide) emissions. However, from a broader perspective, it has evolved into a cutting-edge economic concept with significant societal implications, spanning various industries and management domains. As countries around the world increasingly recognize the need to address global warming and strengthen their commitments to emission reduction, a range of new concepts and policies have emerged, including "low-carbon economy," "carbon footprint," "low-carbon cities," "low-carbon communities," and "low-carbon travel." These developments have paved the way for a new approach towards sustainable development and ecological civilization on a global scale.

Although the concept of "low carbon" was introduced in 2003, the ideas behind low-carbon communities and low-carbon transportation are not entirely new. They have undergone a long process of evolution, development, and maturation. Traditional Neighborhood Development models or Transit Oriented Development models, for example, have long

embraced the planning principles centered around low-carbon transportation[19].

(1) Low-Carbon City

A low-carbon city refers to a city that adopts a low-carbon economy as its development model and direction, where citizens embrace a low-carbon lifestyle as their guiding principle and behavioral characteristic, and where government officials and administrators strive to create a low-carbon society as a benchmark and blueprint for development. In a low-carbon city, the focus is on implementing a low-carbon economy, which encompasses low-carbon production and consumption practices, as well as establishing a resource-efficient and environmentally friendly society. The ultimate goal is to foster a sustainable social development model[20].

(2) Low-Carbon Travel

As a fundamental concept in transportation planning, travel refers to the movement of people, vehicles, and goods between different locations. The study of travel behavior in this paper refers to the mobility activities conducted by residents in their daily lives to fulfill personal or societal needs. It encompasses the choice of transportation mode, which is influenced by factors such as the purpose and distance of travel.

The idea of low carbon travel is to reduce the impact of carbon emissions, having comfortable and affordable journeys to and from work, home, school, college, shops and leisure destinations by using cleaner and greener forms of transportation. As a part of the low-carbon city development strategy, low-carbon transportation plays a major role not only in combating climate change, but can also generate a variety of social and economic benefits, including reduced traffic and parking congestion, public facilities and service cost savings, consumer savings and affordability (savings targeting lower-income households), increased safety and security, improved mobility options for non-drivers (and therefore reduced chauffeuring burdens for motorists), and improved public fitness and health, in addition to their pollution emission reductions.

(2) Mode of Low-Carbon Travel

According to Gehl[21], residents' travel behavior can be divided into necessity activities, spontaneous activities, and social activities. Taking into account carbon emissions, low-carbon travel can be classified as public transportation, cycling and walking (Table 1-1)[22]. The carbon emissions of walking and bicycle are almost zero, while the carbon emissions of electric bicycle

are slightly higher than those of bicycle, followed by public transportation, and the carbon emissions of private cars are the highest. It is important to note, however, that electric vehicles do not qualify as low-carbon travel and even though they use new energy sources, studies have found that the emissions produced by electric cars are even higher than those of ordinary vehicles[23].

Table 1-1 Travel Category

(Source: Reproduced from Evolution Trend Analysis of *Urban Residents' Low-Carbon Travel Development Based on Multidimensional Game Theory* published by Wu et al.)

Travel category	Mode of transportation	Emission intensity (g • person^{-1} • km^{-1})
High-carbon travel	Small cars	135
Low-carbon travel	Public transportation	35
	Bicycle	0-8 (Electric bicycle)
	walking	0

1.3.2 Pedestrian Environment

Considering that this paper focuses on studying residents' travel behavior and the environment within aging communities, where public transportation and cycling are the primary modes of travel at the city level, the research in this paper will specifically examine the most prevalent walking activities within the community. The goal is to contribute to low-carbon transportation at the community level. Walking is a fundamental human activity and serves as a basic component of other transportation modes. Such as walking from home to the bus station, from the bus station to the workplace, walking between different bus stations during transfers, and even walking from home to the parking lot or from the parking lot to the workplace (Figure 1-1). Walking serves various roles in different travel contexts. For instance, during leisure travel, activities such as leisurely strolls or walking the dog are exclusively conducted on foot. In commuting journeys, walking comprises a portion or the entirety of the travel route. Research has shown that humans typically walk at a speed of approximately 1.2m per second. This means that they can walk continuously for about 15 minutes or cover a distance of approximately 1000m without feeling fatigued and opting for other modes of transportation[24].

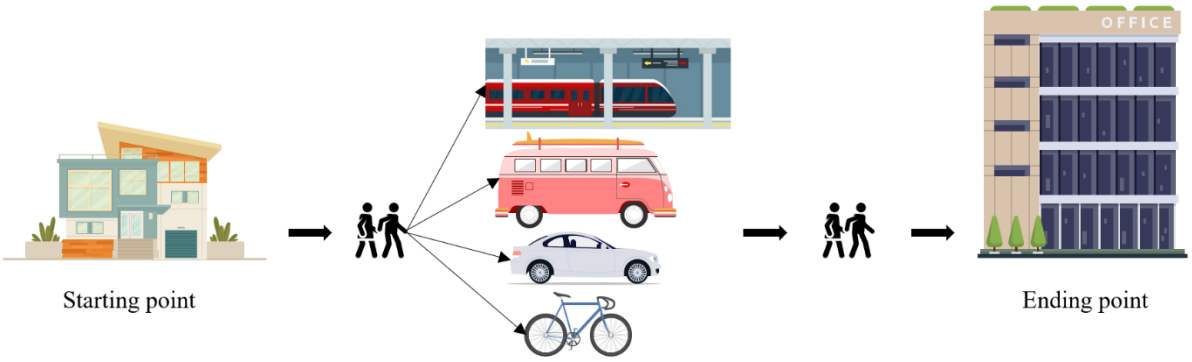


Figure 1-1 Functionality of walking in urban transportation system

(Source: Illustrated by the author)

Walkability expert Dan Burden succinctly highlights the numerous advantages associated with walkable communities. Walkability serves as the fundamental element and linchpin for efficient ground transportation in urban areas. Walking serves as the starting point and endpoint for every journey. Moreover, it remains the most cost-effective mode of transportation accessible to all individuals. Constructing walkable communities offers an opportunity to establish the most affordable transportation system conceivable, one that can be planned, designed, constructed, and maintained by any community. By fostering walkable communities, urban environments can regain a sense of balance in terms of resource sustainability, encompassing both natural and economic resources. Furthermore, such communities promote increased social interaction, physical well-being, and a reduction in crime rates and other social issues. Ultimately, walkable communities foster livability, enabling residents to lead fulfilling, joyful, and healthy lives[25].

The pedestrian environment refers to urban spaces where walking is the primary mode of transportation and pedestrians have priority, ensuring the smooth and safe conduct of walking activities. Traditionally, the pedestrian environment encompasses various open spaces such as pedestrian walkways, public squares, pedestrian-friendly boulevards, etc. It forms a walking network that connects dispersed open spaces within the city[26].

Zhang[27] defines the pedestrian environment as a human and physical environment that allows pedestrians in modern cities to engage in various activities freely and pleasantly, without interference from other types of traffic such as motor vehicles. It is characterized by abundant green landscapes and diverse public service facilities. The pedestrian environment serves as a

vital public open space that carries multiple functions related to transportation, environment, economy, and society within the city. It is considered as an important public space that fully embodies the value of the urban environment.

According to Xu[28], the pedestrian environment encompasses all urban outdoor spaces that are suitable for walking activities. Specifically, this includes pedestrian walkways, streets, pedestrian zones, squares, parks, and other public open spaces. Within the pedestrian environment, walking is considered the primary mode of transportation, and pedestrians have the right of priority. The pedestrian environment holds rich connotations in terms of economy, culture, ecology, and aesthetics. It is formed by a combination of natural environmental elements and socio-cultural factors.

Nevertheless, as multi-dimensional and mixed-use urban areas have evolved, there has been a growing inclination toward indoorization of pedestrian spaces, extending this practice even to public areas beyond the city limits. This blending of outdoor spaces with architectural surroundings has led to a greater interconnection, blurring the traditional distinctions between them. This trend underscores that the notion of a pedestrian environment should not be limited solely to outdoor realms but should also encompass the dynamic interaction occurring within indoor spaces[26]. The pedestrian environment is no longer regarded as an independent open space entity but rather as a complex space influenced by other environmental factors.

Based on the aforementioned perspective, this paper defines the concept of the pedestrian environment as a community public space primarily dedicated to walking activities, serving diverse purposes such as daily commuting, social gatherings, and leisurely pursuits. It is also influenced by factors such as community architectural spaces, road spaces, and landscapes (Figure 1-2).

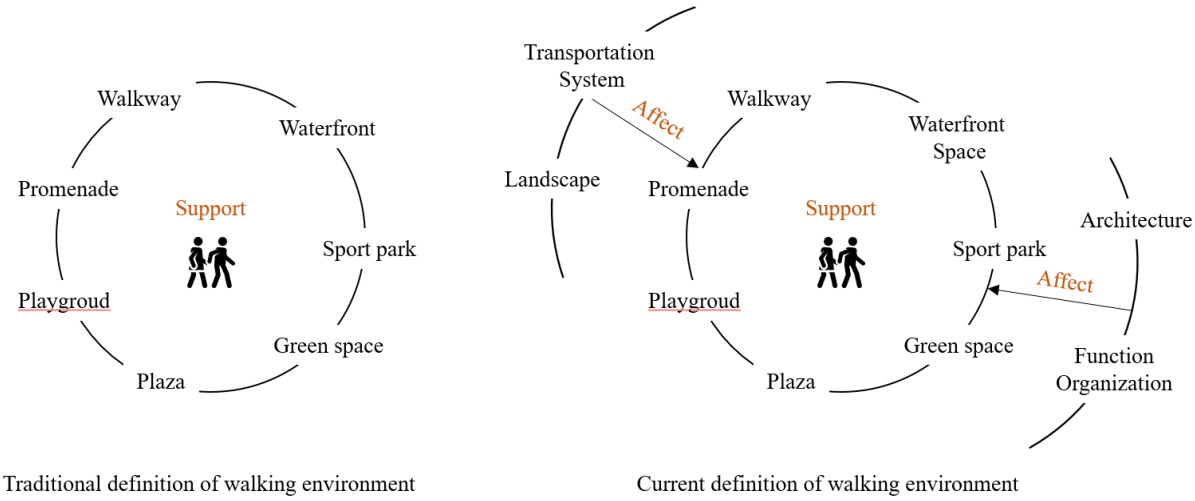


Figure 1-2 Definition of Pedestrian Environment
(Source: Illustrated by the author)

1.3.3 The Old Community

(1) Concept

The term 'community' has been derived from two Latin words 'Com' and 'Munis' which means 'together' and 'servicing' respectively. The community is a group of people living in a specific region that are linked geographically[29]， Based on the common living environment, it emphasizes community feelings and social relationships that arise from residents living together. Among residents of a community, not only do they share the same environment and resources, but they are also able to interact with one another[30], developing common social ideas among themselves. As a unit of society and space, territoriality and sociality are the fundamental essences of community of all those definitions. Human scale, identification and belongingness, obligations, gemeinschaft and culture are five main characteristics of community. Therefore, a community encompasses a much wider range of functions and scope than an apartment complex.

Old communities are living areas within existing communities that are old and outdated, and overwhelmed with historical remains. Buildings, environments and public facilities in communities of this type have begun to deteriorate as a result of the accumulation of usage time. The physical functions and organizational forms at the beginning of construction, as well as hardware support and software control, cannot provide the residents with the material and spiritual necessities of modern life. A new community, as time passes, will also transform into

an old community, as the law of historical development dictates[31]. In this paper, ‘ old communities’ refers to the living areas where the buildings were predominantly constructed from the 1990s to the first five years of the 21st century, and there is no need to demolish them.

(2) The Applicability of Low-Carbon Concept to Improving the Pedestrian Environments Quality in Old Communities

①In terms of the walking subjects of old communities.

As the pace of urbanization accelerates, old communities are facing the challenges of an increasing elderly population among their "original residents". In some communities, the proportion of residents aged 65 and above exceeds 30%[32]. The aging of these communities poses a series of challenges. On one hand, the younger generation of residents is moving out of the community, while newcomers are moving in for work-related reasons through home ownership or renting. Consequently, the community transitions from a "familiar society" to a "stranger society," leading to increased heterogeneity among community residents and a weakened sense of connection between long-time residents and newcomers. On the other hand, the aging infrastructure within old communities, including streets, external walls, green spaces, and building pathways, exhibits varying degrees of deterioration due to the advanced age of these structures. Consequently, the physical space is experiencing signs of aging, rendering it inadequate in meeting the expanding leisure requirements of the elderly population[33].

② In terms of pedestrian environment of old communities. A notable feature of old communities is that their construction was predominantly concentrated in the late 20th century. Due to economic limitations and demographic conditions during their development, the walking environment in these old communities has been influenced in the following ways. Firstly, there was limited consideration given to issues related to motor vehicle traffic and parking, resulting in current challenges such as narrow roadways and the absence of lane divisions, which pose significant safety hazards[34]. With the rapid growth of vehicle ownership, the predicament of pedestrian-vehicle mixed use of street intensifies within aging communities. Indiscriminate parking of e-bike within the community exacerbates traffic challenges while significantly compromising the overall community environment and impeding residents' mobility. Secondly, in old communities, there is a lower standard of construction for public service facilities, resulting in issues such as incomplete functional configurations, inadequate

scale, and limited service coverage[35]. It is inevitable that residents' needs and expectations will continue to evolve as living standards improve. Residents are compelled to travel to farther destinations to access needed public services when the public services provided within the community cannot meet these demands.

③In terms of carbon emission in old communities. A mentioned earlier, there has been a significant increase in the number of motor vehicles, resulting in a shift from a predominantly pedestrian-oriented to a car-dominated transportation environment. This shift has led to a substantial increase in transportation-related carbon emissions within the community, negatively impacting air quality and environmental sustainability.

In 2021, the School of Architecture at Tsinghua University, in collaboration with the China Sustainable Transportation Center, conducted an assessment of low-carbon travel environments in four selected cities: Beijing, Shanghai, Shenzhen, and Haikou. The study focused on four types of typical communities. The study focused on four types of typical communities. The findings revealed that the unit yard, constructed in the previous century, ranked third in terms of low-carbon travel environments. A high density of internal road networks within these communities and the lack of pedestrian-friendly pathways were primarily responsible for this trend[36] (Figure 1-3).

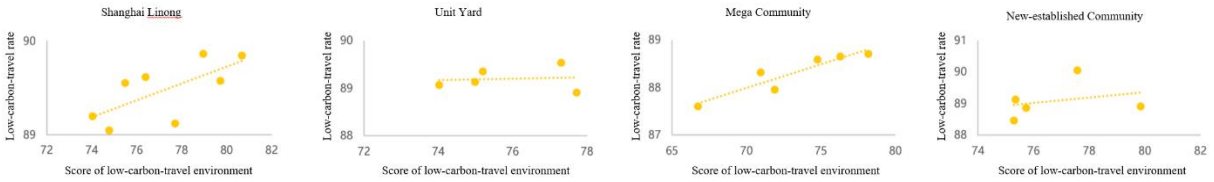


Figure 1-3 Score of Low-Carbon-Travel Environment in Four Communities

(Source: China Sustainable Transportation Center，2021)

In various Chinese cities, there exist numerous old communities. The revitalization of these areas represents more than just a significant endeavor to enhance people's quality of life—it also stands as a pivotal undertaking to drive comprehensive eco-friendly progress on a national scale. To advance the renewal of these older residential neighborhoods, the State Council released the "Guiding Opinions on Comprehensive Advancement of Renovation Work

in Urban Old Residential Areas" in July 2020. This directive outlines the aim to substantially complete the renovation initiatives targeting communities built in the early 21st century by the conclusion of 2025. The issuance of these renovation directives coincided with the nation's "dual-carbon" target proposition. Embracing the "dual-carbon" paradigm to guide the rejuvenation of these old communities is imperative for the realization of national aspirations in green economic growth, the encouragement of urban energy efficiency, emissions reduction, the enhancement of ecological civilization's entire structure, and the improvement of citizens' well-being. Within this context, this paper elects to focus on augmenting the pedestrian environment's quality within these old communities. This strategy not only revitalizes community pedestrian engagement but also aligns with the objective of curbing carbon emissions within the community.

1.4 Research Purpose and Scope of Research

1.4.1 Research Purpose

Pedestrian environments in old communities deteriorate over time and not only fail to meet residents' material and spiritual needs, but also increase carbon emissions associated with community transportation. Consequently, improving the pedestrian environment and encouraging residents to travel in a low-carbon manner is essential. Within the context of low carbon, this paper explores the path and objectives of community pedestrian environment construction from the perspective of reducing carbon sources and increasing carbon sinks. Valuable reference materials will be drawn from exemplary cases. Using an examination of the Tianhe North Street Shipai Creek Community in Guangzhou, the challenges and issues faced by pedestrians will be identified. Corresponding improvement strategies will be proposed and implemented to offer guidance and suggestions for the trial of low-carbon community construction in old communities in Guangzhou.

Based on the background and analysis of the current research situation mentioned above, this paper will now focus on the following two issues for discussion:

(1) What kind of community is suitable for residents to walk in a low-carbon environment?

(2) How to guide the quality improvement of pedestrian environment in old communities?

1.4.2 Scope of Research

The walking activities studied in this paper mainly refer to the walking behaviors of both the internal and external residents in Shipai Creek Community along Tianhe North Road. It focuses on the travel behaviors of accessing destinations within the community, such as public facilities, spaces, and environments. The pedestrian environment mainly encompasses the walking spaces in Shipai Creek Community, including external public spaces and internal building spaces. Therefore, all the material and nonmaterial spaces related to walking studied in this paper are within Shipai Creek Community.

1.5 Innovation and Significance

1.5.1 Innovation

(1) This study aims to implement research on reducing carbon emissions to guide residents' low-carbon living behaviors. While most existing research focuses on material aspects such as technological transformation and energy renewal, there is a lack of emphasis on studying low-carbon living behaviors. However, the construction of low-carbon cities and the achievement of carbon peaking and carbon neutrality goals depend on the active participation of city residents, who play a crucial role in adopting low-carbon practices. Therefore, this paper takes a direct approach by focusing on researching residents' walking behavior. By doing so, it aims to contribute to the development of a low-carbon travel environment for the city, starting from the most fundamental mode of transportation.

(2) This study aims to integrate the low-carbon concept with the renewal of old communities. It has been observed that the majority of low-carbon community pilots focus on newly constructed neighborhoods, with limited research on applying low-carbon principles to existing communities. Consequently, this paper presents two implementation paths that combine low-carbon concepts to reduce carbon sources and enhance carbon sinks in the renewal of pedestrian environment in old communities.

(3) This study aims to broaden the research dimension of improving pedestrian environment quality from a singular spatial level to the community level. In the past,

discussions on the walking environment primarily revolved around physical space characteristics perceived by residents during walking, such as road design and sidewalk width. The focus was often on enhancing the quality of individual public spaces in isolation. This paper reports on how to improve the quality of walking environments in old communities, and attempts to find improving strategies from the source of travel choices.

1.5.2 Significance

Firstly, as the fundamental building block of cities, communities serve as the primary carrier for the comprehensive functionality of urban areas. In China, urban development has shifted from incremental expansion to inventory planning, and urban renewal has become an essential choice for sustainable development. A significant number of old communities have become focal points for renewal. Under the low-carbon orientation, improving the quality of pedestrian environments in old communities represents a relatively new perspective on renewal field. Accordingly, this approach can provide new insights into the research on the renewal of old communities and how the environment affects walking.

Secondly, current research on low-carbon initiatives mostly focuses on regional, urban, or architectural aspects, which either address large-scale issues without addressing specific details or deal with specific details without addressing broader issues. As a matter of fact, environmental changes can influence behavioral patterns, and all technological implementations related to low-carbon initiatives are ultimately intended to help residents adopt low-carbon lifestyle habits. Therefore, this paper shifts the research focus to the community level and emphasizes the guidance of residents' travel behavior. This approach aligns with the effective context and important pathway for implementing sustainable development.

1.6 Methodology and Framework

1.6.1 Methodology

(1) Literature Research Methodology

The literature review is the fundamental work of this research, which comprehensively examines the relationship between travel behavior and built environment under the low-carbon

concept, as well as the practice of low-carbon community construction, through reviewing relevant studies and practical cases from both domestic and international sources. By thoroughly studying cutting-edge information and combining the specific characteristics of the research subject, this study extracts practical theories and experiential knowledge to offer insights and references for the improvement of pedestrian environment quality in old communities under the low-carbon orientation.

(2) Field Research

By conducting on-site investigations and distributing questionnaires in Shipai Creek Community along Tianhe North Road, this research can acquire authentic and reliable data on land use, transportation, buildings, public spaces, and other relevant aspects of the community. Furthermore, this approach allows for an understanding of the residents' genuine experiences and needs, providing valuable insights and guidance for the proposed strategies to improve the environmental quality in the paper. The data gathered from the investigation lays a solid foundation for analyzing and resolving research questions effectively.

(3) Synthesis Methodology

In light of the complexity of the research subject, this thesis adopts a synthesis analysis approach. Building upon the study of relevant literature and data, it deduces suitable community development goals for reducing carbon sources and increasing carbon sinks through pedestrian-friendly pathways. The analysis encompasses various elements involved in community development under each goal. It synthesizes factors such as the mechanisms of these development elements, existing research findings, and specific characteristics of the research object, Shipai Creek Community. By considering multiple facets, the study aims to explore the most appropriate design path for enhancing the pedestrian environment quality in Shipai Creek Community.

(4) Quantitative Analysis Methodology

This study employs two main quantitative analysis methods. Firstly, spatial syntax analysis is used to quantitatively analyze and compare the accessibility of public facilities, roads, and bus stops before and after the improvement of pedestrian walkway quality in Shipai Creek Community. Secondly, a carbon emissions accounting model is established to quantitatively calculate the carbon emissions of the improvement proposals, providing an initial assessment

of their emission reduction effects.

1.6.2 Framework

Framework of this paper is shown in figure 1-4.

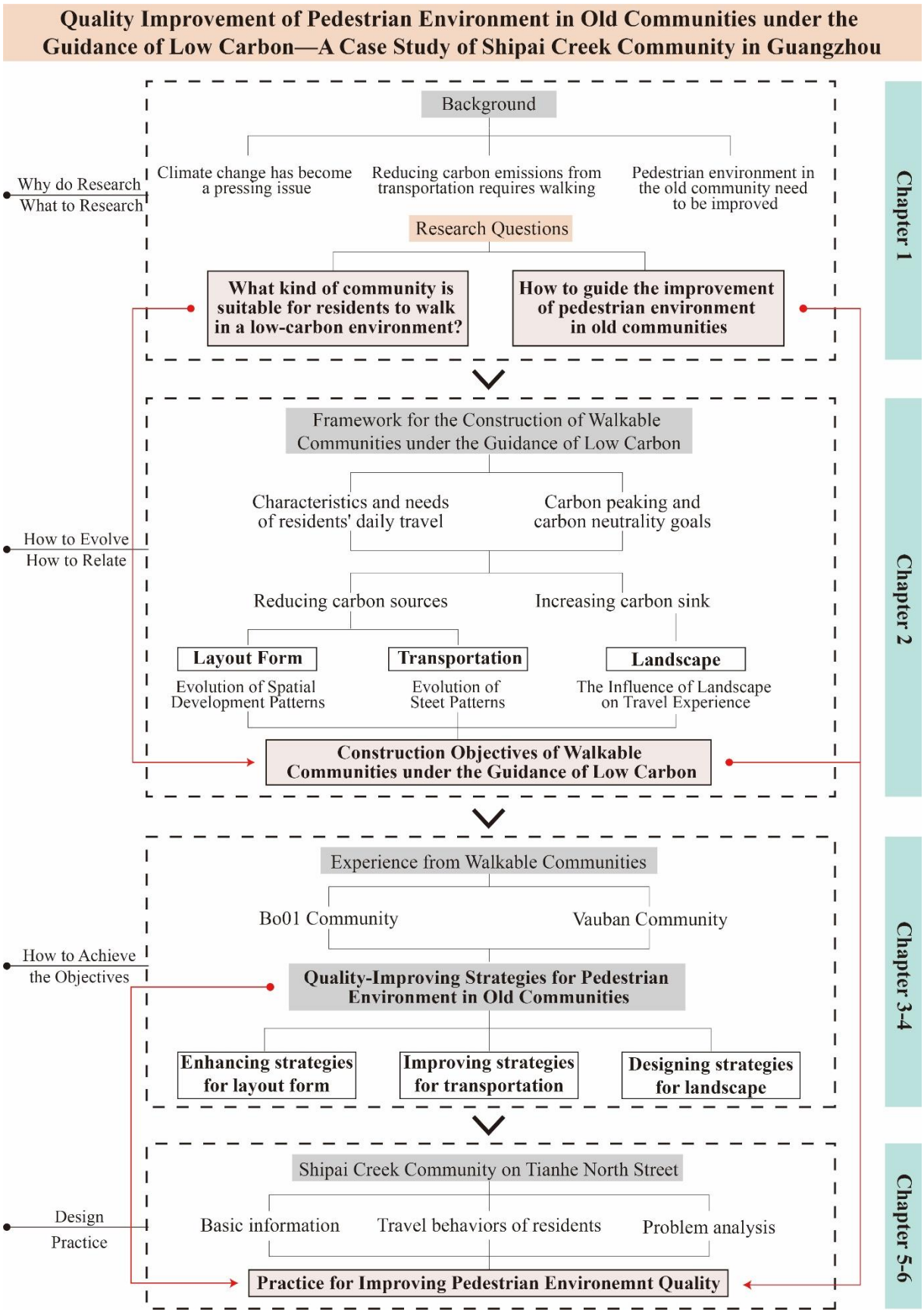


Figure 1-4 Research Framework

(Source: Illustrated by the author)

Chapter 2 Construction Objectives of Walkable Communities Guided by Low Carbon

Communities are regarded as the fundamental units of a city, providing living spaces and public areas where residents interact with others and society. It also serves as the starting and ending points for the daily travels of most residents. The physical environment of a community can either facilitate or inhibit residents' everyday travel behavior, thus impacting community energy usage and carbon emissions[37]. Achieving low-carbon development goals in cities relies on specific practices implemented at the community level. Therefore, compared to planning strategies at the city scale, research on pedestrian environments at the community scale should prioritize the principles of "people-oriented" approaches[38], focusing on studying the characteristics and needs of residents' daily travel patterns.

Examining the definition of the pedestrian environment reveals that enhancing the quality of pedestrian spaces within a community is no longer an isolated endeavor aimed solely at self-improvement. Rather, it demands a holistic approach that encompasses other elements of community construction that influence these spaces. In essence, studying the enhancement of the pedestrian environment requires a thorough exploration of community development conducive to residents' walking habits and an analysis of the interplay between community construction elements and pedestrian activities. By understanding these relationships, we can effectively create a well-rounded and pedestrian-friendly community environment.

Hence, this chapter commences with an analysis of the characteristics of residents' daily travel behaviors and delves into their preferences for community construction. Emphasizing a low-carbon orientation, the study categorizes these developmental elements into three dimensions: layout form, transportation, and landscape, with the overarching goal of reducing carbon emissions and promoting carbon sinks. Furthermore, the chapter investigates the evolution of spatial development patterns, street patterns, and the impact of the landscape on residents' travel experiences to establish the connections between these dimensions and walking behaviors. Finally, building upon the insights gained from prior research, specific objectives for community development that encourage walking are derived (Figure 2-1).

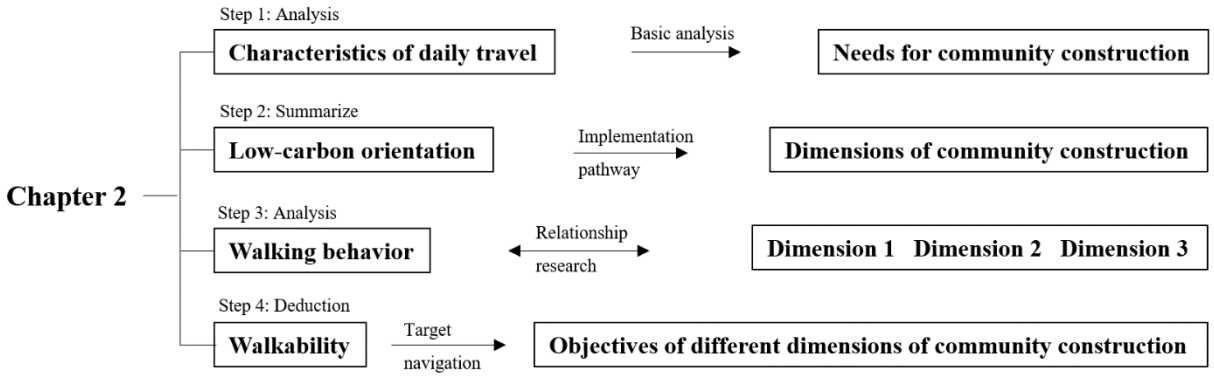


Figure 2-1 Framework of Chapter 2

(Source: Illustrated by the author)

2.1 Framework for the Construction of Walkable Communities Guided by Low Carbon

2.1.1 Characteristics and Needs of Daily Travel Behaviors

It is common for scholars to categorize trip types into three categories according to the daily travel destinations: commuting travel, utilitarian travel and leisure travel[39]. As mobility evolves rapidly, it is necessary to analyze what travelers gain from different types of trips so that the public space in the community that supports them can be designed to address specific benefits. It is necessary to analyze the characteristics and needs of residents' daily travel behaviors in order to effectively plan and design the pedestrian environment within the community.

Commuting travel is frequently fixed in destination, to particular times of day, and to specific modes, periodically recurring between one's place of residence and place of work or study. Residents who work within or in close proximity to the community can easily accomplish short-distance travels through means such as walking, cycling, or public transportation. Conversely, residents who work in more distant communities primarily rely on public transportation or private cars for their commutes. According to the *2021 Annual Report on Transportation Development in Guangzhou*[1] ,the average commuting distance in the city was

[1] Announced by Bureau of Urban Planning of Guangzhou Municipality in 2022.08

8.7m, with an average travel time of 38.7 minutes. This data indicates a substantial demand for public transportation among a significant portion of residents. Therefore, community development should take into account the reasonable coverage of nearby public transportation stops, ensuring that residents can reach these stops from their residences within a five-minute walk.

Utilitarian travel encompasses everyday activities with specific destinations, including shopping, dining, healthcare visits, and educational pursuits, apart from commuting. It is a travel mode that emphasizes practicality and efficiency. Within utilitarian travel, residents place a greater emphasis on travel efficiency, such as the ability to conveniently engage in activities in nearby locations or reach their destinations via the fastest routes possible. Therefore, residents may prioritize factors such as convenience, time-saving, cost-effectiveness, and practicality when making choices, rather than other considerations. Consequently, community construction should pay attention to the allocation of functions and the layout of public facilities in the old communities. The provision of an adequate number of public facilities within a reasonable distance is crucial for the residents' convenience and accessibility. Additionally, the organization and smooth flow of pedestrian pathways around these public facilities are equally important.

Leisure travel refers to activities chosen for pleasure, relaxation, or emotional satisfaction. Within the context of community discussions, leisure travel primarily includes activities such as walking, jogging, cycling, aimed at physical exercise, as well as social activities like chatting, sharing, aimed at fostering social interaction. The layout and landscape design of community open spaces play a significant role in determining whether residents choose low-carbon modes of transportation for leisure activities within the community or opt to drive to more distant locations. Therefore, community development should provide facilities and facilities that cater to leisure and recreational needs while creating a travel environment that meets psychological demands.

2.1.2 Implementation Path for Constructing Walkable Communities under the Guidance of Low Carbon

Achieving carbon peaking and carbon neutrality goals requires two main paths: reducing carbon sources and increasing carbon sinks. Carbon sources refer to processes, activities, or mechanisms in nature and human activities that release CO_2 and other greenhouse gases into the atmosphere. Reducing carbon sources involves taking measures to minimize or avoid emissions of CO_2 and other greenhouse gases, thereby mitigating their impact on climate change. On the other hand, carbon sinks are processes, activities, or mechanisms such as afforestation and vegetation restoration that captures CO_2 from the atmosphere, thereby reducing the concentration of greenhouse gases in the atmosphere[40]. In Zhang's[41] exploration of urban design in the Central Vitality District of Zibo City, he proposes urban design methods that incorporate the reduction of fixed carbon sources, reduction of mobile carbon sources, and promotion of natural carbon sinks.

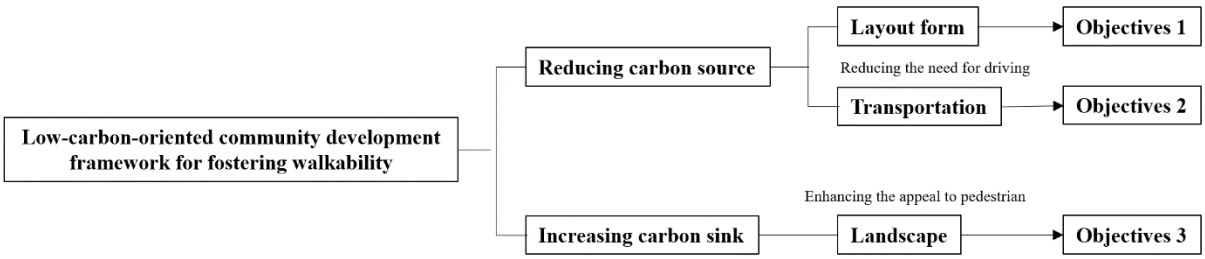


Figure 2-2 Framework of Constructing Walkable Communities From Two Paths
(Source: Illustrated by the author)

This study centers on analyzing walking behavior within communities, with a specific focus on the two pathways under low-carbon orientation that directly contribute to reducing carbon emissions during residents' travel (Figure 2-2). Under the pathway of reducing carbon sources, the construction of pedestrian-friendly communities should consider how to reduce the necessity of motorized transportation. Achieving this involves enhancing the diversity and compactness of the community layout to reduce the necessity for vehicles and implementing a road hierarchy system that restricts motorized vehicles within the community. As for increasing

carbon sinks, community construction should consider how to enhance the motivation for walking through landscape design. By creating appealing and inviting landscapes, residents are encouraged to engage in walking activities.

2.2 Relationship Between Layout Form that Reduces Carbon Sources and Walking

2.2.1 Evolution of Space Development Pattern

Technological advancements have significantly transformed transportation, leaving a profound impact on social development. Urban rail transit systems, such as subways and light rails, are now extending their reach to more cities and regions. However, they also encounter challenges related to energy depletion and land scarcity, leading to a more complex situation in modern community planning.

On one hand, community planning must strive to create aesthetically pleasing environments despite limited land resources. On the other hand, it must also guide residents towards low-carbon travel options, given the increasing prevalence of automobile usage. Examining the development process of community spatial patterns sheds light on how communities maintain a synergistic relationship between layout patterns and encouraging walking as a sustainable mode of transportation. The following study primarily explores three spatial development models that have a significant impact on modern community planning: The Neighborhood Units Concept (NUC), Traditional Neighborhood Development (TND), and Transit-Oriented Development (TOD).

(1) NUC

In 1929, Clarence A. Perry, an American urban planner, introduced the concept of "Neighborhood Units" (NUC). NUC was designed as a response to the changing planning structure caused by the development of motorized transportation in modern cities, departing from the grid-based residential layout previously determined by street divisions[42]. NUC proposed a new theory for residential area planning. According to NUC, a neighborhood should occupy approximately 64 hectares, with residential living blocks extending up to 700m. The population of the neighborhood was suggested to be around 5,000 to 9,000 residents, with

essential facilities such as schools, places of worship, and recreational areas located at its core. The boundaries of the neighborhood intersected with major urban transportation arteries, while commercial establishments were situated along the periphery of the neighborhood, adjacent to arterial streets. Interior curvilinear streets facilitated residents' movement within the neighborhood, while e-bike were restricted to the periphery, creating a clear separation. Adequate open spaces were incorporated within the units, with parks and recreational systems typically provided at the central area of the region (Figure 2-3).

a. Principles of NUC
(Source: Carpio-Pinedo, 2021)

b. Diagram of NUC
(Source: Azzam, 2021)

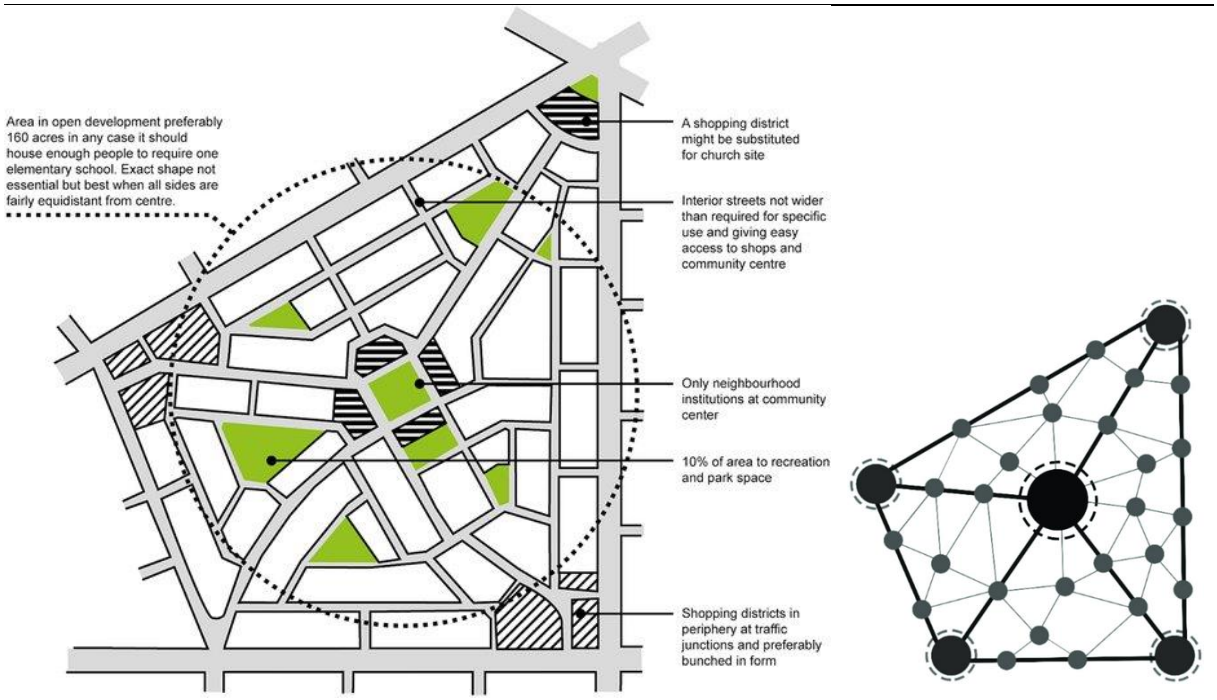


Figure 2-3 Characteristics of NUC
(Source: Compiled by the author)

In China, community planning has developed based on the concept of neighborhood units, forming a residential neighborhood planning model that is grounded in functionalist planning principles. It is a product that combines functionality with underlying conceptual ideologies[19].

NUC is based on the assumption that residents are satisfied with the facilities provided within their respective residential areas. It scatters public facilities throughout the community, focusing only on residents' independent use of specific facilities, while neglecting the

synergistic effects between facilities and resulting in inefficient land use. Additionally, NUC strictly segregates internal streets from external city streets. Although this promotes walking within the community, it overlooks the potential for residents to engage in cycling and the use of public transportation. As a result, some residents' travel needs remain unmet, hindering the cultivation of walking habits.

(2) TND

Traditional Neighborhood development (TND) was proposed by Andres Duany and Elizabeth Zyberk. Similar to NUC, TND starts from the community level and emphasizes the neighborhood unit as the fundamental building living block of the community. The transportation network is designed to revolve around the neighborhood unit, resulting in smaller land parcels and narrower streets (Figure 2-4)[43].

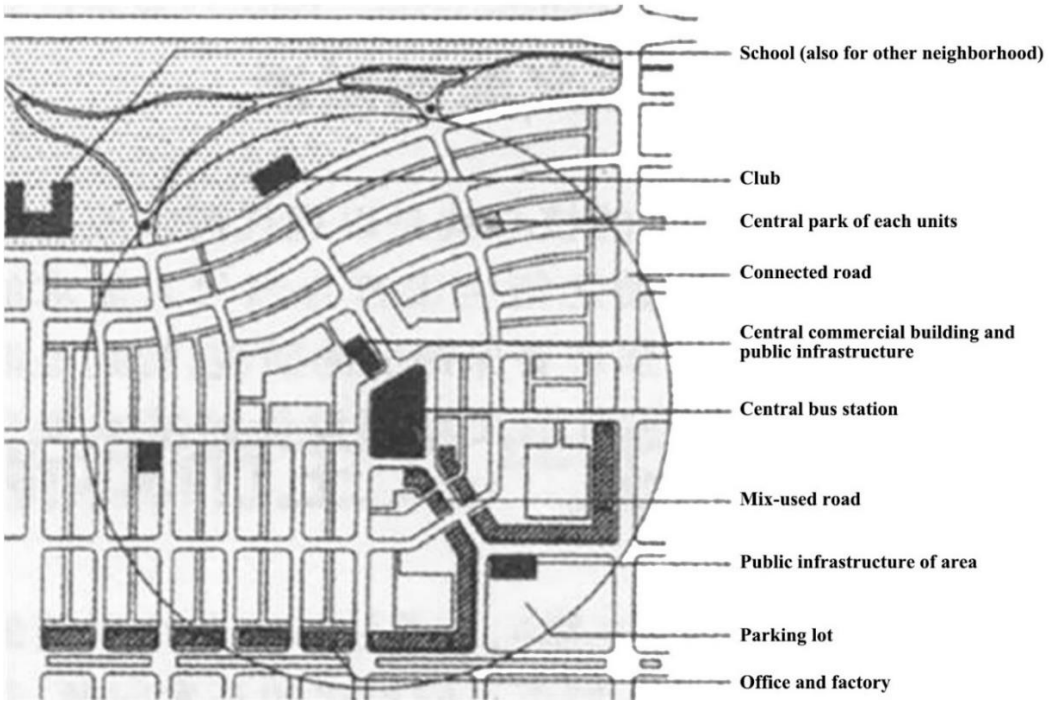


Figure 2-4 Characteristics of TND

(Source: Dutton, 2000)

In a TND community, there is a recognizable center that can be a green space, a commercial hub, a memorial street corner, or similar features. Buildings and transportation infrastructure are constructed within a well-connected network of streets, providing multiple route options. Walking is emphasized as the most crucial mode of transportation. The ideal

distance for most activities is within 400m, and the scale of residential living blocks ranges from 70 to 100m. Various public facilities are conveniently located within a 5minute walking distance. Activity spaces are provided within a 160m radius of each residential area. Commercial and public facilities are situated on the periphery of the community to cater to the daily needs of residents[44].

TND builds upon NUC by addressing the coexistence of different modes of transportation within the community. It achieves this by delineating various levels of streets (such as boulevards, main streets, streets, alleys, and pathways) to provide residents with diverse travel options. However, the walking system remains the core network, connecting public facilities, commercial areas, and residential zones. Cars are allowed to park on the streets, acting as a barrier between bike lanes and traffic lanes. Additionally, TND emphasizes the seamless integration of open spaces within the community. Pedestrian pathways not only serve as part of the streets but also act as important conduits leading to key open space nodes within the community. This greatly enhances the potential for residents to engage in walking.

(3) TOD

In Peter Calthorpe's 1993 book *The Next American Metropolis: Ecology, Community, and the American Dream*, he introduced the concept of Transit-Oriented Development (TOD). TOD refers to development centered around public transportation facilities. It is based on creating a central plaza or city center within a 600m radius of rail stations, airports, subways, light rails, and major bus transit lines. The central area is characterized by a mix of work, commerce, culture, education, and residential functions, with each living living block ranging from 150 to 200m. Residents have convenient access to multiple modes of transportation such as buses, bicycles, and walking[45]. Calthorpe categorizes TOD into Urban TOD and Neighborhood TOD (Figure 2-5). Urban TODs are located along major transit lines, with larger transportation hubs (light rail, railways, buses), commercial areas, and employment centers accessible within a 10minute walk or a 600m distance. Neighborhood TODs are connected to the main transit lines through bus feeder routes, ensuring that residents are within a 400m distance from the public transit stations when traveling from their residential areas[46].

Although TOD and TND have different design emphases, their underlying principles are aligned. Both emphasize compact layouts and mixed land use, with the community radius

designed within walking distance. TOD advocates for walkable communities and prioritizes walking and cycling. By optimizing the connections between key points through mixed high-density land use, travel time for residents is significantly reduced, thereby increasing their willingness to engage in walking. Furthermore, TOD also emphasizes the importance of community open spaces, not only to enhance public life and social interaction but also to provide a safe environment for pedestrians and cyclists.

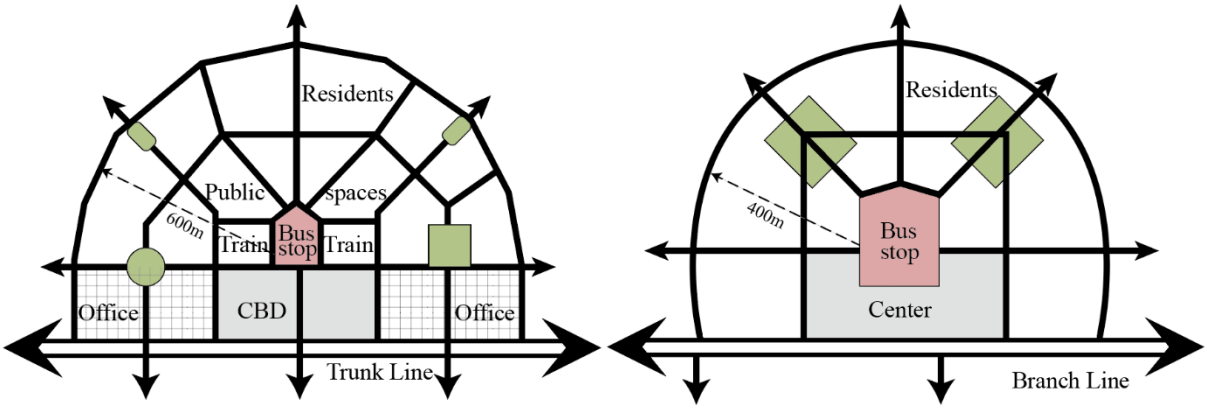


Figure 2-5 Urban TODs (left) and Neighborhood TODs (right)

(Source: Reproduced from *The next American metropolis: Ecology, communities, and the American Dream. New York: Princeton Architectural Press* published by Calthorpe)

2.2.2 Construction Objectives of Walkable Communities in Layout Form

It is evident that in the development of spatial planning models, the importance of walking in community planning has become increasingly prominent. In order to meet the diverse travel needs of residents, developers are gradually moving away from an excessive focus on functional divisions and actively embracing the concept of humanism. They strive to achieve designs that are centered around people, aiming to reshape a diverse, human-centric, and community-oriented urban living atmosphere. For instance, the layout of public facilities in communities has transitioned from the scattered approach of NUC to the outward-to-inward extension of TND, and further to the core-centric approach of TOD. Additionally, the community scale has evolved from the 64-hectare neighborhood of NUC to the 400-600m community radius in TND and TOD (Table 2-1). These efforts contribute to promoting walking among residents and reducing carbon emissions generated from motorized vehicle use.

Table 2-1 Comparison Between Three Development Patterns

(Source: Compiled by the author)

Development pattern	Size of living blocks	Center of the community	Functional mix	Main travel manner
NUC	A land area spanning 64 hectares and residential living blocks extending up to 700m.	Schools, places of worship, green open spaces	Functions operating independently from one another	Walking and vehicles
TND	A radius of 400m and residential living blocks ranging from 70 to 100m.	The community center	Land mixed-use	Walking
TOD	A radius of 400 to 600m and residential living blocks ranging from 150 to 200m.	Transportation hubs, public facilities, offices	Horizontal land mixing and vertical building mixing	Walking, cycling, and public transportation

In conclusion, construction objectives of walkable communities in layout form are as follows:

(1) **Mixed land-use pattern.** This refers to the integration of different functions (such as residential, commercial, office, recreational, etc.) in community planning. A higher degree of functional mix offers several advantages.

①By focusing on pedestrian-friendly designs, the convenience of residents' daily lives is significantly improved, making it easier for them to reach various destinations. ②Pedestrian-oriented communities offer a plethora of options within short walking or cycling distances, including shops, restaurants, entertainment venues, and more. This diverse range of choices caters to different population groups, addressing their unique needs and interests. ③ Concentrating residential, office, and recreational facilities fosters community cohesion, facilitating social interaction, community participation, and the development of neighborly relationships. This, in turn, creates a closer-knit and harmonious community atmosphere.

(2) **Highly accessible public facility layout.** Public facilities encompass spaces that offer a variety of public goods and services essential for daily life, including commercial facilities, office spaces, sports facilities, public transportation stations, and more. Organizing these facilities efficiently ensures high accessibility, which can be understood as the ease with which residents can reach various destinations, making the most of urban opportunities[47]. The

accessibility of public facilities is determined by the level of ease or difficulty for residents to access and utilize these amenities within their community. Accessibility is inversely proportional to the friction of distance[48], which depends on the time consumption, economic expenses and inconvenience involved when traveling from one place to another. When public facilities are situated close to residential areas, residents experience lower travel costs, reducing their dependence on private vehicles and fostering a preference for walking. On the contrary, longer travel distances result in higher transportation costs for residents, dampening their interest in accessing these public facilities.

(3) **Living block with an appropriate scale**. Living block refer to the neighborhoods or are defined by community streets or natural boundaries. Within a thoughtfully planned and diverse community, the most enchanting aspects are the vibrant, welcoming, and visually intriguing small blocks that resonate with human-scale aesthetics. There are several disadvantages associated with over-scaled living blocks.

①They resemble closed, high-density complexes where all connections to the urban transportation system converge at the entrances and subsequently spread out onto city thoroughfares, frequently leading to traffic congestion. ②These designs lead to limited route options and necessitate residents to walk longer distances to reach the living block entrances. When bus stations cannot access the interior of the living blocks, residents often have to walk for more than five minutes to reach the nearest bus stop (Figure 2-6).

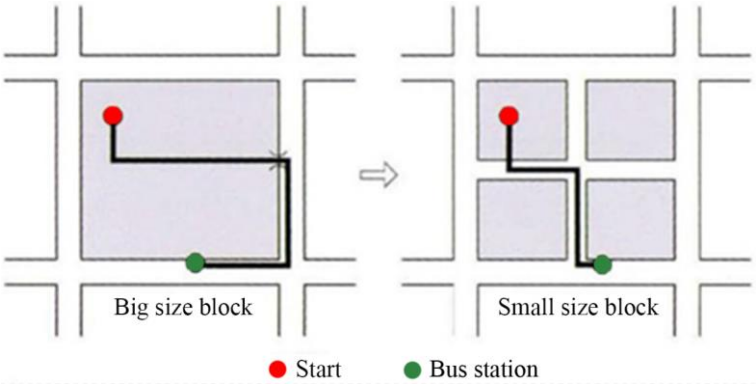


Figure 2-6 Comparison of Distance in Different Size of Living Blocks

(Source: Zhou，2017)

③The discontinuity and segregation between the internal and external spaces of the living block, hampering residents' activities and diminishes the vibrancy of the community[49].

(4) **A vibrant hub that attracts residents and visitors.** A vibrant hub is a dynamic fusion of spaces that cater to a diverse range of activities and functions, often situated near residential areas for easy access to essential services and facilities. Residents can conveniently walk or bike to the vibrant hub, reducing their dependence on private cars and encouraging a walking culture. The vibrant hub serves as a bustling focal point where social interactions flourish: residents have the opportunity to forge new acquaintances, interact with neighbors, share experiences and benefits, thereby fostering community cohesion. This lively center establishes networks of mutual support, promoting a sense of harmony and unity within the community.

2.3 Relationship between Transportation that Reduces Carbon Sources and Walking

2.3.1 Development of Street Pattern

Streets connect the private with the public domain and also link different parts of a neighborhood. These linkages support social interaction and exchange—both vibrant urban functions. Well designed street not only provide space for vehicles to move and parking, but also encourage residents to interact with one another and make the streets more attractive and vibrant. Observing the evolution of community street pattern design reveals that land use patterns and vehicle development play a significant role[50].

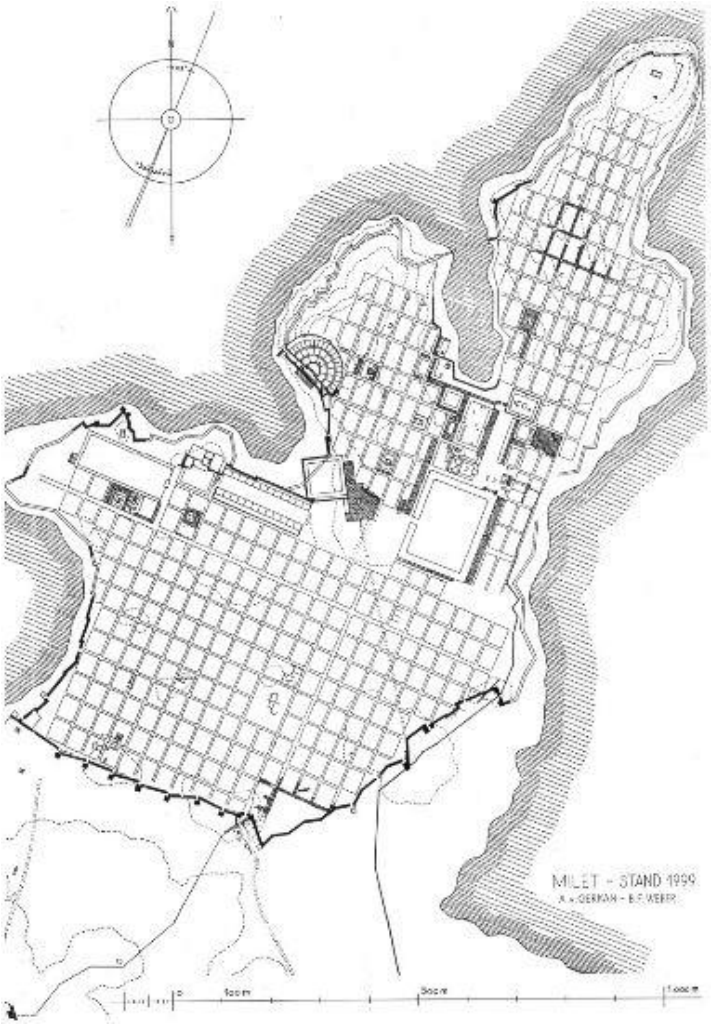


Figure 2-7 Greek City Planning on 479 BC
(Source: Steadman P, 1980)

Historically, many cities were built using a grid layout, where streets intersect each other at perpendicular angles and living blocks are fairly small. The Greeks used this layout in planning cities, despite the obvious conflict with steep terrain (Figure 2-7). It is built upon the pursuit of aesthetic order, representing a rationalized diagram that divides residential communities into organized and systematic patterns. With its neat and precise arrangement, the spatial logic and relationships are clearly defined. This form represents the most prevalent configuration of street networks, emphasizing a sense of order and coherence[51]. There are many benefits to the grid pattern:

①The precise division of plots facilitates optimal building arrangement, while the high accessibility and strong street connectivity enhance efficient transportation and movement. ②

The clear orientation ensures easy recognition of directions. ③Facilitates flexible and agile traffic organization with high system capacity for smooth flow (Figure 2-8). ④Allows for easy organization of community axes[52].

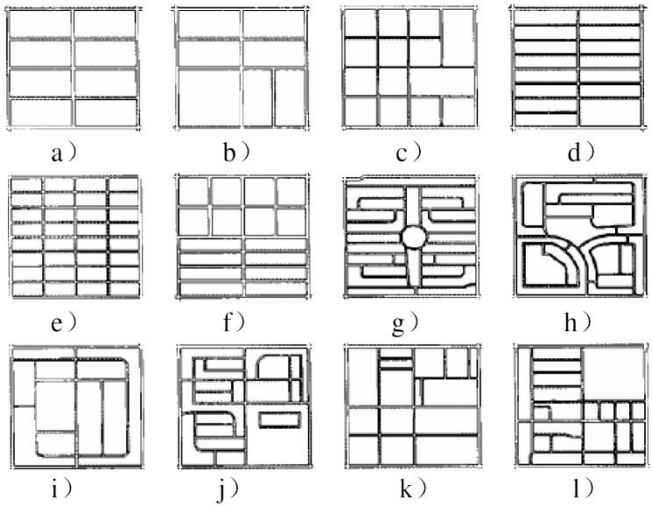


Figure 2-8 Subdivision Method of Grid Layout
(Source: Ben-Joseph E, 1995)

However, there are also some disadvantages to this pattern: Firstly, it is susceptible to the impact of through traffic. The strong public nature of the grid network in urban areas facilitates efficient traffic flow in multiple directions, allowing for comprehensive utilization of street space resources. However, in residential communities, this smooth flow characteristic can disrupt the tranquility of home life and hinder the formation of neighborly relationships. Secondly, in terms of visual quality, the layout of a grid network can appear monotonous in terms of spatial configuration, with limited spatial distinctiveness and poor recognition of individual living block spaces[53].

With the refinement of land use classifications, community streets are also evolving towards more specialized patterns. Residents are gradually moving away from bustling city centers and choosing suburban areas with greater contact with nature. The planning model of curvilinear street and cul-de-sacs has emerged. Curvilinear street pattern are designed to harmonize with the natural topography, featuring graceful curves and smooth corner transitions, overcoming the drawbacks of rigid and lifeless grid street systems. (Figure 2-9). However, due

to their free-form layout, these street networks also have disadvantages such as weak directional orientation and lack of street hierarchy within the community[54]. Cul-de-sacs (dead-end streets pattern), which are more common than curvilinear street, physically separate pedestrians and vehicles, providing residents with protection from vehicle disturbances. An exemplary cul-de-sac community is Radburn Garden City. The community strictly separates streets into different levels, avoiding unnecessary traffic crossings. Each residential unit has one side connected to the driveway and the other side connected to the pedestrian walkway, which in turn connects to public open spaces. Pedestrians can reach schools or other public buildings via walking paths without conflicting with vehicular routes[55] (Figure 2-10).

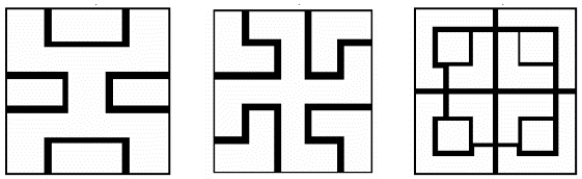


Figure 2-9 Curvilinear Street Pattern
(Source: Chen，2006)

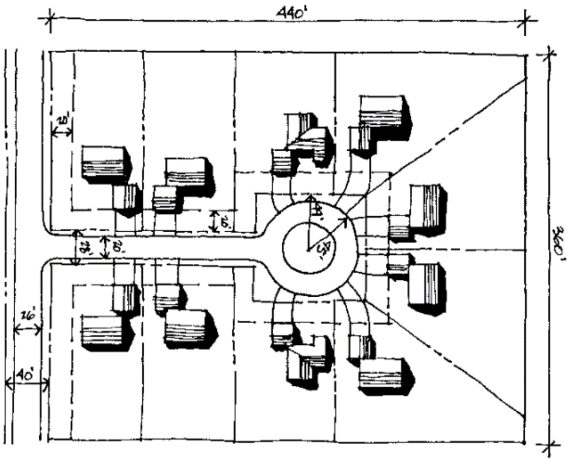


Figure 2-10 Radburn Pattern
(Source: https://arquiscopio.com/archivo/2013/04/28/supermanzana-de-radburn/?lang=en)

While the planning concept of separating pedestrians and vehicles has helped alleviate conflicts between residents and e-bike to a great extent, it does come at the cost of sacrificing convenience in residents' mobility. In order to do something as basic as buy a gallon of milk, it is often necessary to navigate several miles to the nearest store. Instead cul-de-sacs create places that are disconnected, inward looking and where people have car dependent lifestyles[54]. Also, they force all traffic pressure onto a few major streets where speeds and volumes can become unsafe for residential use.

The combination of grid streets, ring streets, and cul-de-sacs can create an optimized street pattern called the Residential Quadrant[56] (Figure 2-11). The Residential Quadrant concept was overlaid on an existing 1970s subdivision near Ottawa and is more efficient than other layouts. Its key feature is the creation of a five-minute walking neighborhood, which is bounded by two collector streets and two arterial streets. Within the quadrant, residential streets are laid out in a modified grid so that cars cannot cross the quadrant, eliminating non-residential traffic. The use of looped, narrow and dead-end streets. The utilization of looped, narrow, and dead-end streets effectively connects open spaces with street networks, enhancing connectivity and promoting a sense of walking experience.

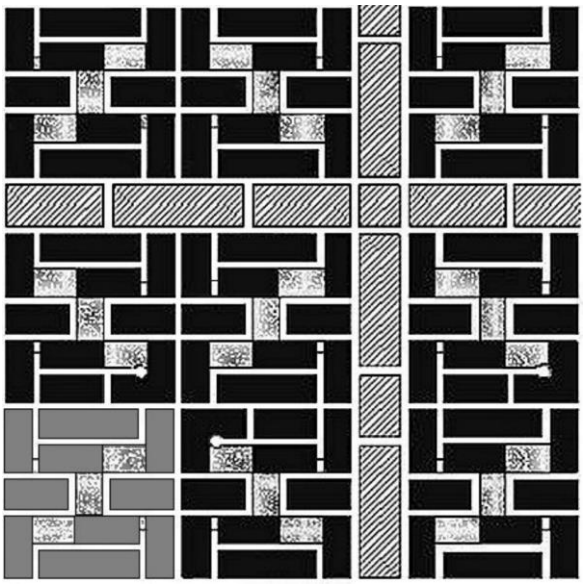


Figure 2-11 Residential Quadrant
(Source: Grammenos, 2002)

Gradually, the high-speed movement of vehicles within the street posed a significant threat to pedestrians who unintentionally entered the street leading to a rise in traffic accidents. As a response, in the late 20th century, the Netherlands pioneered a more suitable street system known as shared streets, where electric vehicles are allowed to travel within a designated space without posing a threat to pedestrians and cyclists. This approach emphasizes the priority of residents' activities within the community and recognizes that streets are vibrant spaces for residents' daily lives. (Figure 2-12). In 1976, the Dutch government introduced legislation regarding "livable streets" in the Street Traffic Act, establishing minimum design standards for

such streets[57]. The Woonerf concept, which promotes shared spaces for pedestrians and vehicles, not only addresses safety concerns in residential areas but also enhances the attractiveness of street spaces through landscape design that aligns with human behavior and preferences.

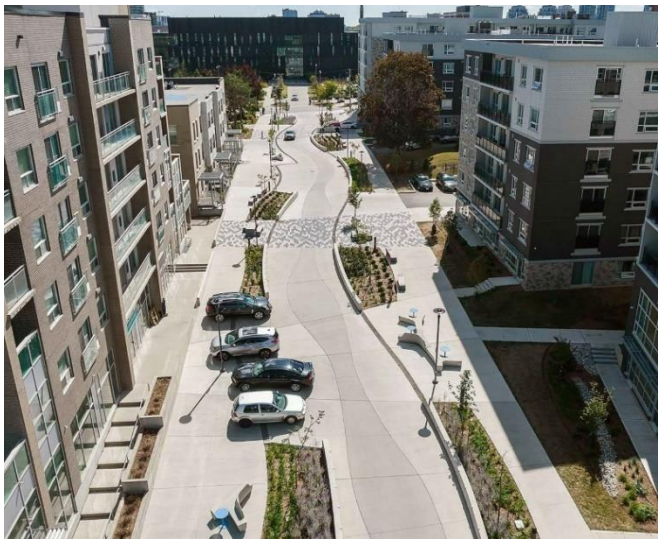


Figure 2-12 The Larch Street Woonerf
(Source: https://www.gspgroup.ca/work/larch-street-woonerf/)

2.3.2 Construction Objectives of Walkable Communities in Transportation

The evolution of street patterns reflects the ongoing integration of sustainable development principles. It has transitioned from the pursuit of orderly grid patterns to the hierarchy of streets during the automobile era, and now focuses on human-oriented streets that prioritize residents' living spaces (Table 2-2). Incorporating sustainable modes of transportation has become a widely embraced and popular strategy. Urban designers increasingly acknowledge the significance of promoting walking through thoughtful street design. Things have to change – we should not allow the car to dominate the streets when a well-designed street can help create sustainable communities, enable people to get around, promote walking, civic pride and identity, provide safe play for children and allow the community to interact. With the advent of the modern subdivision, the character of residential streets began to change substantially. Streets became wider to better accommodate traffic, houses were set back further, pedestrian walkways

often disappeared completely, and the front door became less of an activity area[58].

Table 2-2 Comparison Between Five Street Patterns

(Source: Compiled by the author)

Street pattern	Characteristics	Main travel manner	shortages
Grid layout	Neat and precise arrangement, the spatial logic and relationships are clearly defined	Walking and vehicles	susceptible to the impact of through traffic, limited spatial distinctiveness and poor recognition
Curvilinear street pattern	Natural topography, featuring graceful curves and smooth corner transitions	Walking and vehicles	Weak directional orientation and lack of road hierarchy
Dead-end streets pattern	Separates roads into different levels, avoiding unnecessary traffic crossings	Walking, cycling and Vehicles	Roads are disconnected, inward looking and where people have car dependent lifestyles
Residential Quadrant	Five-minute walking neighborhood without vehicles moving inside. Looped, narrow, and dead-end streets effectively connects open spaces with street networks	Walking, cycling, and public transportation	-
Livable streets	Shared spaces for pedestrians and vehicles. Through space design to give priority to pedestrian	Walking and cycling	-

In conclusion, construction objectives of walkable communities in transportation are as follows:

(1) **Continuous and convenient non-motorized networks**.

Continuity plays a vital role in determining the effectiveness of a street network. An isolated and heavily fragmented pedestrian or cycling network, no matter how well-designed, is unlikely to attract users. On the other hand, establishing continuous and convenient pedestrian and cycling networks encourages residents to opt for walking. This yields numerous benefits, including:

①Encouraging residents to incorporate physical activity into their daily lives, fostering improved physical health. ②Reducing the reliance on vehicles, alleviating traffic congestion, and enhancing overall transportation efficiency within the community. ③Facilitating easy access to schools, shops, parks, and other community facilities, fostering interaction and

connection between residents and the community.

(2) **A well-connected street hierarchy system**. Urban streets are classified into four levels - expressways, trunk roads, secondary streets, and local streets - based on their position in the street network, transportation function, and the services they provide to the surrounding areas[1]. Achieving a smooth connection between different street levels goes beyond simple access and exit connections. A purely hierarchical connection can result in traffic congestion on higher-level streets and ultimately diminish the overall operational efficiency of urban streets[59]. A well-connected street hierarchy system enhances traffic flow efficiency, improves safety, and ensures seamless connectivity between walking, cycling, and public transportation. For instance, cars of varying speeds can travel on streets corresponding to their respective levels, reducing congestion and the risk of accidents arising from conflicts between different traffic flows. Furthermore, residents who use public transportation can conveniently access the nearest bus stop by walking or cycling on lower-level streets within the community, thereby minimizing time spend on travel.

(3) **Street spaces with people-oriented design.** The fundamental goal of community streets is to cater to the needs of people. As a result, street space design should be guided by People-oriented principles, emphasizing the interplay between people, nature, and society. This necessitates the following considerations: ①Taking into account potential challenges that residents may encounter while walking, the design should prioritize the user experience. This involves optimizing the fundamental layout of streets to create a comfortable, convenient, natural, harmonious, and aesthetically pleasing environment for residents. ②Providing suitable transportation conditions for different modes of travel is essential to ensure a harmonious coexistence of street users. Safety and security for all individuals using the streets must also be ensured in this design approach.

[1] *Project Code for Urban Road and Transportation Engineering* published by Housing and Urban Construction Department in 2021

2.4 Relationship between Landscape that Increases Carbon Sinks and Walking

The spatial dimension studied in this article mainly refers to outdoor open spaces in the community, such as parks, green spaces, and squares, where people can rest and relax. The green space system within the landscape not only enhances the environment's beauty but also provides functions such as dust prevention, sound insulation, temperature regulation, oxygen production, and protection of natural ecology. In the construction of low-carbon cities, the development of blue-green spaces is crucial as it contributes to carbon sequestration and serves as an important channel for absorbing carbon emissions from transportation. Therefore, the quality of the landscape environment is an essential criterion for evaluating the travel environment. For communities, the integration of green spaces with various activity areas in the landscape is particularly important. They collectively form the most vibrant open spaces and dynamic public spaces in the community. Creating a favorable community landscape can promote communication among residents and even attract non-residents to visit.

In conclusion, construction objectives of walkable communities in landscape are as follows：

(1) **Continuous landscape environment.** An environment that promotes walking and cycling needs to ensure the comfort of residents' different senses, including physical comfort, visual comfort, acoustic comfort, and thermal comfort. When activity areas, transportation hubs, and green open spaces are connected to pedestrian pathways within the community, residents can have a more comfortable experience of walking[60]. A continuous landscape environment creates a pleasant walking experience. The enchanting scenery, with its abundant flowers, trees, and natural elements along the path, adds to the joy and pleasure of walking. The presence of green vegetation, fresh air, and captivating seasonal changes allows people to savor the beauty of their surroundings, transforming walking from a mere mode of transportation into a delightful and gratifying activity.

(2) **Clearly defined landscape boundaries.** According to environmental psychology theory, human beings are inherently inclined to seek both outlook and shelter. The concept of prospect enables them to have a view of their surroundings, while shelter provides a sense of

security and protection[61]. This indicates that users require visibility and unobstructed lines of sight to feel secure and navigate easily. Moreover, the feeling of safety is augmented by a sense of enclosure and a place of refuge[62]. Moreover, landscape boundaries also serve to segregate various traffic routes, assisting drivers in evaluating vehicle speeds and consequently contributing to reduced overall speeds. This, in turn, enhances pedestrian safety on the streets.

(3) **Artistic and stimulating design.** Walking behavior is strongly influenced by the visual quality and attractiveness of streets and pedestrian routes, which are directly affected by the provision of green space[63]. Thoughtfully designed environments featuring high-quality pedestrian walkways, lively ground-level spaces, open parks, and plazas significantly increase the likelihood of residents choosing walking as their preferred mode of transportation.

(4) **Necessary facilities.** These are essential in the landscape environment to meet the basic needs of residents when traveling outside. The lack of resting facilities along the streets greatly hinders residents' choice of walking. Well-maintained street surfaces, curbs, and smooth and slip-resistant pavement is also an important measure to enhance the likelihood of walking[64]. Installing bike racks, providing public bike-sharing stations, and integrating bus stations within the landscape design can make it more convenient for individuals to choose sustainable modes of transportation. Furthermore, the provision of seating areas, restrooms, and water fountains can enhance the overall user experience, promoting longer and more enjoyable journeys by foot or bicycle.

From the perspective of travel purposes, the community landscape primarily caters to residents' needs for daily leisure, recreation, and exercise. However, in practical projects, various factors, such as design and management, often hinder most community landscape environments from fulfilling their intended roles. As a consequence, some residents find themselves driving to more distant locations in search of better exercise facilities. On one hand, because the community landscape does not directly generate economic benefits, it is often perceived as a secondary concern within the community, with aesthetics taking precedence over practicality. On the other hand, the continuity of outdoor public spaces in the community is frequently disrupted by buildings, streets, and parking lots, resulting in fragmented landscape environments that lack a sense of cohesion.

2.5 Relationship Between Three Dimensions

In summary, under a low-carbon orientation, the construction of walkable communities involves different objectives in layout form, transportation and landscape: such as public facilities, streetways, green spaces, and plazas. It is important to note that in the actual planning process, these objectives should complement each other rather than exist in isolation, as they are interdependent. Separating them would not lead to the desired outcomes effectively[65]. For instance, a beautifully designed community park loses its safety and diminishes residents' desire for mobility if it is surrounded by busy thoroughfares. Similarly, a small-scale neighborhood grouping loses its significance if it is far from other public facilities, green spaces, and gathering areas.

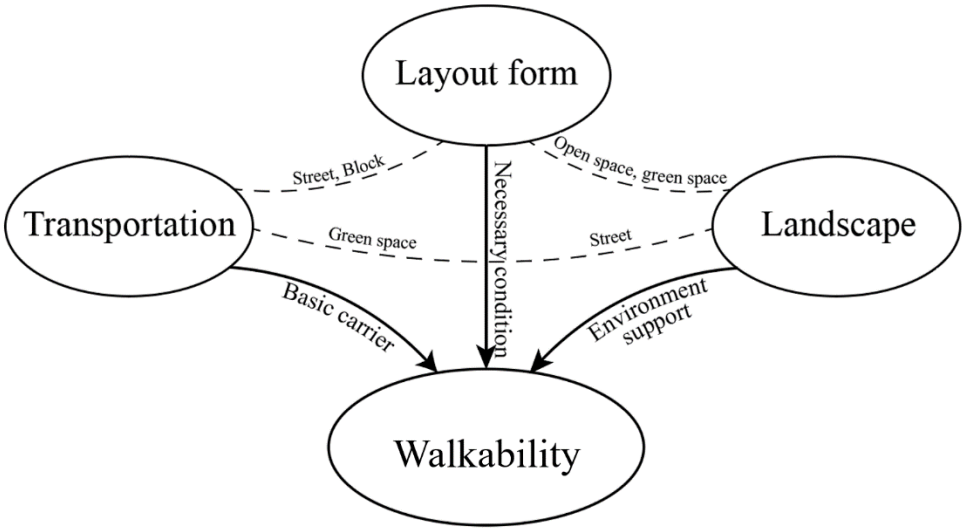


Figure 2-13 Relationship Between layout form, transportation and landscape
(Source: Illustrated by the author)

Layout form is essential for walking in communities, transportation is the basis for residents' sustainable travel, and the landscape provides the environment for enjoyable walking experience (Figure 2-13). Only by providing residents with a variety of blue-green spaces, well-organized transportation, passive design and a supporting infrastructure, residents may be encouraged to adopt low-carbon lifestyle habits, thereby reducing their daily emissions of carbon dioxide.

2.6 Conclusion

This chapter provides a detailed analysis and summary of the objectives for constructing walkable communities under a low-carbon orientation. The aim is to identify the elements involved in community construction for reducing carbon emissions during residents' daily travel, reacting to the research question raised in Chapter 1: What kind of community is suitable for residents to walk in a low-carbon environment? As a theoretical foundation, this analysis will serve as a springboard for the subsequent experience learning and site analysis.

As part of this chapter, the characteristics of residents' daily travel behaviors are analyzed and identified in order to determine their needs for community construction. Second, under the carbon peaking and carbon neutrality goals two paths are proposed for reducing carbon sources and increasing carbon sinks, and the needs analyzed in the previous section are summarized into three dimensions: layout form for reducing carbon sources, transportation for reducing carbon sources, and landscape for increasing carbon sinks. Following this, the thesis explores the relationship between communities and walking within these three dimensions. The analysis of layout forms encompasses the characteristics of three spatial development patterns: NUC, TND, TOD. Regarding transportation, the evolution of grid road patterns, Cul-de-sacs patterns, Curvilinear street pattern, and mixed road patterns is investigated. A landscape assessment is also conducted to identify whether the landscape meets the needs of residents in terms of comfort, safety, aesthetics, and facilities when walking. Based on these relationships, specific objectives for walkable community construction within each of the three dimensions are derived. Lastly, the chapter emphasizes the complementary nature of these dimensions in the practical planning and construction process.

Chapter 3 Experience from Existing Projects

Given that existing pedestrian environment improvement cases mostly focus on enhancing the landscape of isolated public spaces, with less consideration for improvements in other dimensions, this chapter will examine two successful low-carbon community in pedestrian environment development outside China. The reasons are presented below:

Firstly, with a focus on creating walkable environments, these projects adopted a low-carbon travel orientation at the outset of the planning process. They explored corresponding aspects in different dimensions comprehensively. Bo01 Community achieved a pedestrian-friendly environment through spatial enclosure, while Vauban Community created a car-free environment through road allocation. Secondly, the land area of the two communities is proportionate to that of the Shipai Creek Community. Thirdly, both of these communities encompass a diverse mix of residential, commercial, office, and service properties within their premises. This alignment in functionality parallels the status quo of the Shipai Creek Community. Fourthly, both communities enjoy close proximity to notable natural or urban landscapes, offering valuable insights for the revitalization of the Shipai Creek Community while integrating with the creek's surroundings. Lastly, both of these communities boast well-structured road planning, a noteworthy attribute particularly pertinent to a city like Guangzhou. In such urban environments where multiple modes of transportation coexist on shared road surfaces and where road rights allocation can be ambiguous, this serves as a significant point of reference.

By conducting an integrated study of the layout form, transportation, and landscape of two communities, valuable insights into pedestrian environment development can be derived. Whenever possible, these observations can be adapted as improvement strategies to improve the pedestrian environment in old communities (Figure 3-1).

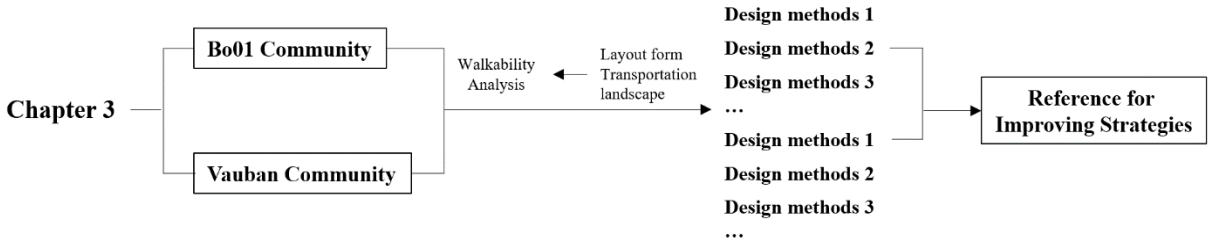


Figure 3-1 Framework of Chapter 3

(Source: Illustrated by the author)

3.1 Bo01 Community, Malmo, Sweden

3.1.1 Context

(1) Background

Bo01 Community is located in Malmö, Sweden, which is the third-largest city in Sweden. It is a former industrial city with a dismantled ship-building economy (Figure 3-2 and Figure 3-3). Decades of industrial development have resulted in severe soil pollution in the western harbor area. In 1996, when the shipyard closed down, the Malmö government purchased the 350-acre property where the Bo01 Community is situated. Shaping a cultural and environmentally sustainable city in the post-industrial era became a strategic goal for urban development. In 2001, Malmö hosted a housing exhibition with a focus on sustainable development and concurrently launched the Bo01, a City of Tomorrow international housing exhibition[66]. This housing demonstration area project was aimed at showcasing innovative residential solutions. Construction of the demonstration area was completed in 2008 and it continues to serve as a catalyst for further development in the Western Harbor area.

Figure 3-2 Overview of Bo01 Community
(Source: https://digitalcommons.calpoly.edu/)

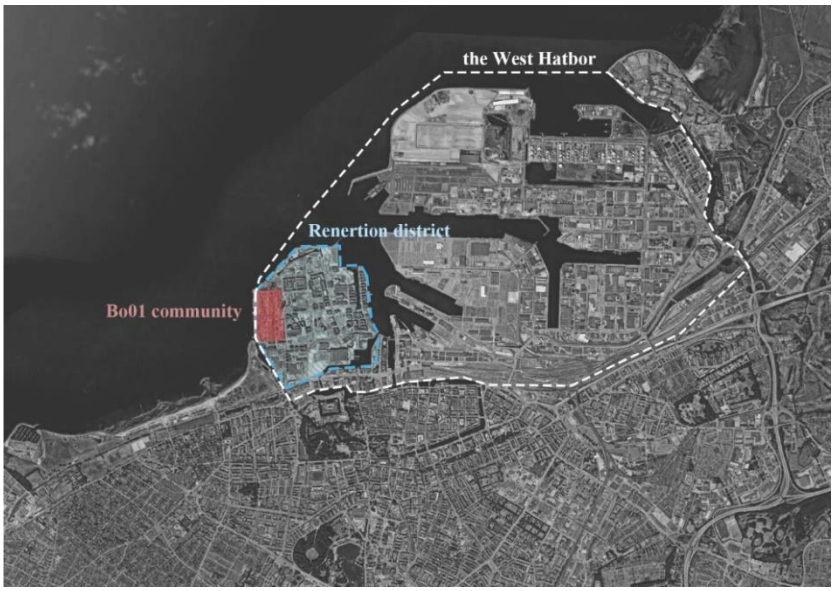


Figure 3-3 Location of Bo01 Community
(Source: Reproduced from Google Map)

The Chief Architect of the Bo01 Community, Klas Tham, placed residents at the center of attention, aiming to encourage them to adopt a low-carbon lifestyle through environmental changes. “The urgent conversion of society to long term sustainability will only be possible when the sustainable alternative is regarded not only as the wisest, but also as the most attractive one…The prevailing quantitative standards for environmental sustainability, such as saving energy are necessary, but insufficient…It will not be until people’s aesthetic, emotional and social needs are also met that the sustainable society can be attained”.

(2) Planning Process

The cogitation and ingenuity intertwined with the inception of Bo01, heralded as one of the pioneering Swedish prototypes for sustainable urban design, were rendered feasible by the impetus of overarching governmental policies and financial initiatives. The birth of Bo01 was profoundly influenced by the far-reaching aspirations of SVEBO (Svenska Bostäder, an organization formed by BOVERKET, the Swedish National Board of Housing, Building and Planning). SVEBO harbored lofty ambitions to fashion a "paragon of sustainable urban development" on a national scale, an indelible vision that decisively steered the trajectory of Bo01's evolution[67].

3.1.2 Public Facilities Placed on the Periphery

The Bo01 Community covers an area of 30 hectares with a total built area of 175,000 m^2. In terms of functional allocation, residential functions account for 84% of the area, complemented by commercial facilities as the main supporting function. Additionally, there are offices, hospitals, schools, government institutions, and other facilities available. The eastern side of the community features a linear park, which serves as the main mixed-use area along the street, acting as a boundary between the city and the community. It creates a contrast with the inward-oriented residential areas, where the lively streets surround the relatively tranquil residential zones (Figure 3-4). In the western residential area, there are also several public facilities distributed along the main streets, with shops integrated at the ground level of the residential buildings. Thanks to the smaller scale of the living blocks and well-connected street networks, all residents in the community can reach the public facilities within a 5minute walk.

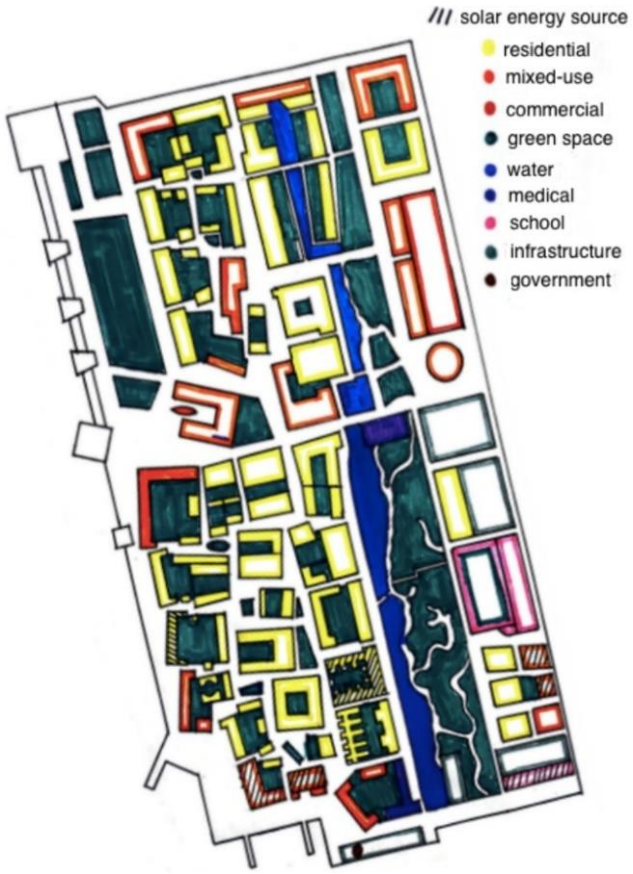


Figure 3-4 Functional Plan of Bo01
(Source: https://alicontreras.medium.com/bo01-6f0e5a33e10b)

3.1.3 Living Blocks that Break the Order

Klas Tham envisioned a network of streets with a broken-up character, much like that of the inner-city of medieval towns (Figure 3-5)—its compact high density, its complex layering of many different architecture and design strategies, its mixed use, its integration of public parks and plazas with distinct and quiet residential neighborhoods[68].

Each enclosed housing unit is a living block. The longest boundary of the living block does not exceed 150m and has an independent courtyard green space (Figure 3-6). Different living blocks are designed by different architects, who use both bold and subtle ways to turn the building angle, creating a richer order structure and forming irregular flows within the overall planning framework. This approach not only living blocks the strong wind but also breaks the traditional rigid order, providing the possibility of discovering mystery, surprise, and making accidental discoveries, establishing a profound connection between the community, residents, and tourists.

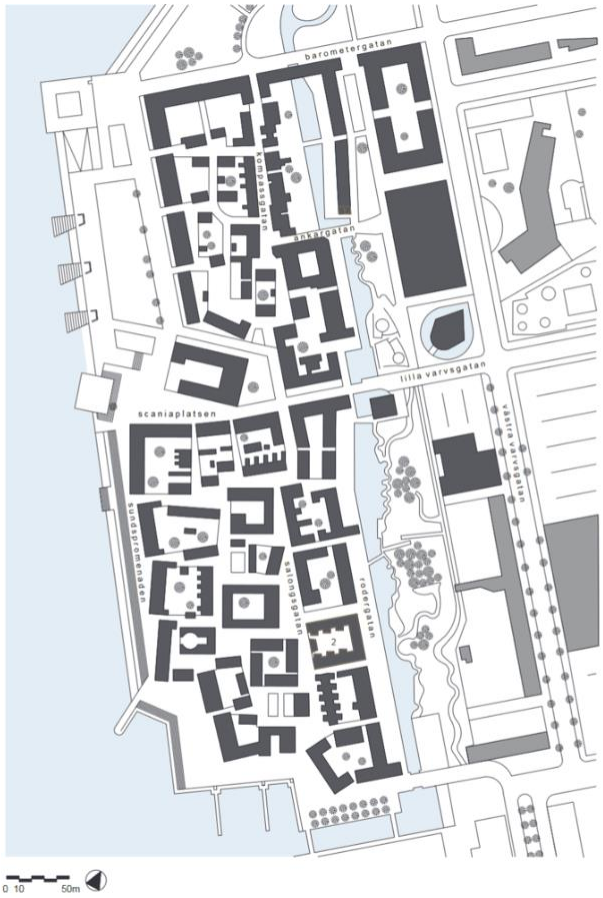


Figure 3-5 Plan of Bo01 Community
(Source: https://dash-journal.com/bo01-city-of-tomorrow/)

Figure 3-6 Living Blocks in Bo01 Community
(Source: Fraker, 2013)

3.1.4 Vibrant Axis that Penetrates from the Periphery to the Interior

Bo01 Community has two significant linear vibrant hubs. The first is a service-oriented vibrant axis composed of different functions, where a street connects the continuous artificial ecological zone on the east side with the public facilities on the right side, and residents travel in a well-designed landscape. The second is a landscape-oriented vibrant axis near the sea on the west side, where the southwest area is built into a pedestrian zone with many activity spaces and rest facilities, and the northwest part remains wide and rough as a community park. The two vibrant axes penetrate into the internal streets from the outside and connect various open spaces such as small squares and courtyards of different scales within the community. This organization method pushes the vibrant atmosphere of the community to a climax, both visually and spatially (Figure 3-7).

Figure 3-7 Vibrant Hub in Bo01 Community

(Source: Reproduced from the plan of Bo01 Community)

3.1.5 Shared Streets with Priority for Pedestrians

The green transit strategy places utmost importance on the bicycle circulation system and pedestrian network, considering them as pivotal components. These modes of travel, characterized by their complete reliance on renewable energy and absence of carbon emissions, are given top priority in the design. The bicycle circulation system and pedestrian network may be the most important elements of the green transit strategy because the design gives priority to these completely renewable, carbon-free modes of travel (Figure 3-8).

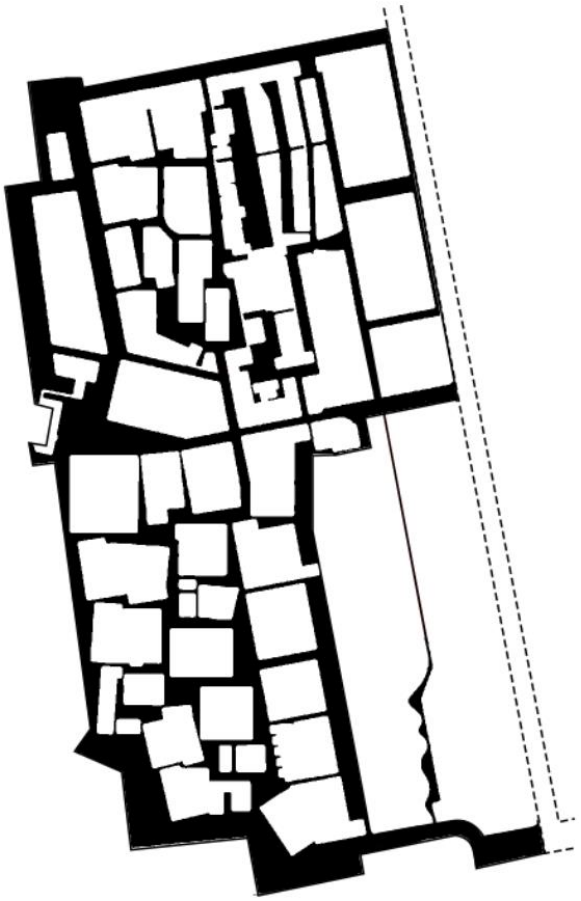


Figure 3-8 Street network that Gives Priority to Pedestrian
(Source: Reproduced from the plan of Bo01 Community)

The plan of Bo01communitiy did not call out specific targets for the split among different transit modes but instead used design, incentives, and an information system to encourage walking, biking, car sharing, and use of public transportation and green vehicles over the use of private cars. While cars can enter the internal street space, pedestrians and cyclists still have priority. The speed limit for streets open to cars and buses is 30km/h[68]. Ground-level parking is limited and provided only at the community's edge, with parking mainly provided in underground structures. In addition, the community provides shared electric scooters, minimizing the use of private cars within the community and creating a large, safe, comfortable pedestrian and bicycle area.

Bus stops are located within 300m walking distance for all residents, with buses running every 6-7 minutes. All residents and businesses in the area can access traffic management information, including bus schedules and arrival times, on the city's transportation website. The

stations themselves also display the same information, providing important information to passengers and helping them plan their use of public transportation.

Figure 3-9 shows the section of the street. Unlike straight conventional streets, the streets in Bo01 Community are influenced by the angle of the building living blocks, resulting in varying widths and sizes. Residents can easily come across a street plaza while traveling and enjoy a distant view of the sea. This irregular form fully expresses the artistic appeal of the street space and provides emotional preparation, gathering, and sublimation for space users.

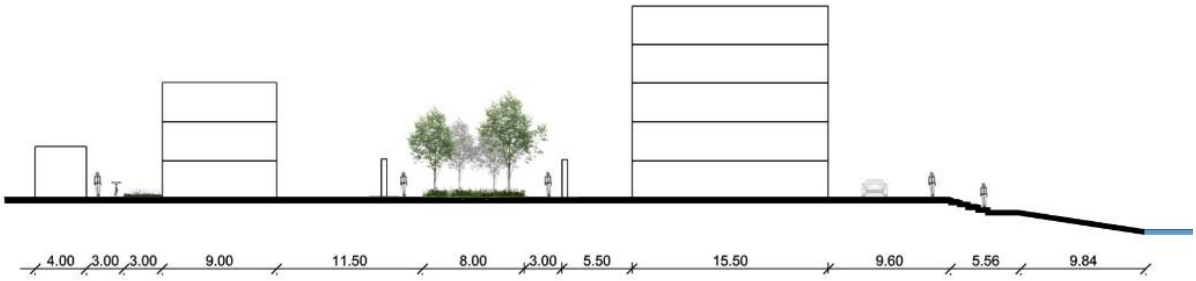


Figure 3-9 Section of Bo01 Community
(Source: Illustrated by the author)

3.1.6 A City Garden Enveloped by Nature

The green spaces in the Bo01 Community are divided into three levels: urban green space, community public green space, and living block green space (Figure 3-10). The community public green space is mainly arranged with an artificial canal, forming a rich river wetland habitat. These wetlands are connected to private gardens and riverfront promenades, becoming the most loved green space by residents. Living block green space is mainly distributed in the courtyards of each living block and is the most important public space for neighbors, as well as a playground for children, greatly promoting communication and interaction between residents and tourists (Figure 3-11).

Figure 3-10 Green and Blue Spaces in Bo01 Community

(Source: Reproduced from *Landscape Architecture in the Sustainable Urban Development Bo01 Eco-community in Western Harbour in Malmo, Sweden* published by Han et al.)

At the beginning of the Bo01 Community project planning, the Malmo government set two goals for the water system planning: first, to connect the community to the old city center through the water system; second, to achieve direct contact between each building and water and nature[69]. Architects achieved the goal of having every building face the water by constructing an artificial canal that crosses the community in a north-south direction. Starting from a central collection pond, this canal forms the east linear community park of the Bo01 Community, enters the community in the form of lakes, small waterfalls, and wetland streams, and finally flows into the sea from the north and into the artificial leisure pier from the south (Figure 3-10). The layout of green spaces and water bodies tightly connects every corner of the community, and residents can enjoy the surprises carefully designed by the architects during their travels. The Bo01 Community is like a city garden surrounded by nature.

a. Public Green Spaces of the Community (Source: https://wwf panda org/wwf_new/24433/MalmrBo01)	b. Green Spaces of Living Blocks (Source: https://wwf panda org/wwf_new/24433/MalmrBo01)

Figure 3-11 Types of Green Spaces

(Source: Compiled by the author)

3.1.7 An Seaside Promenade Offering a Breathtaking View of the Ocean.

The most important environmental design strategy of the Bo01 Community is its response to the connection between the sea and the city. Architects have created a wide, varied-scale public promenade at the western edge of the community, overlooking the panoramic view of the sea, and incorporating romance into the community's landscape design (Figure 3-12). The promenade extends from the water's edge to the building facades, creating a vibrant multi-functional activity center for residents and tourists. A robust barrier comprised of stone boulders creates a rugged buffer zone, separating the promenade from the water's edge. This barrier is intermittently interrupted by stadium-like steps and secluded seating areas, providing direct access to the waterfront. Atop the boulders, a wooden boardwalk extends along the entire length, accompanied by continuous stepped seating that faces both directions.

Figure 3-12 Seaside Promenade

(Source: https://csis.myclimateservice.eu/node/5201)

3.2 Vauban, Freiburg, Germany

3.2.1 Context

(1) Background

The Vauban community (Figure 3-13) is located in the southwest corner of Freiburg, Germany, about 3km from the city center (Figure 3-14). It was built on the site of a former French military base. Following the fall of the Berlin wall in 1989 and the reunion of Germany in 1990, French armed forces withdrew from their garrison in Vauban. Ownership of the district reverted to the German federal government and the City of Freiburg purchased it[70]. Because of the serious housing shortage in Freiburg at the beginning of the 1990s, the city decided to develop the site as a new sustainable urban district. In 1994, the city held an urban design competition to bring out a range of ideas from the community. In 1998, the Vauban community officially entered the construction phase. After 12 years of construction, the Vauban district was fully completed in 2010. In 2012, Freiburg was awarded the German Sustainability Award, making it the most sustainable city in Germany.

Figure 3-13 Overview of Vauban Community
(Source: https://www.freiburg.de/pb/,Lde/208732.html)

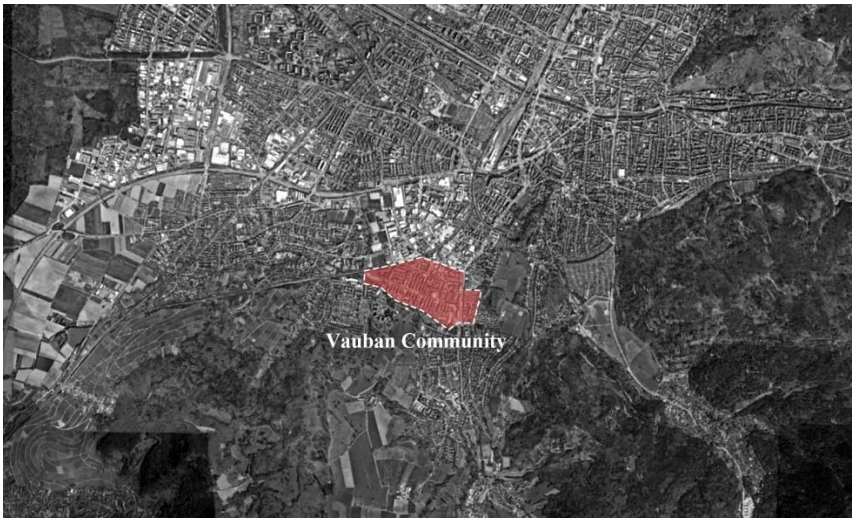


Figure 3-14 Location of Vauban Community
(Source: Reproduced from Google Map)

During the design competition, the goal of creating a high-density housing district with spaces for small businesses and public services infrastructure, including schools, kindergartens, and recreational areas, was established. Bicycle paths and pedestrian walkways were prioritized over automobiles, and the city's light rail line was extended into the heart of the community to connect the district to the city center. The concept of a "car-free community" was established at the beginning of construction, where streets primarily serve pedestrians and cyclists, with cars

almost entirely excluded. Residents with cars can park them in a parking lot at the edge of the community and are not eligible for car-free subsidies. If they want to park within the community, they must pay a higher rental fee[70]. According to statistics, when the first batch of residents moved into the Vauban community, 57% of them said they did not stop using their car until they moved into Vauban. 57% of residents decided to give up their cars, and 81% of car-free households surveyed indicated that organizing their everyday lives without a car was very easy on a five-point scale[71]. Thus, with most residents with or shortly before the move into Vauban a drastic change in the mobility behavior has taken place.

(2) Planning Process

The low-carbon-city plan of Freiburg places "people" as the central topic and ultimate goal of sustainable development, emphasizing that the sustainable development of cities cannot be achieved without public participation. Therefore, at the beginning of the planning of the Vauban community, a non-governmental organization called the Forum Vauban was established to promote and coordinate public participation. All topics, including transportation, energy, housing, and social issues, are discussed at open forums aimed at the public, as raising public awareness is seen as a key component of environmentally-oriented urban planning.

In addition, if people's existing concepts can change (such as carpooling and using public transportation), a new overall framework for the community may emerge based on a common awareness of the community. The concept of a "car-free living" was proposed by Forum Vauban. Philipp Spath, one of the founders of the Vauban housing cooperative, said, "A lot of people care for their environment and for their community, if they get an opportunity and are encouraged to do so. Key to successful urban development is that people are heard and encouraged to explore and freely express their needs and that they are enabled to form communities and to realize their dreams together - in mutual support with the public services"[68].

3.2.2 Public Facilities Dispersed Evenly throughout the Area.

The Vauban community covers an area of 41 hectares with a total building area of 18 hectares. As of 2020, the community has more than 5,000 inhabitants[72]. At the beginning of the design, the Vauban community hoped to create a mixed-use community that would provide

more than 600 job opportunities for local residents. Therefore, the community has a considerable number of office and industrial buildings, as well as commercial, university dormitories, elementary schools, government agencies, hospitals and other facilities to meet the different needs of residents. There are 9 living blocks with a total of 4.5 hectares of land for mixed-use living blocks, including living blocks that are mainly office-oriented and living blocks with a low degree of mixing with service facilities interspersed in residential areas. The functional mixing inside the building mainly reflects the combination of commercial and service facilities with residential and office buildings (Figure 3-15).

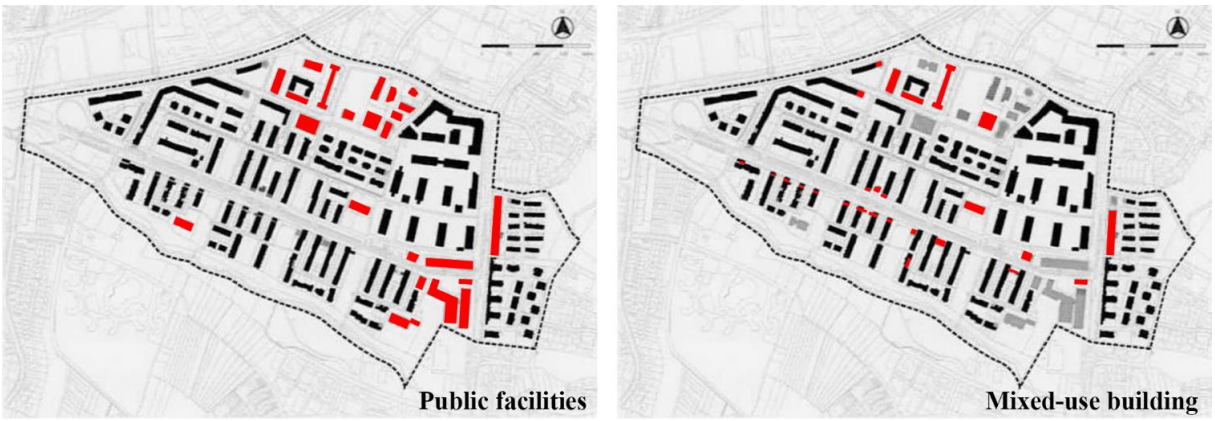


Figure 3-15 Functional Analysis of Vauban Community
(Source: Reproduced from *Approaches for Car-free Residential Planning in Contemporary Germany: A Case Study of Vauban* published by Liu et al.)

In support of the car-free concept, the layout of public facilities in the Vauban community is not concentrated based on the principle of convenient operation and management, but is scientifically and evenly dispersed to improve usability and pedestrian safety and reduce motorized traffic areas[73], forming a mixed layout pattern of street and living block layout. Based on considerations of user and activity relevance, commercial facilities are placed on both sides of Vaubanallee Avenue (especially at the regional entrance), and residents on both sides of the residential area can directly and conveniently go to the shops. Office and industrial buildings are placed in the northern area away from residential areas and downwind; the location of educational facilities ensures pedestrian safety and takes advantage of the landscape. Based on the above arrangement, primary school students in the area need to cross a motorized street at most once.

3.2.3 Well-Defined Living Blocks

Figure 3-16 Living Blocks of Vauban Community
(Source: Fraker, 2013)

Table 3-1 Living Block Data for Vauban Community
(Source: Compiled by the author based on *The Hidden Potential of Sustainable Neighborhoods: Lessons from Low-Carbon Communities* published by Fraker)

	Living block A	**Living block B**	**Living block C**
Living block area	7296 m^{2*}	12308 m^2	10226 m^2
Size	81m*109m	106m*128m	113m*123m
Path	1077 m^2 (14 %)	930 m^2 (8%)	532 m^2 (5%)
Green spaces	3868 m^2 (53%).	3692 m^2 (30%)	3119 m^2 (30%)

The Vauban community follows the principle of "dispersed concentration" in organizing construction sites. "Dispersed" means that the construction site is divided into several living blocks of similar size, with each part maintaining a distance to distinguish between private and

public areas. "Concentration" means that the building layout within each living block is compact in order to reduce the area of transportation and support the creation of a car-free environment.

The Vauban community is divided into nearly 20 living block by straight streets of varying sizes but similar shapes. The street boundaries near the community edge are complete and respond to environmental challenges or landscape advantages according to local conditions, providing a clear and complete public space interface for residents' travel activities. The scale of living blocks is no longer than 210m, and each residential building has a dedicated garden in front of it. The green space area of each living block is no less than 30%; most of the building forms within each living block have regular linear contours, and each living block has a crossing street (Figure 3-16 and Table 3-1).

3.2.4 Interconnected Vibrant Axes

The Vauban community has two significant linearly arranged vibrant hubs (Figure 3-17). The first is a service-oriented vibrant axis composed of different functions: the internal main facility and public space are organized by a T-shaped spine (Vaubanallee Avenue), which includes a north-south head composed of a single-sided commercial street, and an east-west tail composed of a combination of double-sided commercial streets and single-sided open squares. Together, they form a strong and clear community vibrant hub. The second is a landscape-oriented vibrant axis composed of major large open spaces: the natural ecological protection area located at the southern end of the community. The tail of the T-shaped spine is connected to the two vibrant axes and nearby residential areas through a U-shaped pedestrian and bicycle path, creating a circular traffic pattern that connects all parts of the community.

A number of benefits can be derived from this organizational approach. Firstly, it allows residents to freely transition between urban living and leisure activities, in line with Howard's "city-country" magnet concept[73]. Secondly, there is seamless integration between commercial areas, green spaces, and plazas, improving the environmental quality of walking and encouraging residents to spend more time on their trips. Thirdly, it effectively reduces the fragmentation of green spaces, facilitating the establishment of rainwater management systems.

Figure 3-17 Vibrant hubs of Vauban Community

(Source: Reproduced from Vauban Official Website:

https://www.freiburg.de/pb/,Lde/208732.html)

3.2.5 Create Car-Free Zones by Classifying Streets

The street planning in the Vauban community adopts a hybrid model of grid and loop street systems. The grid forms the main framework of the community's street system, while the loop connects the residential areas and the T-shaped spine. This approach allows for a coherent flow of traffic while cleverly distinguishing between public and private spaces. Bike paths are shared with pedestrian walkways, with a minimum width of 3m. The pedestrian walkways and bike paths radiate outward from the central service-oriented vibrant axis in a circular network, forming a connected loop. Residents of any residential area can ride their bikes to the community's public facilities within 100m. The basic walking space for residents is complete and orderly.

The street system in the Vauban community is divided into four levels (Figure 3-18): the city's main streets outside the community (speed limit of 50 km/h), the semi-circular main streets (speed limit of 30 km/h) connecting the residential areas to the external main streets, the U-shaped inner streets (speed limit of 5 km/h) connecting the car-free areas to the semi-circular main streets, and the life streets connecting the various living blocks, living blocks and open spaces. Life streets are divided into bike and pedestrian shared streets and pedestrian-only streets. The car-free area includes eight groups separated by five north-south green belts, and

the semi-circular main street surrounds the north car-free area, with car-frees allowed to pass through the community. The community's central parking lot is located near the semi-circular main street and also serves as the edge of the car-free area. Among the four street levels, pedestrian walkways have the highest permeability in the community, and the interference of e-bike in community life is minimized, ensuring walking.

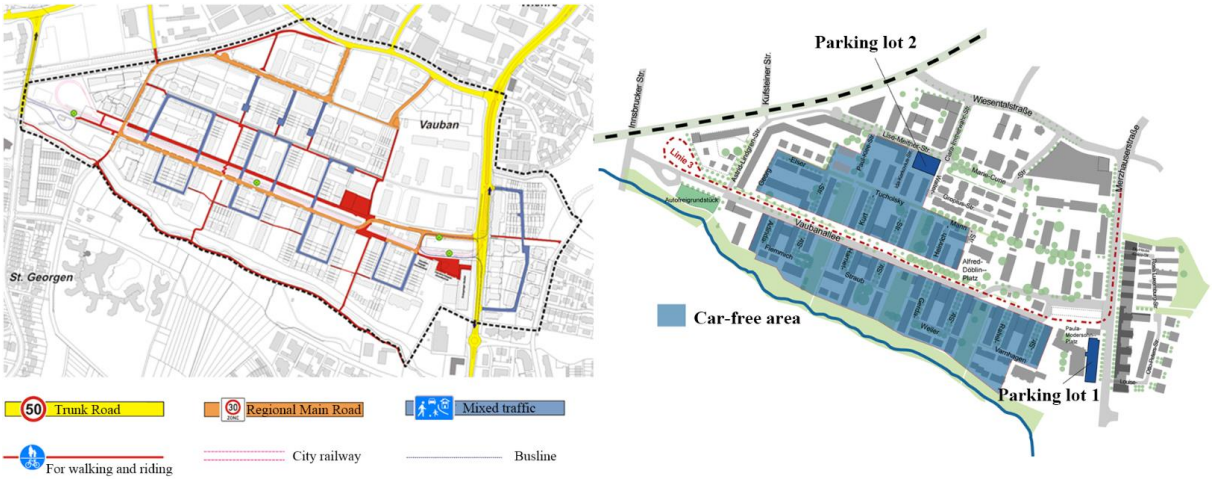


Figure 3-18 Hierarchical Traffic System for Vauban Community

(Source: https://stadtteil-vauban.de/en/traffic/)

3.2.6 Segmentation of Streets in Order to Protect Pedestrians

The dimensions of different modes of transportation are shown in the figure 3-19. The buildings and streets do not directly touch but are separated by a narrow or wide green buffer zone. The green space, attached to the ground level of the residential buildings, has been used for private gardens and custom-designed bicycle sheds. These green spaces have become the best place for bike parking. There are also barriers between pedestrian/bike paths and motor vehicle ways, greatly enhancing the safety of walking for residents. The T-shaped spine is the main vehicle street in the Vauban community, with a tail width of about 37m, which is too large in scale. Therefore, a combination of motor vehicle ways, on-street parking spaces, central leisure and entertainment spaces, and pedestrian walkways is adopted to solve this problem ((Figure 3-20). The on-street parking space not only serves to define the boundary and solve the community's temporary parking needs but also reduces the speed of vehicles by compressing the size of the street.

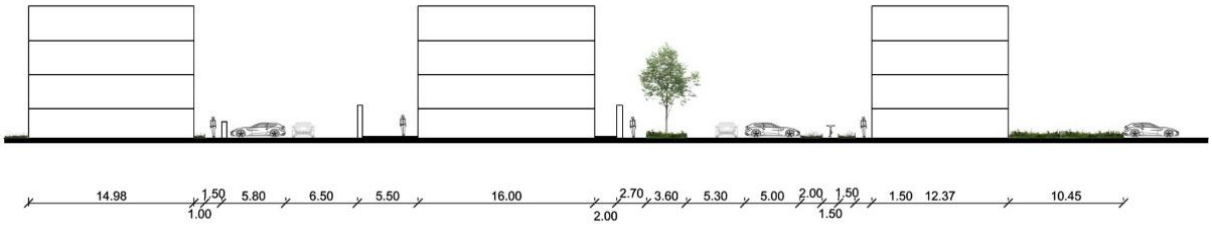


Figure 3-19 Section of Vauban community

(Source: Illustrated by the author)

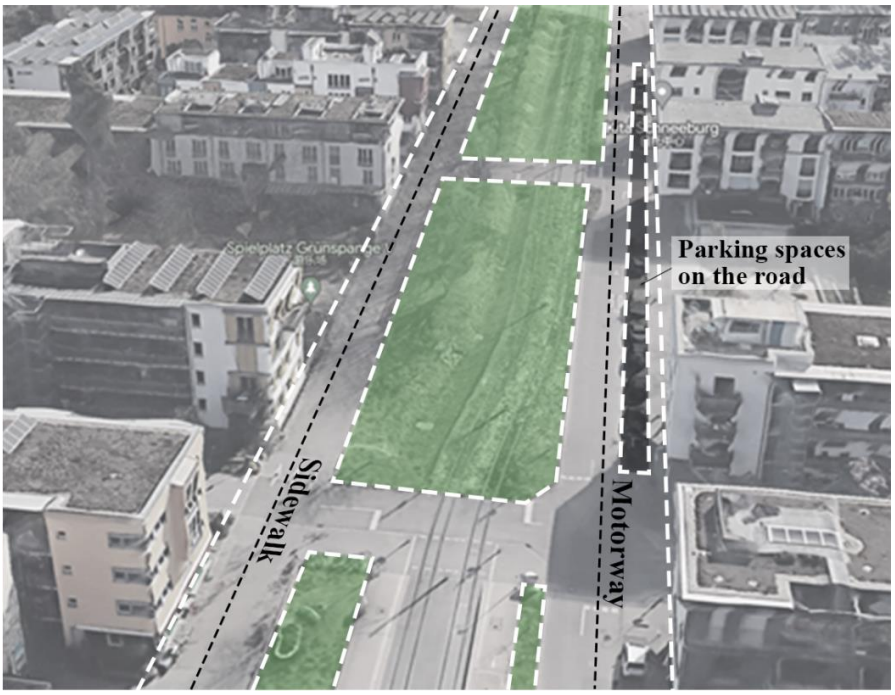


Figure 3-20 Separation of the Big-Size Street

(Source: Reproduced from Google Map)

3.2.7 Design of Open Spaces that Meet the Needs of Various Activities

Differentiated design has been applied to each strip-shaped group green space, with small activity areas of varying shapes and positions set among preserved trees to create a strong contrast with the straight boundaries and highlight the individuality of each group green space. (Figure 3-21).

There are two large gathering plazas in the community, with a bazaar located on the eastern third of the T-shaped spine, which is one of the community's most vibrant open spaces. The design principle of the square is fashioned so that the existing area was maintained in its current dimensions while an extension in the shape of a turned rectangle was added as well as a zoning

of the space itself. This is achieved by the use of granite strips running from east to west connecting the different sub-areas of the square (Figure 3-22).

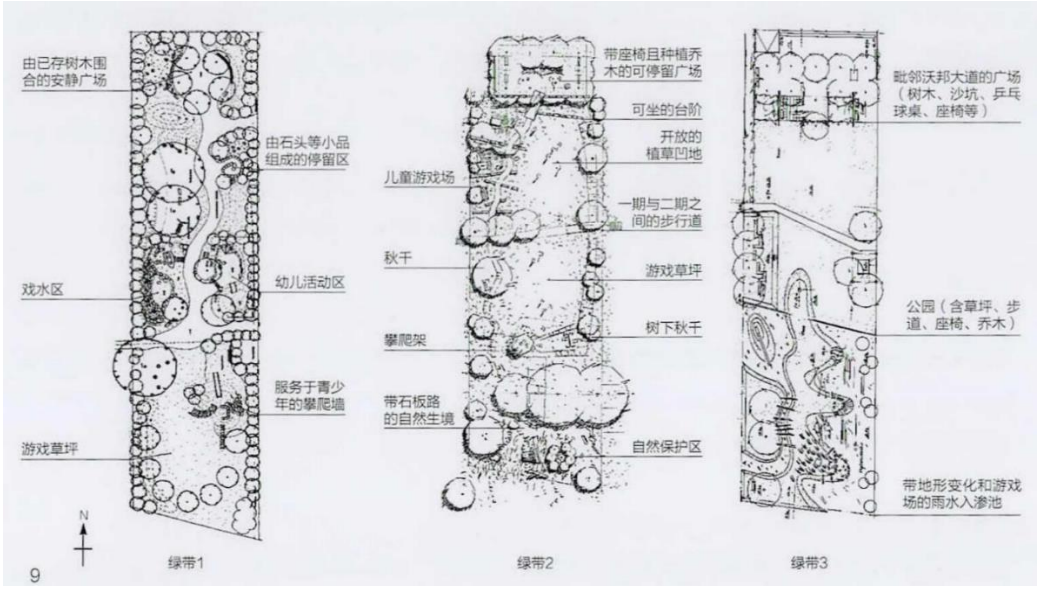


Figure 3-21 Design of Living Block Green Spaces

(Source: Liu, 2019)

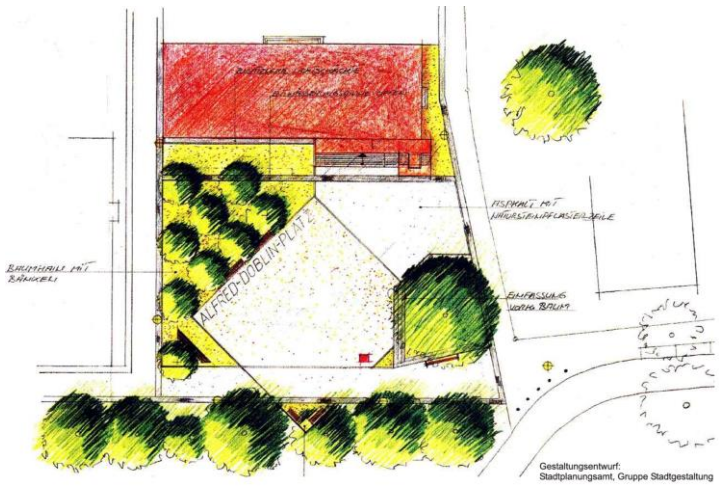


Figure 3-22 Design of the Market Plaza

(Source: https://www.freiburg.de/pb/,Lde/208744.html)

3.3 Inspiration for Old Communities

To conclude, both low-carbon communities prioritize and promote walking as the design starting point and ultimate goal. This emphasizes the importance of resident involvement in the

implementation of sustainable cities. Based on the analysis of the design strategies for these two communities, the following characteristics may serve as valuable references for improving the quality of pedestrian environments in old communities.

①Whenever feasible, ensure the provision of diverse and well-organized functional facilities. When facilities are dispersed, strengthen ground-level connections to enhance accessibility.

②Emphasize the creation of small-scale living blocks, incorporating both irregular and regular-shaped layouts. Irregular-shaped clusters offer a wealth of public spaces, while regular-shaped clusters facilitate the organization of a well-connected road network.

③Prioritizing the development of community vibrant hubs typically entails establishing hubs with a focus on landscaping, and when feasible, considering the establishment of service-oriented vibrant hubs.

④Maximize the permeability of the pedestrian network within the community, ensuring smooth and convenient access to different destinations.

⑤Consider designating certain areas as car-free zones, encouraging residents to adopt car-free lifestyles within the community.

⑥Restrict ground-level parking spaces within the community, with limited on-street parking available. Instead, concentrate parking facilities should be moved to the periphery of the community.

⑦Create engaging and dynamic activity spaces, complemented by aesthetically pleasing landscape environments that inspire a sense of place and enhance the overall pedestrian experience.

⑧Emphasizing public participation in the construction process is of paramount importance for the success and sustainability of walkable communities.

3.4 Conclusion

The aim of this chapter is to learn from two low-carbon community construction projects that prioritize the development of pedestrian environment. The first scheme is Bo01 Community, a community facing the sea that breaks away from the grid pattern. Its features include an outward-oriented layout of public facilities, unconventional residential blocks, a vibrant axis permeating from the outside to the inside, mixed-use streets prioritizing pedestrians and cyclists, urban gardens surrounded by nature, and scenic pedestrian walkways overlooking the sea. The second scheme is Vauban Community, a community located in a natural ecological area with a "dispersed concentration" layout. Its features include evenly distributed public facilities, well-defined residential blocks, interconnected vibrant axes, car-free zones organized through street organization and hierarchical division, varying street widths, continuous central green spaces, and block-specific green space designs to cater to different activity needs. As a final note, key insights are drawn primarily from the construction of non-motorized networks as well as mixed-use functions, residential blockage, and types of vibrant hubs.

Chapter 4 Quality-Improving Strategies for Pedestrian Environment in Old Communities

Unlike newly built communities that can be constructed according to established standards from the beginning to achieve the desired outcomes, old communities face physical and social challenges. Therefore, it is necessary to give full consideration to the characteristics of the old community and existing problems. Based on the two paths of reducing carbon sources and increasing carbon sinks, the design methodology of successful cases can be drawn upon and improved. Suitable strategies can then be proposed for the enhancement of the pedestrian environment in the old community (Figure 4-1).

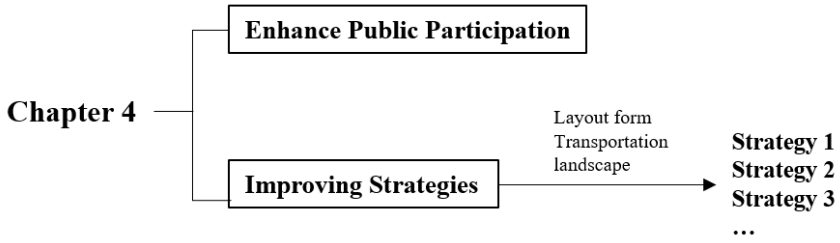


Figure 4-1 Framework of Chapter 4
(Source: Illustrated by the author)

4.1 Promoting Public Participation

The long-term users of old communities are the residents themselves. Facing old communities that have been built and used for a long time, the complexity of the environment is inevitable. Only those who have lived in the community for a long time will be able to truly understand the issues and their own needs. In reality, the process of improving and shaping the community environment is a collaborative effort involving community managers, designers, and community residents. Residents have a significant degree of control over this process. Public participation is the most efficient way to revitalize old communities, which establishes a clear sense of community identity. It is through extensive participation in the community regeneration process that residents are able to not only express their own desires and shape an environment suitable for themselves but also ignite a love for their residential

community (Figure 4-2).

Furthermore, to enhance public participation in the context of low-carbon transportation, it is important to improve relevant policies and institutional frameworks. Knowledge dissemination about low-carbon lifestyles, such as promoting low-carbon transportation, waste recycling, and water conservation, should be emphasized, along with the implementation of incentives. The development of walking as a habit will occur only when residents have the opportunity to experience the benefits of walking.

Accordingly, from the perspective of the designer, it may be beneficial to place mobile facilities as low-carbon stations in the community in order to provide residents with information about low-carbon living and the opportunity to exchange carbon credits for goods. For example, the government of Jiangbei New District in Nanjing has established 200 "Carbon Coin Exchange House" in residential areas, introducing the concept of "carbon credits." Within these houses, residents can experience low-carbon lifestyle activities through virtual reality, freely exchange items they no longer need, and use "carbon credits" to redeem essential goods or other services (Figure 4-3).

Figure 4-2 Public Participation Process

(Source: Reproduced from the website: https://www.researchgate.net/publication/339089996)

Figure 4-3 Nanjing Top Hill Street Carbon Coin Exchange House
(Source: https://www.163.com/dy/article/GV2DVPRC05349AL5.html)

4.2 Enhancing Strategies for Layout Form

4.2.1 Function Substitution and Supplementation

Community service functions can be divided into six categories based on their usage: education and research, medical and health care, commercial services, cultural and sports activities, finance and telecommunications, and administrative management. The more comprehensive the community service functions are, the more residents can meet their daily needs and the less external transportation is required. China's community service functions have been configured according to the "thousand-person index," which is a measuring standard used to assess the homogeneity of urban spaces. In spite of this, the improvement of living standards has resulted in more personalized needs, and the calculation of functional ratios based on the proportion of land area does not take human characteristics into account. Therefore, the functional configuration of the community should be further optimized in light of the five-minute- walk life circle in which the residents reside, taking into account their actual needs and diversified lifestyles.

As important landmarks, public buildings remain in the memories of residents of communities because of their functional characteristics. Due to development, operation, and disappearing needs, many of the public service buildings in current old communities are damaged or abandoned. In the regeneration of old communities, these damaged and idle buildings should be integrated and reused. Optimizing the layout and configuration of existing functions through functional replacement and supplementation can lead to the achievement of

functional mixing. This, in turn, brings about rich and diverse activity spaces and fosters strong emotional ties within the community.

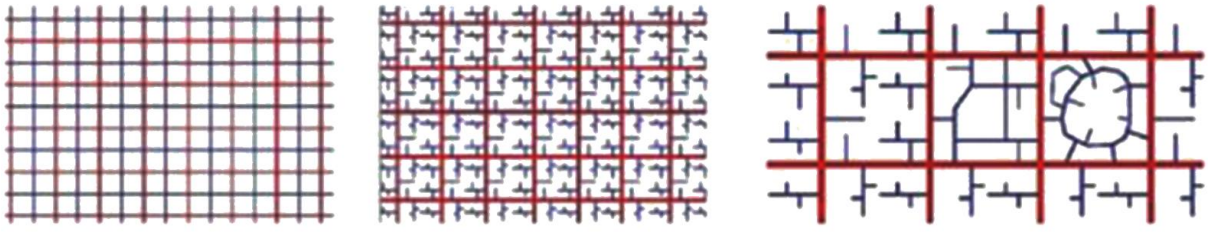
4.2.2 Open the Closed Boundary and Reorganize Living Blocks

There is a proposal in the 14th Five-Year Plan for 2021 to gradually open up the existing residential areas and large unit yards, and to make internal streets public, as well as to resolve the problem of traffic network layout. Traditional enclosed residential areas suppress residents' willingness to adopt walking due to their fully enclosed street network and tight boundaries. The public transportation system in larger settlements is often unavailable, and residents must walk up kilometers in order to reach the settlement gate by crossing an internal winding road from their household gate. The journey to the bus stop is cumbersome, and the cost of the trip is already more than the time spent getting from the household gate to the parking lot.

The scale of living blocks should be defined based on the scale of human activities: humans have a vision range of about 70-100 meters, so when a street length is between 70m and 200m, it can ensure that people and their activities in at least one direction can be seen when standing in the center of the street[59] (Figure 4-4). A community space at this scale has a high degree of permeability, and interactions between residents can be enhanced. Also, The distance of 70-200m is also suitable for walking and cycling (Figure 4-5).

Figure 4-4 Range of Vision for People

(Source: Illustrated by the author)



Pattern 1
suitable for walking with
scale of 70-100m

Pattern 2
suitable for cycling with
scale of 150-200m

Pattern 3
suitable for driving with
scale of 400-600m

Figure 4-5 Different Scale of Living Blocks

(Source: Xiao, 2006)

Figure 4-6 Reorganization of Living Blocks

(Source: Reproduced from Baidu Map)

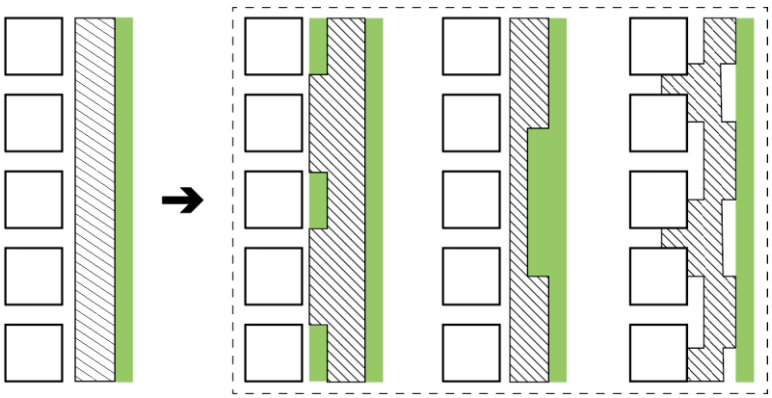


Figure 4-7 Improvement of Boundary Spaces

(Source: Illustrated by the author)

Most old communities, however, are divided into blocks according to the scope of their residential areas, with high walls or fences serving as boundaries, restricting other residents to the open spaces within the district that are reserved for residents of the interior. Therefore, the boundaries that were originally closed can be opened in an orderly manner, dividing them into smaller living blocks, providing residents with inward collective spaces while returning some street space to the community (Figure 4-6). Correspondingly, there should be a dense street network, a street space suitable for walking, orderly management, and a compact and mixed land development mode. Residents can only benefit from walking in this manner[49]. It is also possible to utilize the space at the boundary of small-scale dwellings to provide leisure, entertainment, and social activity spaces, allowing residents to spend more time in the open spaces and to develop a greater sense of belonging to the community (Figure 4-7).

4.2.3 Activating Vibrant Hubs

Vibrant hubs are the most crowded and frequently used open spaces in every community. The construction of vibrant hubs cannot rely solely on a single public space (such as a large square), but should be linked together through green spaces, squares, parks, and pedestrian walkways to provide carriers for various activities for residents and even attract residents from the outside to come for leisure and entertainment. Furthermore, there can be more than one vibrant hub within a community with different types and sizes (Figure 4-8).

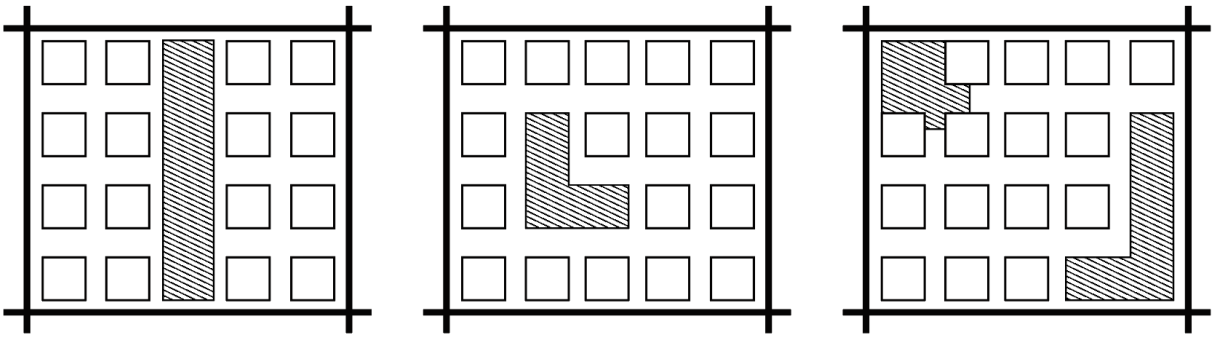


Figure 4-8 Vibrant Hubs

(Source: Illustrated by the author)

Usually, the open spaces that can attract crowds in old communities, such as green spaces and squares, are located within residential areas and are available exclusively to internal

residents for support services. Therefore, the vibrant spaces of the entire community have a dispersed layout. Since the number of cars owned by residents is rapidly increasing, the spatial configuration of old communities cannot sustain the demand for parking, and must encroach on open spaces in order to expand parking spaces. There has been a gradual decline in popularity of the original vibrant space in the community, the facilities have become aging and unmanned, and residents no longer consider the space to be a good place to engage in leisure activities. Therefore, it is necessary to use spatial regeneration methods to re-activate the vibrant of old communities. According to the distribution of community functions, the existing nodes of vibrant space can be grouped together to create a cohesive and open hub of vibrant activity. For example, combining green open spaces, waterfront spaces, and important commercial areas that run through the living block to build a vibrant district or vibrant axis.

Behavioral scientist Gehl proposed in Cities for People that "only places that people can reach can provide opportunities for choice and inspiration, so the number of opportunities for people to move from one place to another in a link becomes an important criterion for measuring a place's vibrancy". The isolation and fragmentation of open spaces makes it difficult to facilitate a wide variety of activities, which is why it is necessary to connect the scattered vibrant spaces with a vibrant hub to create a "linkage effect" which can create cohesion (Figure 4-9).

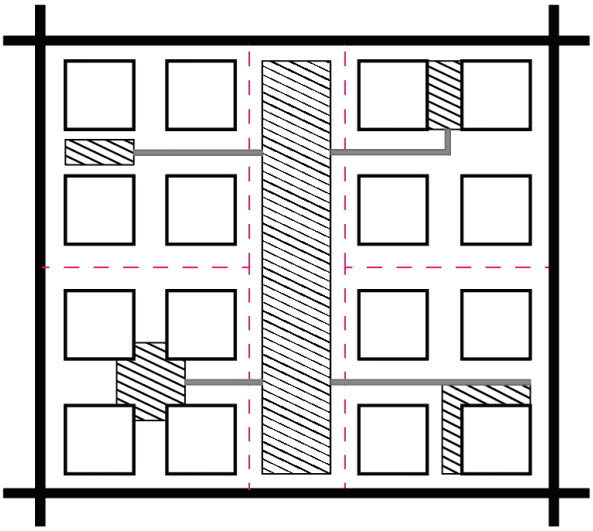


Figure 4-9 Network of Vibrant Hubs

(Source: Illustrated by the author)

4.2.4 Strengthening the Connection of Public Facility Spaces

Combining public facilities with different functions in an organic manner to form a compact and mixed space organization. Such facilities being in close proximity in compact communities lead to individuals walking up to two and half times more than those who live in sparse communities[74]. The layout of public facilities affects not only individuals' daily activity spaces, but also acts as the primary hub for residents' daily activities and travel, as well as a venue for communication between communities. Layout forms that are well designed can not only assist residents in meeting a wide range of travel needs in their daily activities, but they can also stimulate residents' desire to travel and extend their stay. Wu[75] found that when adopting a mixed layout, community residents have a higher preference for walking. She then proposed a large centralized, small decentralized mixed layout form (Figure 4-10).

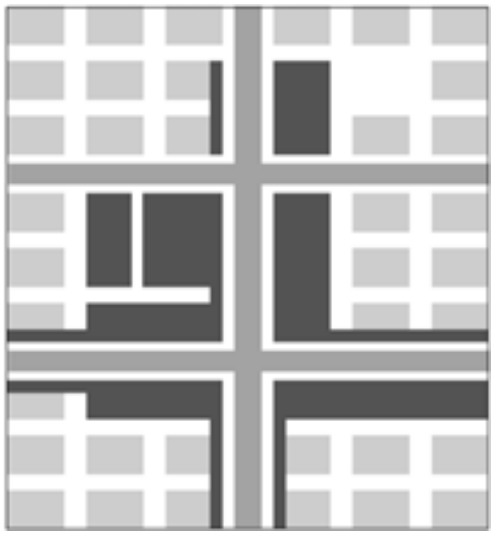


Figure 4-10 Mixed Layout of Public Facilities
(Source: Illustrated by the author)

However, there were some old communities that lacked overall planning at the beginning of construction. They had scattered public facilities, a chaotic layout, and a limited service scope that was difficult to provide for all residents. Considering the constraints on community land and the inability to provide sufficient space for new construction, it may be possible to initiate regeneration from the external space of existing public facilities, improve pedestrian environments, and establish a coherent route. Consider, for example, combining the gray space

of the ground floor stores to ensure a smooth pedestrian flow (Figure 4-11). Pedestrian zones can also be integrated with transportation hubs, commercial centers, public activity centers, and multi-functional all-weather three-dimensional pedestrian systems (Figure 4-12). As part of the overall design, the environment is designed to create a greater emphasis on the emotional needs of residents of the travel space at the same time as forming "safe, short distances, the smallest volume of physical consumption, and the highest utilization" of the interconnections.

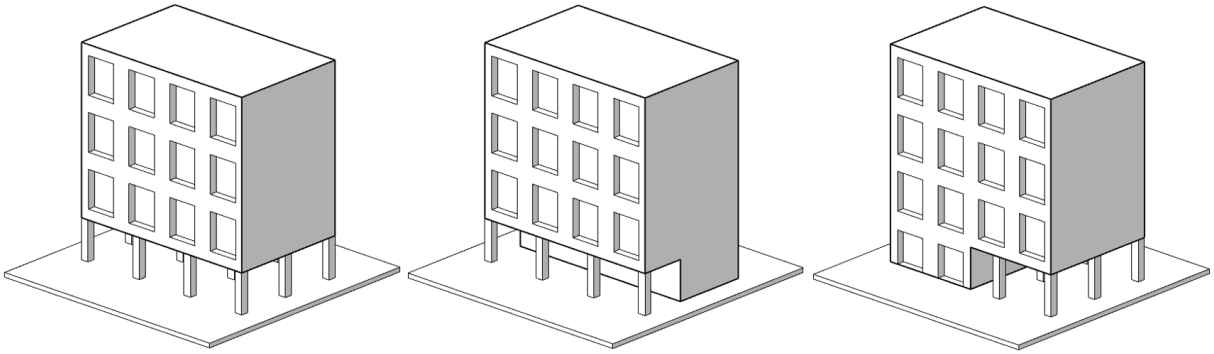


Figure 4-11 Open Ground Floor Spaces

(Source: Illustrated by the author)

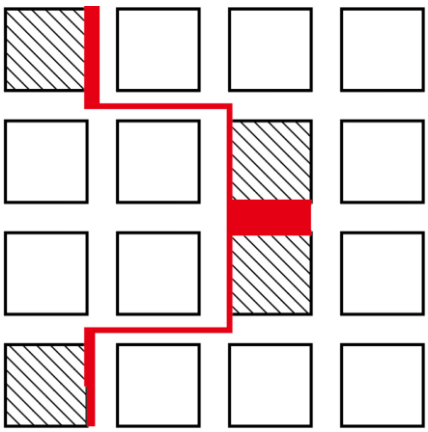


Figure 4-12 Second Floor Connection Between Scattered Public Facilities

(Source: Illustrated by the author)

4.3 Improving Strategies for Transportation

4.3.1 Improvement of the Organization of Non-motorized Networks

Walking is the primary means of transportation in old communities, and cycling is another major mode of transportation due to the proliferation of battery-operated vehicles in Guangzhou. The quality of walking environment in old communities should therefore not only be improved by considering the basic walking network, but also by adding the cycling network, so they can be connected with each other in order to create a more diverse and integrated slow transportation system. It is believed that a coherent and smooth street network not only enhances the sense of belonging and unity of the community, but also enhances the enjoyment of community life.

To establish a good non-motorized network in old communities, it is necessary to start with the overall improvement of the street system. The fundamental problem cannot be resolved if only a few pedestrian streets are regenerated in certain areas, but other community streets that are linked to these pedestrian streets are neglected. Hence, the first step should be to assess the existing street network in old communities, sort out the organizational patterns of various modes of transportation, and then determine the spatial sequence in which walking and cycling networks should be constructed based on the spatial layout of the community. Finally, a complete and interconnected walking and cycling network can be formed by increasing the density of the street network, extending dead-end streets, and establishing links with open spaces (Figure 4-13).

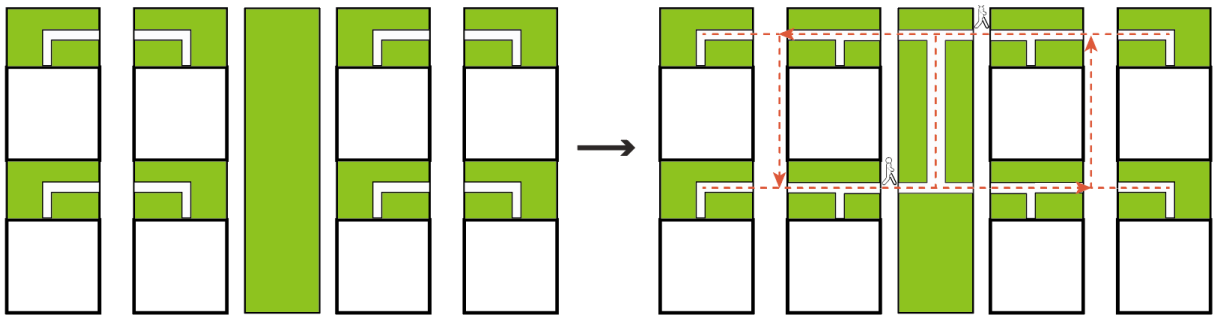


Figure 4-13 Complete Network of Walking and Cycling Paths

(Source: Illustrated by the author)

4.3.2 Sorting and Adjusting the Original Street Hierarchy System

It is important to note that enhancing walking and cycling networks does not mean excluding motor vehicle ways, but rather allocating street rights according to the priority given to pedestrians. The motor vehicle roads should yield to pedestrians and cyclists, but they should also have a continuous and complete network of streets. Therefore, it is necessary to summarize and sort the original street hierarchy, adjust the allocation of street rights by appropriately raising or lowering the level of certain streets, and ensure that various modes of transportation are harmoniously coexisting and connected in an orderly manner.

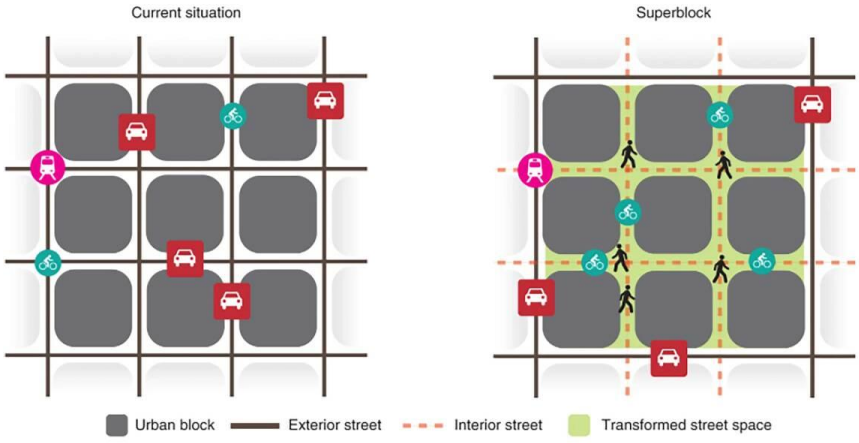


Figure 4-14 Superblocks Model

(Source: https://www.baulinks.de/webplugin/2022/0433.php4)

In 2015, the Barcelona Superblock project was launched, which involved combining existing city blocks into nine-grid patterns. In these superblocks, car-free zones were established, prohibiting motor vehicles from entering. Moreover, there were activities for children and opportunities for community interaction at the entrances of the internal streets (Figure 4-14).

Generally, the streets in old communities are divided into three levels: Trunk roads, community main streets, and residential alleys[76]. Most streets allow cars to pass through: trunk roads and community main streets are the primary motor vehicle routes, which are equipped with exclusive pedestrian walkways. Trunk roads provide connections to public transportation and internal streets within communities. Residential alleys are mostly mixed-use streets for pedestrians and vehicles. To promote walking and reduce residents' dependence on vehicle, the

street rights of residential alleys should be returned to pedestrians, and the use of cars on these streets should be restricted, which be realized by classifying the streets (Figure 4-15). Secondly, group streets should be added to community main streets and residential alleys as buffers between pedestrian walkways and motor vehicle ways, creating a "car-free environment" in living blocks and ensuring that residents' walking and cycling from residential alleys to urban streets are smooth and not threatened. Finally, the speed of vehicle traffic should decrease according to the street hierarchy.

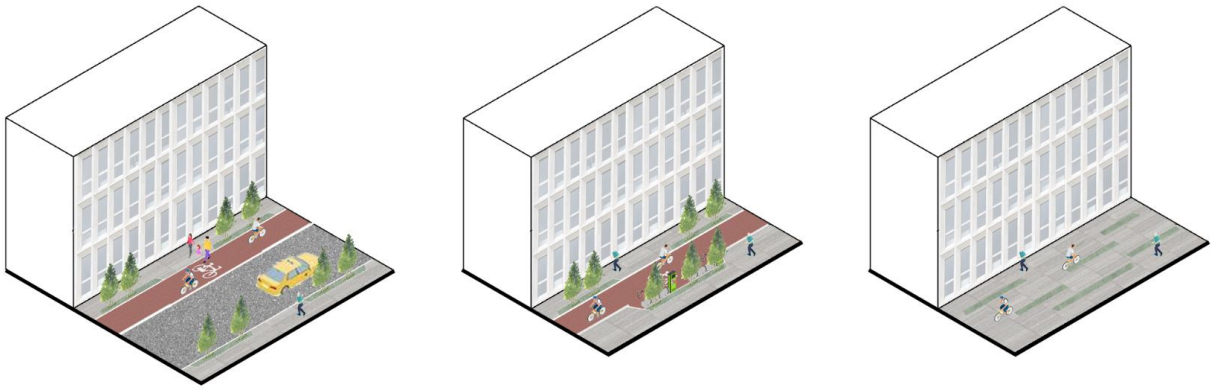


Figure 4-15 Classification Types of Streets

(Source: Illustrated by the author)

4.3.3 Relocating Parking Facilities from the Interior to the Periphery

From the moment residents step out of their building entrances, communities should pay attention to the impact of the environment on residents' travel choices. Seeing vehicles everywhere may subconsciously lead residents to believe that vehicles are the most appropriate mode of transportation for their community. Additionally, the widespread use of motor vehicles in the community results in certain environmental and traffic problems, making life and travel difficult for residents. Therefore, it is recommended that underground parking spaces, multi-story parking garages, as well as surface parking spaces be located on the outskirts of the community to minimize the demand for vehicle parking. If the distance between residential areas and parking lots is greater than or equal to the distance between residential areas and bus stops, residents are more likely to be able to walk (Figure 4-16).

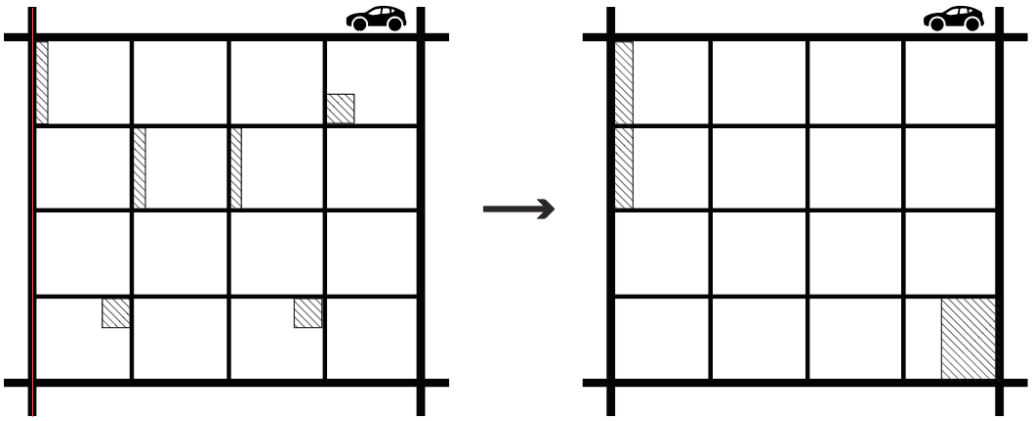


Figure 4-16 Moving Parking Spaces from Inside to Periphery

(Source: Illustrated by the author)

4.3.4 People-Oriented Design of Street Space

It is not uncommon for people living in old communities to feel a sense of dilapidation, rigidity, and dimness. Residents' travel experiences are adversely affected by the dull street environment and the view of the street ending in sight. Streets are not only used for transportation in the community, but also for interaction and recreation among residents. A pedestrian-friendly environment is a crucial prerequisite for residents to enjoy walking. Therefore, spatial changes in old communities are essential in order to increase the appeal of walking. Specific measures include:

(1) Street cross-section design should meet basic size requirements. The recommended sizes for different street components are 2m for pedestrian walkways, 2.5m for cycling paths, and 3.5m for motor vehicle ways[1]. However, when designing pedestrian walkways, it is important to go beyond the minimum width and facilities. Adequate lighting, shading, and street-level activities should also be incorporated to create a pleasant and comfortable environment for pedestrians.

(2) Make active use of curb extensions to create a dynamic space experience. Curb extensions can be continuous curb extensions and mid block curb extensions, which can slow traffic speeds and add public space. It can serve as a place where residents of a living block can communicate and a place where they can wait for their friends to arrive. To encourage residents

[1] *Code for Design of Urban Road Traffic Facility published* by Housing and urban construction department in 2019

to actively use bicycles, they can also become docking stations for bike sharing (Figure 4-17).

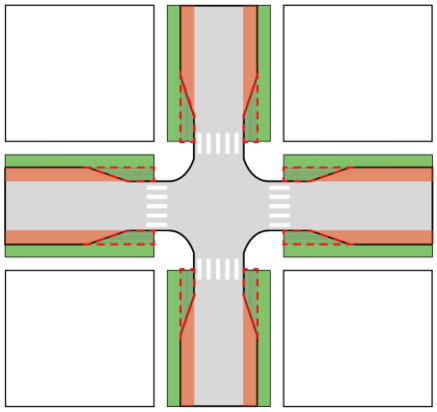


Figure 4-17 Curb Extension
(Source: Reproduced from *Urban Street Design Guide* published by National Association of City Transportation Officials)

(3) Residents may feel less safe walking across irregular intersections with chaotic traffic flow and low efficiency, such as acute and obtuse intersection corners. Thus, it is necessary to re-design such intersections, combine them with street squares to increase activity space for residents and alleviate traffic congestion (Figure 4-18).

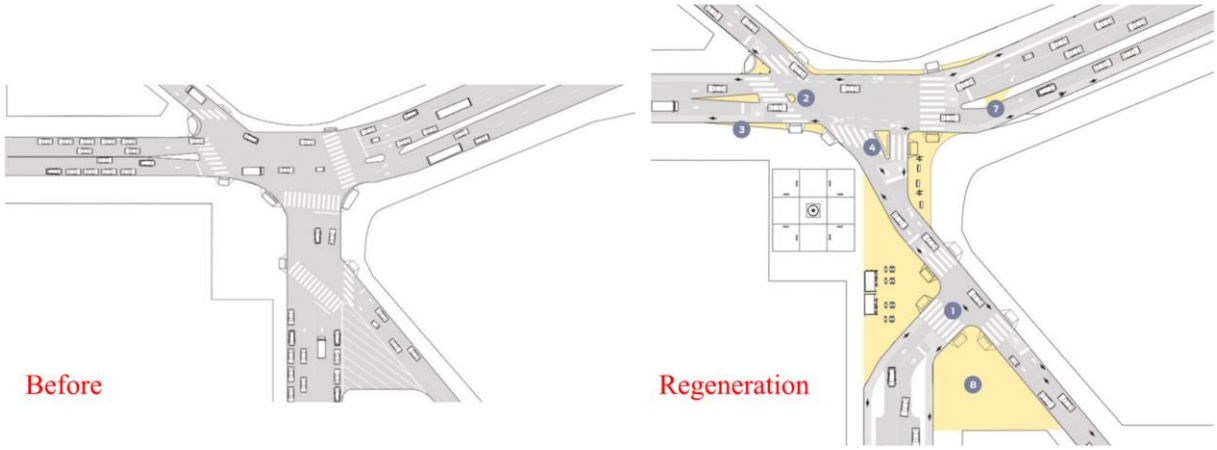


Figure 4-18 Improvement of Irregular Cross Section
(Source: National Association of City Transportation Officials, 2017)

(4) Utilizing corner spaces to create small playgrounds, living block parks, and resting areas to meet the needs of residents of different ages and various leisure activities. The street corner space contributes greatly to the creation of public space on the road since it is an outward-oriented public space that differs from the courtyard space in the community.

The Quanzhou Municipal Government has launched initiatives such as "Greening the Ancient City" to revitalize the old city. Through measures such as greening in every available space, removing walls to create green spaces, redesign dilapidated areas, and implementing three-dimensional greening, a series of small-scale green spaces and pocket parks have been constructed in the streets and alleys of the old city. Through these initiatives, the once monotonous and uninteresting travel environment has been transformed into one that is vibrant and lively (Figure 4-19).

There are typically several forms of existing street intersections and corner spaces in the scattered public spaces of old communities (Figure 4-20). Despite their relatively small size and complex surrounding environment, corner spaces are located in relatively open and public areas within the community. It is possible to optimize and redesign these spaces in conjunction with surrounding sites and architectural environments in order to increase their attraction to travelers by providing them with specific themes and functions.

Figure 4-19 Pocket Parks in the Old Town of Quanzhou
(Source: http://qz.fjsen.com/2019-09/11/content_22705643_all.htm)

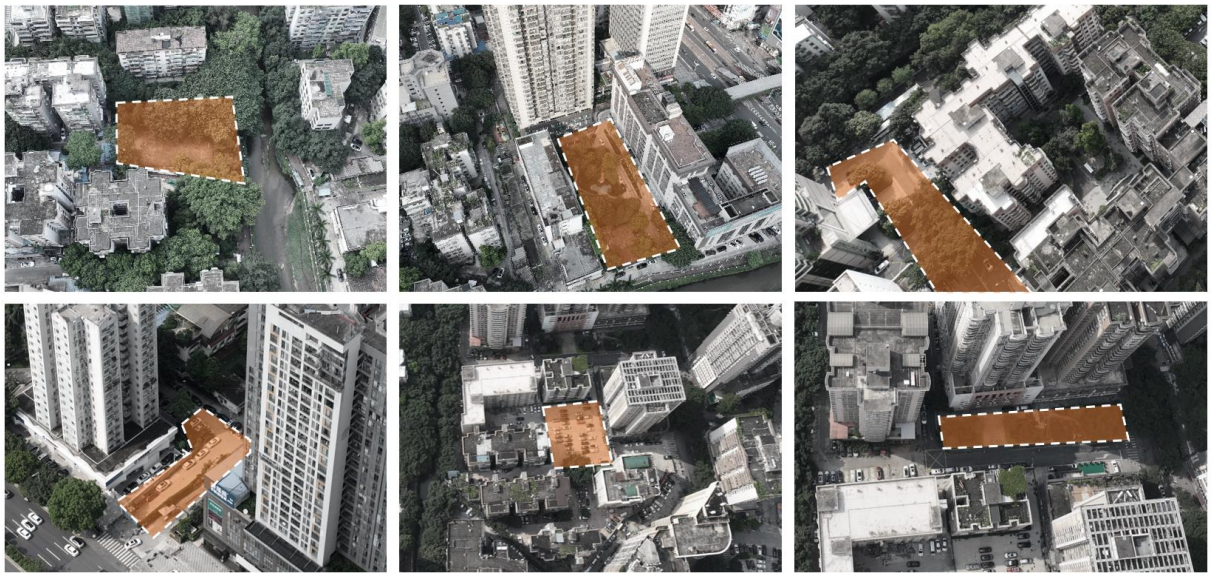


Figure 4-20 Places can be Used for Pocket Parks

(Source: Illustrated by the author)

4.4 Design Strategies for Landscape

4.4.1 Landscape Design Based on Community Characteristics

It is important to note that a good community landscape not only provides aesthetic enjoyment for residents, but also contributes to the identity of a community and becomes a landmark for the community as a whole. In addition, it can create a different living environment, enhance the attractiveness of the travel environment, and stimulate the desire for walking among residents. Through innovative design techniques, a better, healthier, and more interactive community can be created based on the characteristics of the community.

To achieve this goal, a deep understanding of the characteristics and needs of old communities is necessary, integrating community features and culture into landscape design. For instance, if the community contains historical buildings, natural ecological parks, and river systems, their spatial forms can be combined with design techniques such as variations in elevation, a mix of curves and straight lines, a balance between movement and stillness, and the interplay of virtual and real elements. Furthermore, the inclusion of diverse leisure and entertainment functions will result in a beautiful scenic route within the community that will serve as a distinctive community business card. As a result, not only will community residents utilize the space frequently, but other neighbors will also be attracted to experience the charm

of walking through this scenic environment.

In the Caoyang Xincun Community in Shanghai, there is an abandoned railway that has been revitalized and transformed into a fresh, multilevel, and mixed-use park. This linear space, which was once neglected, has been reprogrammed to create a walkable and community-centered green space for the neighborhood (Figure 4-21).

Located in the heart of San Francisco's South of Market District (SOMA), South Park is a public space that was first established in 1855 and has since served numerous local tech companies. After its latest renovation, it has been redesigned as a public place for visitors. By linking these points with a single path, the design forms a consistent linear promenade amongst colorful and drought-tolerant plants along the length of the park, while allowing for lateral crossings throughout (Figure 4-22).

Figure 4-21 Caoyang Xincun Community
(Source: https://www.gooood.cn)

Figure 4-22 Heart of SOMA
(Source: https://www.gooood.cn)

4.4.2 Vibrant Space Design and Facility Configuration to Meet Activity Needs

The main destinations for leisure and travel in the community are vibrant spaces. By overlaying cultural and entertainment activity sites with existing vibrant space nodes, the internal environment of the old community can be comprehensively improved and clearly defined. It is important to note that the addition of flexible activity spaces, the creation of rich cultural and entertainment activity scenes, and the organization of community cultural activities are all capable of helping residents maintain and optimize the environment of community.

Further, the elderly and children often constitute a significant portion of the population in old communities. Therefore, the design of vibrant spaces should also take into account the activity requirements of the elderly and children, including cultural, entertainment, and rest areas.

4.4.3 Rebuild the Enclosed Boundary

Considering the prevalence of physical fences in old communities, it is advisable to retain some separation between public and private spaces during the regeneration process. In this manner, a smooth flow can be achieved while maintaining a sense of privacy in some areas. It may be advantageous to consider retaining a degree of separation between public and private spaces during renovation. As pointed out by Jane Jacobs in "The Death and Life of Great American Cities," the boundary space in the street is the most popular because it provides favorable conditions for observing surrounding dynamics. By providing both a good view and some shelter, users are able to view multiple spaces simultaneously while maintaining an appropriate distance from others, thereby gaining a sense of comfort. People tend to spend more time on a street's boundary space since it provides a convenient place for them to rest. (Figure 4-23).

Figure 4-23 Physical Wall and Flexible Wall

(Source: Illustrated by the author)

4.4.4 Continuous Green Space Arrangement

Green space is an important component of community landscapes, which contributes to the overall quality of life in a community. By providing continuous green spaces, residents will

not only be able to interact with nature but will also be able to walk and cycle along the paths provided. However, old communities are influenced by social and economic development and planning concepts during the urban development period, and there is a low percentage of green space in old communities. The ratio of green space in old communities is typically below 25%, and most green patches are fragmented and poorly connected. A number of other phenomena, such as illegal construction and illegal parking, contribute to the degradation of the green spaces and streets of the community[77]. Therefore, it is necessary to improve the green space in old communities and reduce the degree of fragmentation.

According to several studies, trees can store 30 times more carbon than lawns, and shrubs can store six times more carbon than lawns for the same amount of green space[78]. Trees, shrubs, and other vegetation types that are highly efficient at sequestering carbon should be prioritized in the planting design of community green spaces. Ideally, there should be 50-70% of trees and shrubs in the green space coverage[79]. In order to provide residents with an opportunity to continue to enjoy their surroundings on their journeys, it is necessary to strengthen the association between different green spaces during the renewal, so that greenery can penetrate from the vitality center to the living groups, resulting in a highly interconnected greening network (Figure 4-24).

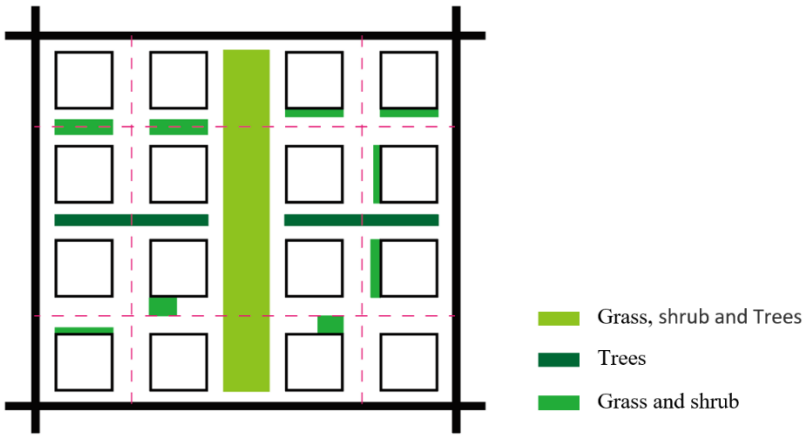


Figure 4-24 Continuous Green Spaces

(Source: Illustrated by the author)

4.5 Conclusion

In this chapter, the integration of key findings from previous case studies, an in-depth

analysis of the present condition of Shipai Creek Community on Tianhe North Road, Guangzhou, and a comprehensive review of existing renewal initiatives have culminated in the development of effective strategies aimed at improving the pedestrian environment.

Chapter 5 Shipai Creek Community in Guangzhou

Presented in this chapter are the findings of the field research conducted in the target community, Shipai Creek Community, located in Tianhe North Road, Guangzhou. Following the framework (Figure 5-1) for community construction summarized earlier, the current issues will be examined from three perspectives: layout, transportation, and landscape.

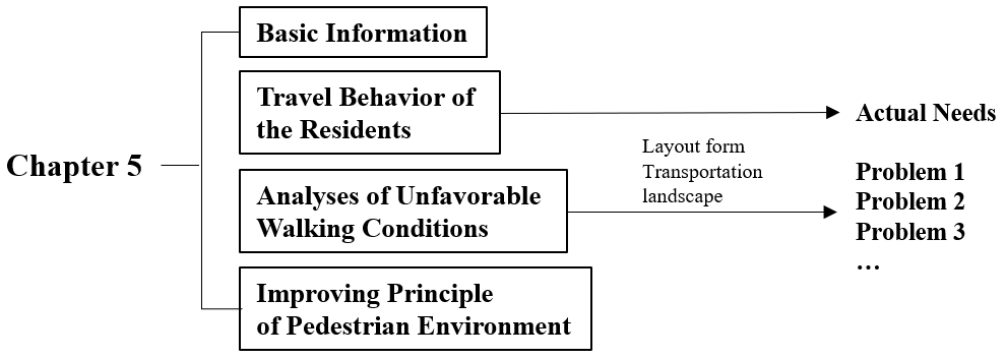


Figure 5-1 Framework of Chapter 5

(Source: Illustrated by the author)

5.1 Basic Information

(1) Location Analysis

Shipai Creek Community is located in Tianhe District, Guangdong Province, China (Figure 5-2), enclosed by Tianhe North Street, Tianhe East Street, Tianhe Street, and Longkou West Street, and belongs to the Peri-Wushan Innovation Area. Shipai Creek area is adjacent to Jintian Plaza (shopping center) in the north, Tianhe East Community in the south, Yakang Community in the west, and Longkou West Community in the east. In January 2023, the Guangzhou Housing and Construction Bureau stated that more than 100 existing communities would be renovated this year, and the overall planning and implementation plan for the "1+N" Peri-Wushan Innovation Area would be accelerated, aiming to create high-quality demonstration areas for the renovation of existing communities with "embroidery" craftsmanship.

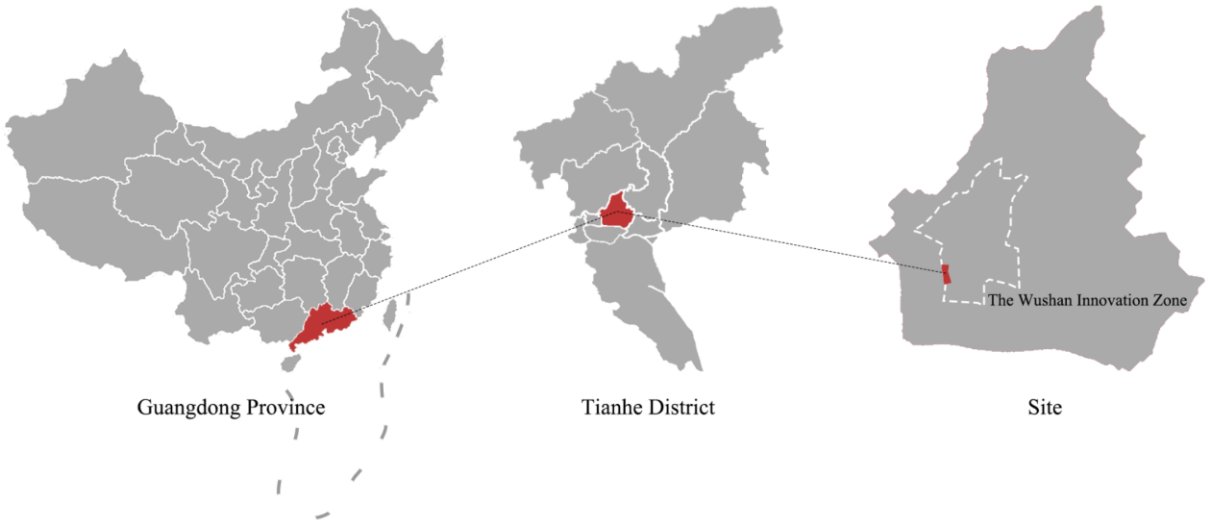


Figure 5-2 Location of the Site

(Source: Reproduced from Baidu Map)

(2) Creek Analysis

Shipai Creek is located in the center of the community. It originates from South China University of Technology in the north, connects to Liede Creek in the south, and merges into Zhujiang New Town (Figure 5-3).

Figure 5-3 Location of the Creek

(Source: Reproduced from Baidu Map)

With a total length of approximately 4.3m, its regional location is significant, as it is the

only creek that flows through the central business district of Zhujiang New Town in Tianhe District. The construction of the Creek's greenway serves six main functions: flood control and drainage, promotion of traditional culture, shaping the urban landscape, providing recreational spaces for citizens, climate regulation and air purification, and driving economic development in the surrounding areas of the Creek[80]. However, In the present, only a portion of Liede Creek near the central business district has a well-constructed greenway, while the rest of the Creek is only paved and planted with trees, failing to fully utilize the creek's potential. (Figure 5-4).

a. Liede Creek Source: http://slt.gd.gov.cn/gdwlbdjxs/content	b. Shipai Creek Source: Photographed by the author
	

Figure 5-4 Comparison Between Liede Creek and Shipai Creek
(Source: Compiled by the author)

(3) Status of the Existing Buildings

Shipai Creek Community covers an area of about 27 hectares, with a total of 75 buildings, including residential, commercial, and office properties (Figure 5-5). According to the survey, the age, usage status, and household population of all buildings in the community are shown in Table 5-1. Most of the buildings in the community were built between 1990s and the first five years of 21st century. Most of the residential districts are unit yards mainly with 7-9 story mid-to-high-rise buildings, still retaining closed interfaces and management systems. There are a considerable part of the public buildings unoccupied. Based on data from platforms such as Anjuke and Beike that provide real estate information services, 4,830 households are identified for different residential buildings. According to the household population ratio of Tianhe District in 2022, it is estimated that there are 9,747 people in Shipai Creek Community.

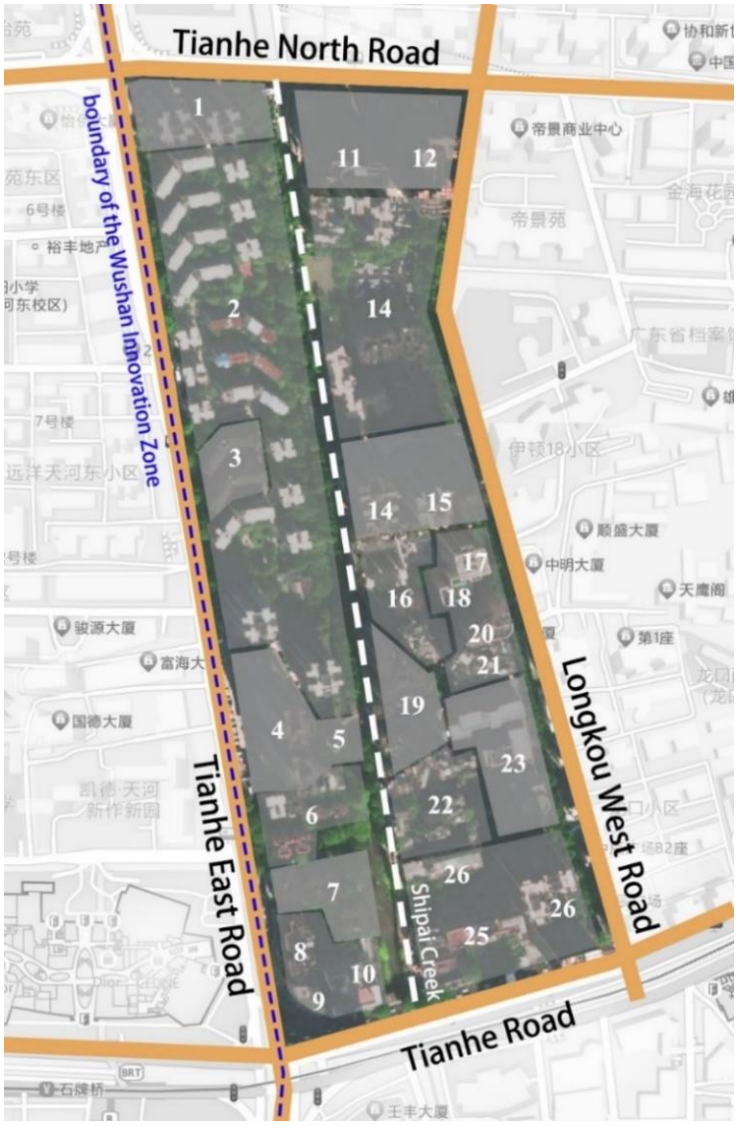


Figure 5-5 Architectural Arrangement

(Source: Reproduced from Baidu Map)

Table 5-1 Architecture Information in Shipai Creek Community

(Source: Compiled by the author based on Anjuke and Beike official websites)

NO	Name	Property	Floor	Finished Time	Status quo	Households
1	Tianxing Pavilion and Tianfeng Pavilion	Housing with ground floor stores	19	1995	Being used	256
2	Derong District	Housing with ground floor stores	6/8/18	1995	Some are unoccupied	1100
3	Guangzhou High tech Entrepreneurship	Office	8	2001	Being used	-
4	Jiabao Huating	Housing with ground floor stores	29	2008	Being used	360

Table 4-1 Architecture Information in Shipai Creek Community (Continued)

5	Tower A, Tianxin Building	Office	18	1997	Unoccupied	-
6	Tianhe East Street District	Housing	10	1994	Being used	875
7	Television Station District	Housing	8	1998	Being used	192
8	Shipai Hotel	Hotel with ground floor stores	8	1991	Being used	-
9	Building 168	Commercial building	8	1991	Unoccupied	-
10	China Telecom Corporation Limited	Office	6	-	Unoccupied	-
11	Grand International Hotel	Hotel with ground floor stores	20	2004	Being used	-
12	Hillton Sunshine	Housing	31	2002	Being used	264
13	Longkou Garden	Housing with ground floor stores	9	2002	Being used	471
14	Commodity Inspection Dormitory	Housing with ground floor officce	30	1997	Being used	175
15	Julong Pavilion	Housing with ground floor stores	30	1999	Being used	236
16	Tianhe Border Defense Longkou West Living Area	Housing	9	-	Being used	261
17	Paco Hotel	Hotel with ground floor stores	16	2006	Being used	-
18	Huayu Plaza	Commercial building	9	-	Unoccupied	-
19	Sage Pavilion	Office	9/22	1995	Some are unoccupied	-
20	Tower B of Tianxin Building	Office	18	2000	Unoccupied	-
21	Tianhe District Maternal and Child Health Hospital	Hospital	8	1986	Being used	-
22	Longkou West Street District	Housing	8	1993	Some are unoccupied	295
23	Tianhe District People's Procuratorate	Government building	8	1985	Being used	-
24	Dongteng Decoration Engineering Co., Ltd	Office	6	-	Being used	-
25	Guangdong Huaxing Bank	Ofice	10	2017	Being used	-
26	Poly Zhongchen Plaza	Housing and office	27	2010	Being used	345

5.2 Survey of Travel Behaviors

To investigate how Shipai Creek Community residents travel on a daily basis, questionnaires and interviews were utilized. Daily travel was categorized into commuting travel, utilitarian travel, and leisure travel. The transportation modes included walking, bicycle, e-bike, buses, metro, and private vehicles. A total of 30 individuals were surveyed with statistical results shown in figure 5-6 and responses shown in figure 5-7.

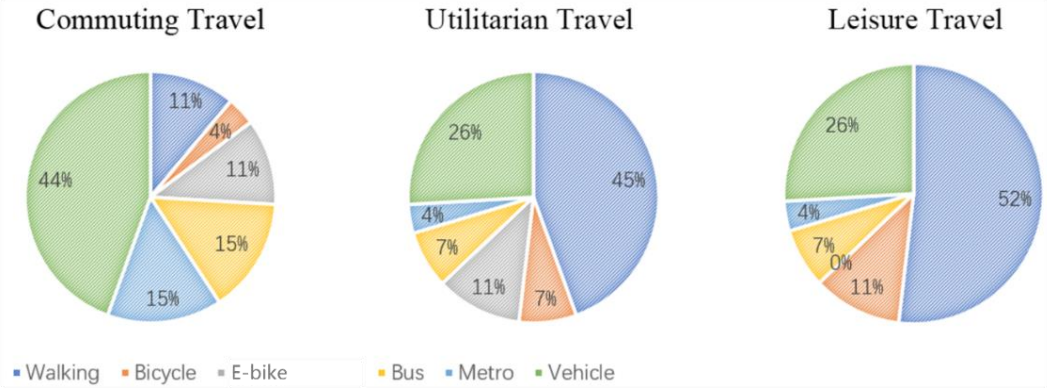


Figure 5-6 Choices of Travel Mode

(Source: Illustrated by the author)

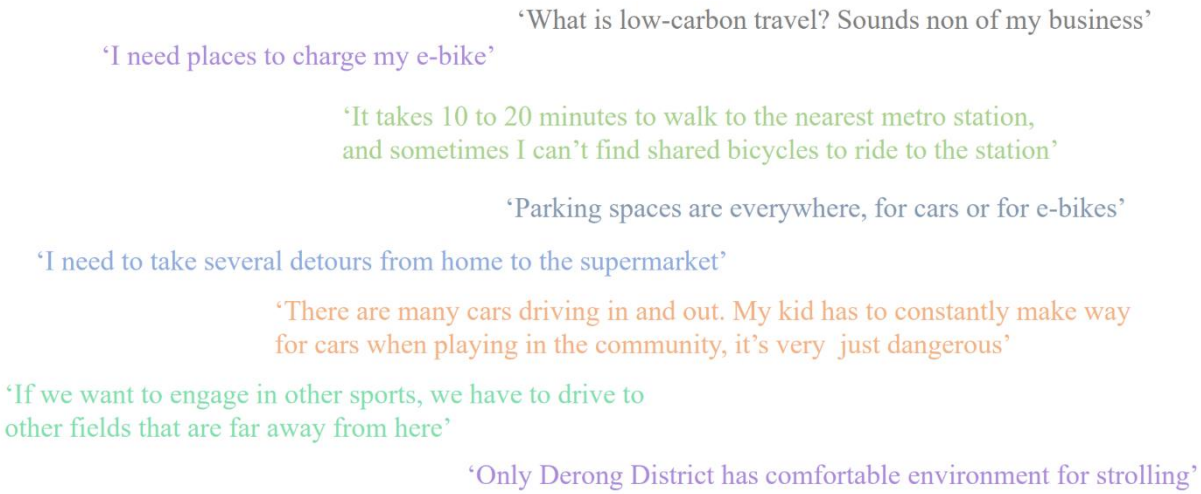


Figure 5-7 Responses from Residents

(Source: Illustrated by the author)

For commuting travel, the survey reveals that private vehicles are the most widely used mode of transportation for commuting purposes in the old community, accounting for a

substantial 44% of respondents. Walking, bicycle usage, and e-bike and transportation collectively represent 41%, indicating some preference for low-carbon travel.

Most residents consider private vehicles to be the most convenient mode of transportation for commuting, primarily due to long distances. Additionally, residents mentioned that it takes them 10 to 20 minutes to walk to the nearest metro station, and sometimes they are unable to find shared bicycles to ride to the station. E-bike also face challenges in supporting commuting travel, as there are limited parking spaces with charging facilities in the community. In most cases, residents have to extend power cables from their homes to charge their e-bike downstairs.

For utilitarian travel, walking emerges as the most prevalent mode of transportation, chosen by 45% of respondents. E-bike and buses are also used to a considerable extent, with 11% and 7% respectively. Private vehicles constitute 26% of the utilitarian travel modes, indicating a significant reliance on personal cars for daily errands and tasks. Bicycles and metro are utilized by smaller proportions of the community for utilitarian travel, with 7% and 4% respectively.

Residents who choose to travel by vehicle mentioned that they need to go through several detours between their houses and the supermarkets. When they have significant shopping needs or need to purchase many items, walking becomes tiring, and cycling is perceived as risky. Therefore, they prefer driving as a more convenient option in such situations.

In terms of leisure travel, walking is the predominant mode, chosen by a majority of respondents at 52%. Bicycles also have a significant presence with 11%. Notably, e-bike do not appear to be utilized for leisure activities, representing 0% of the travel modes. Bus and metro are used by 7% and 4% of the community respectively, while private vehicles constitute 26% of the leisure travel modes.

Residents expressed dissatisfaction with the lack of community activity spaces. A mother with children mentioned, "The parking lots in the community are always full, and my kids have to constantly make way just to kick a ball." Sports enthusiasts among working professionals stated, "There are too few basketball courts in the community, and they are mostly occupied by young people," and "If we want to engage in other sports, we have to drive to other fields that are far away from here." Furthermore, it was discovered that many residents from other neighborhoods often come to Derong District for walks, stating that it offers the best pedestrian

environment in the vicinity.

During the interviews, it was also noted that there is a lack of knowledge dissemination regarding sustainable and low-carbon lifestyle behaviors in the community. Although there are waste sorting stations in the community, they are merely symbolic, and most residents have vague and uncertain understanding of the concept of low-carbon transportation. They generally believe that they can contribute very little to the construction of a low-carbon community on an individual level.

5.3 Current Problem Analysis

5.3.1 Layout Form Analysis

(1) Morphology

Overall, Shipai Creek Community is divided into two plots by Shipai Creek, which runs through the middle. A variety of building forms and combinations are found on each plot, including slab buildings, tower buildings, row buildings, and enclosed buildings. Comparatively, the western plot presents a relatively uniform morphology, while the eastern plot exhibits a more dense and uneven pattern. Longkou Garden in the north occupies a spacious area with ample space, while the Longkou West Street community in the south is squeezed in between surrounding buildings like a needle in a haystack. The variety of building forms creates rich forms in the public spaces enclosed by the buildings, which makes it possible to expand later renewal strategies (Figure 5-8).

a. Figure-Ground Organization (Source: Illustrated by the author)	b. Aerial View of Architecture (Source: Photographed by the author)

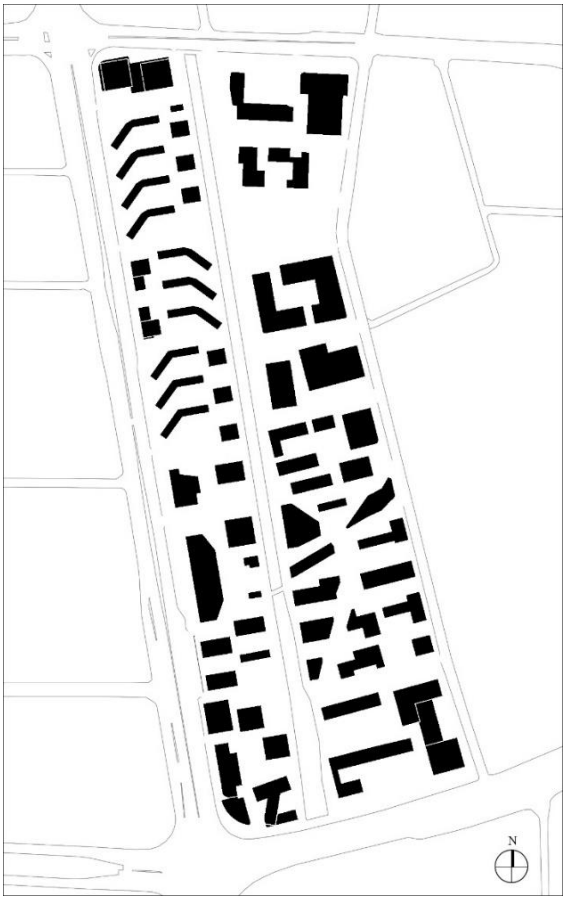


Figure 5-8 Morphology of Shipai Creek Community
(Source: Compiled by the author)

(2) The Distribution of Functions

Based on field research and Baidu Map POI data, the existing distribution ratio of functions is shown in figure 5-9. It can be seen that the main functions of the community are commerce and catering, with a smaller proportion of cultural, educational, and sports functions. In addition to the mixed arrangement of functions in commercial and residential office buildings, the rest are mostly mixed arrangements of residential buildings with ground floor stores (Figure 5-10). However, many ground floor stores only face internal residents and have a low usage rate (Figure 5-11).

Figure 5-10 Mixed-Use Buildings
(Source: Illustrated by the author)

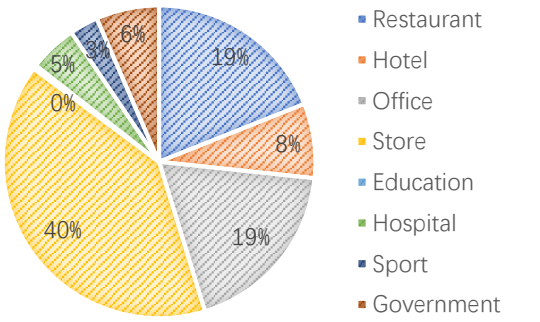


Figure 5-9 Distribution Ratio of Functions
(Source: Illustrated by the author)

Figure 5-11 Ground Floor Stores
(Source: Illustrated by the author)

(3) The Distribution of Public Facilities

The distribution of public facilities in the community is relatively dispersed. In the west plot, there are mainly residential buildings, with Derong District being interrupted by two office buildings, and the public facilities on the south side of the plot serving as a buffer between residential buildings and noisy streets. In the east plot, the distribution of public facilities and residential buildings is more scattered, and the internal boundaries are fragmented. Longkou West Road, for instance, is surrounded on all sides by office and government agency buildings, with two one-story bicycle parking facilities located in the middle which completely cut off the community. Also, the different service facilities are only connected by ground-level traffic, which isolates them from one another. For instance, residents who live in the west must bypass the community and cross Shibai Creek from the outer ring to reach the commercial area in the east. Similar facilities are located at a distance from one another, such as commercial buildings

that are not adjacent to one another, making them incompatible for mutual promotion (Figure 5-12).

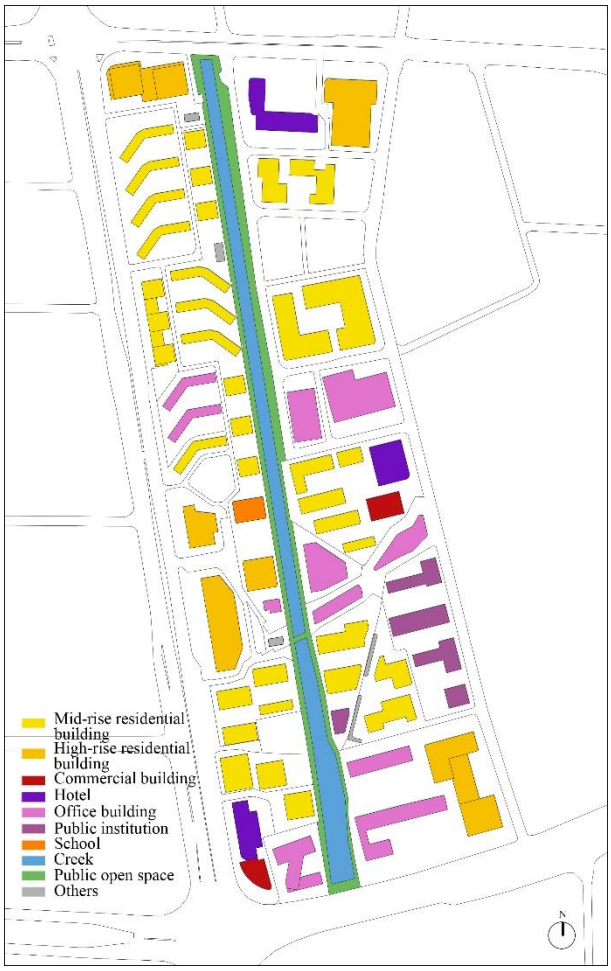


Figure 5-12 Function Analysis
(Source: Illustrated by the author)

(4) Accessibility of Public Facilities and Bus Station

The concept of spatial syntax was introduced by British scholar Bill Hillier in the 1970s and has now developed into a comprehensive theoretical framework and specialized software technology for analyzing spatial relationships. The fundamental principle of spatial syntax is to divide and segment the space. Axial Analysis, one of the methods for spatial segmentation, involves dividing the entire spatial system using the longest and fewest possible straight lines. This approach is commonly applied to the segmentation of linear open spaces and is frequently used in urban research[81].

Based on the current situation of Shipai Creek Community, spatial syntax axial maps and visibility obstruction maps were created and imported into the DepthMap software platform to calculate integration values and depth values. Integration value reflects the degree of aggregation or dispersion of a spatial unit with respect to all other spaces in the system. A higher integration value indicates better accessibility and permeability of the spatial unit. Integration value represents the spatial accessibility and measures the potential of a space to attract traffic.

(1) Axial integration value: The highest integration value is 2.09, the lowest value is 0.47, and the average value is 1.14. The areas with higher integration values are the peripheral streets of Shipai Creek Community, with the western main street having the highest integration value and the eastern urban side street having the lowest. The integration values within the community are relatively lower compared to the periphery, with higher integration along the Shipai Creek and lower integration along other community streets, which makes it less convenient to access various public facilities. Among the four surrounding bus stops in the community, Bus Stop 1 and Bus Stop 2 are located in areas with higher integration values, indicating higher accessibility based on spatial structural features and theoretically higher usage frequency. Bus Stop 3 and Bus Stop 4 are located in areas with lower integration values, indicating relatively lower accessibility and lower usage frequency (Figure 5-13).

(2) Axial depth value: The maximum depth value is 12.02, the minimum value is 3.47, and the average value is 5.80. Overall, the side of public facilities facing the surrounding streets in the community has lower depth values, indicating greater convenience in terms of spatial access. However, the side facing the internal streets of the community has higher depth values, indicating lower convenience in terms of spatial access. For example, the central-eastern part of the community shows significant differences in depth values on both sides of the public facilities. The depth values of the four bus stops are generally low, indicating convenient travel, with Bus Stop 1 and Bus Stop 2 having higher levels of convenience (Figure 5-14).

Figure 5-13 Axial Integration
(Source: Illustrated by the author)

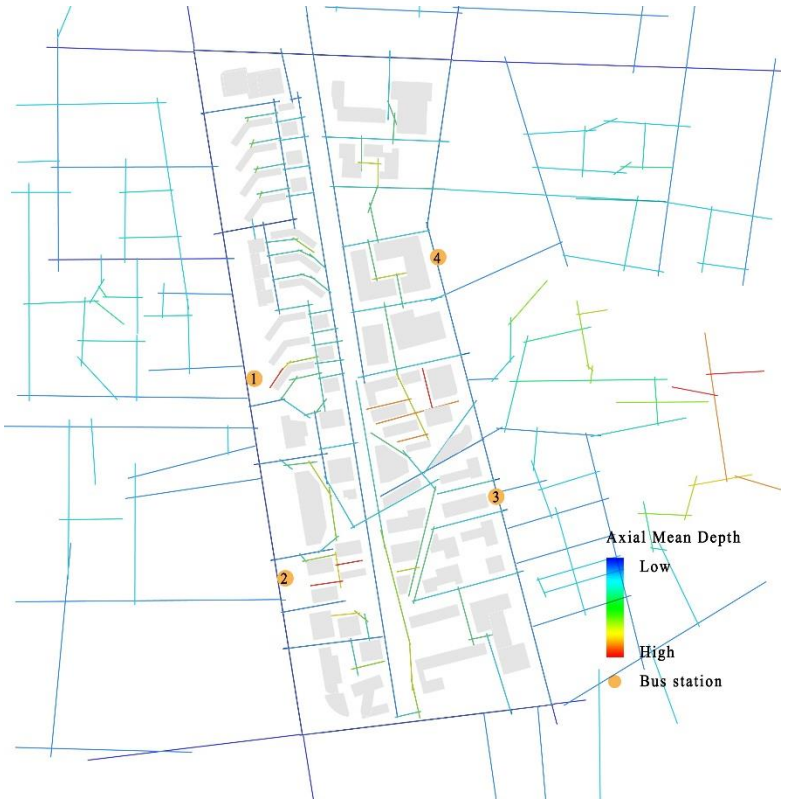


Figure 5-14 Axial Mean Depth
(Source: Illustrated by the author)

(5) Characteristics of Living Blocks

Due to historical and cultural reasons, large-scale enclosed living blocks are common in the old city of Guangzhou. These "urban islands" are mostly "unit compounds" produced during the planned economy era. In addition, many modern communities are implementing closed access control systems in order to meet their traditional security awareness and self-protection requirements. Shibai Creek Community has no exception, with disorderly internal living block divisions, separated by fences and walls (Figure 5-15).

This disorderly internal division method brings troubles to residents' walking behaviors:

① The lack of clear road positioning creates confusion for residents, impeding their ability to navigate and find their way around effectively.

② There is a limited range of walking for residents; they are only permitted to walking within the enclosed area, and if they wish to go to other parts of the community, they must first traverse their current block.

③ Certain ground floor stores within the residential complex exclusively cater to its residents, but due to low foot traffic and inadequate profits, these businesses struggle to sustain themselves. As a result, the store environments deteriorate, and some may even be forced to shut down. Consequently, residents are compelled to seek goods from more distant shops to meet their needs.

④ Over time, neighborhood relationships start to drift apart, and while the enclosed community appears to encourage communication among residents, the truth is that large-scale enclosed spaces actually lead to a disconnect between neighbors. As the distance between buildings increases, residents' sense of space diminishes, making the environment less intimate and affecting their willingness to socialize.

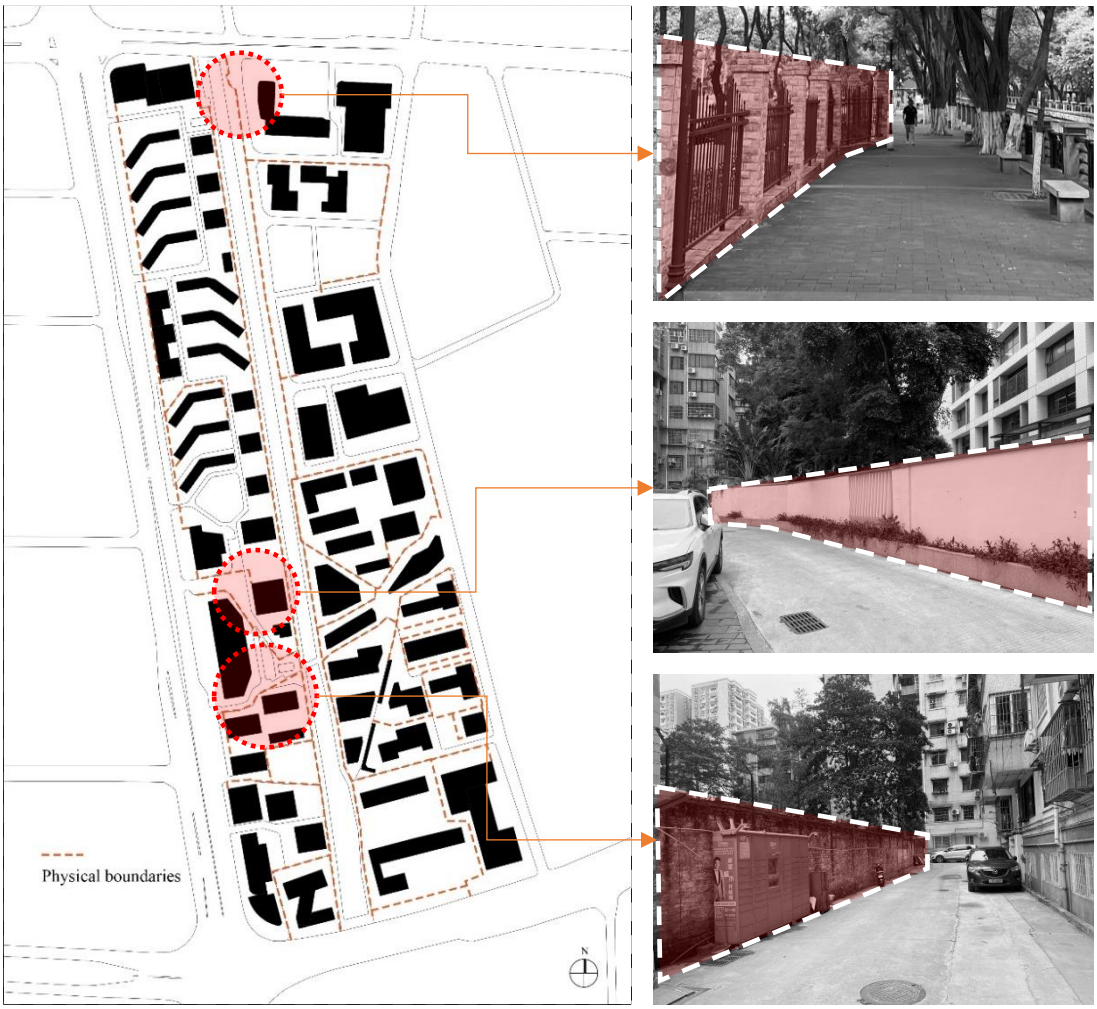


Figure 5-15 Physical Boundaries of Living Blocks

(Source: Illustrated by the author)

(6) The Distribution of Community Vibrant

According to the pedestrian flow situation reflected by Baidu Heat Map (Figure 5-16), the areas with higher pedestrian flow in Shibai Creek Community are distributed at the periphery of the community. The two gathering points on both sides of Tianhe North Street, the gathering area in the middle of Longkou West Street, and the gathering area on Tianhe Street are all affected by ground floor stores and surrounding commercial facilities (such as Taikoo Hui on Tianhe East Street). In contrast, the pedestrian flow inside the community is relatively low, indicating poor spatial vitality.

This situation arises due to numerous closed partitions within the community, which hinder the connection between residents and their surroundings as well as among residents themselves.

Consequently, the spatial vitality becomes unbalanced and overall diminishes. As a result, the lackluster and less vibrant environment fails to attract residents as a leisure destination, pushing them to commute to more distant but more appealing leisure venues.

Figure 5-16 Distribution of People Flow

(Source: Baidu Map APP)

5.3.2 Transportation Analysis

(1) Street Network Organization

The community Street Pattern is a typical combination of dead-end streets and looped streets (Figure 5-17). One end of the dead-end street is connected to motor vehicle ways, and the other end is connected to the building, but some are connected to impassable sites (such as green spaces, walls, etc.), forming the real dead ends. The street network organization suffers from a lack of clarity, with pedestrian walkways and motor vehicle ways arranged haphazardly and in an alternating manner. As a result, pedestrian flow is disrupted and frequently interrupted. In addition, due to the impassability of the internal boundaries, the internal street's ability to

connect with bus stops is reduced. In large and irregular living blocks, residents need to walk a distance to the entrance and exit of the group, and then cross the entire community along the right-angled route to reach bus stations.

a. Street Organization (Source: Baidu Map)	b. Figure-Ground Organization (Source: Illustrated by the author)

Figure 5-17 Street Pattern of Shipai Creek Community
(Source: Compiled by the author)

(2) Classification of Streets

There are four levels of the streets: trunk roads connected to the city, with vehicle speed limits of 40-60 km/h; branch streets adjacent to the eastern community, with vehicle speed limits of 30 km/h; block streets crossing living blocks, with vehicle speed limits of 5 km/h; and park ways crossing Shipai Creek, allowing only pedestrians to pass (Figure 5-18).

By analyzing the level division, it becomes evident that the block streets have the highest penetration rate within the community. Cars can easily traverse the living spaces, making them

the preferred mode of transportation for residents.

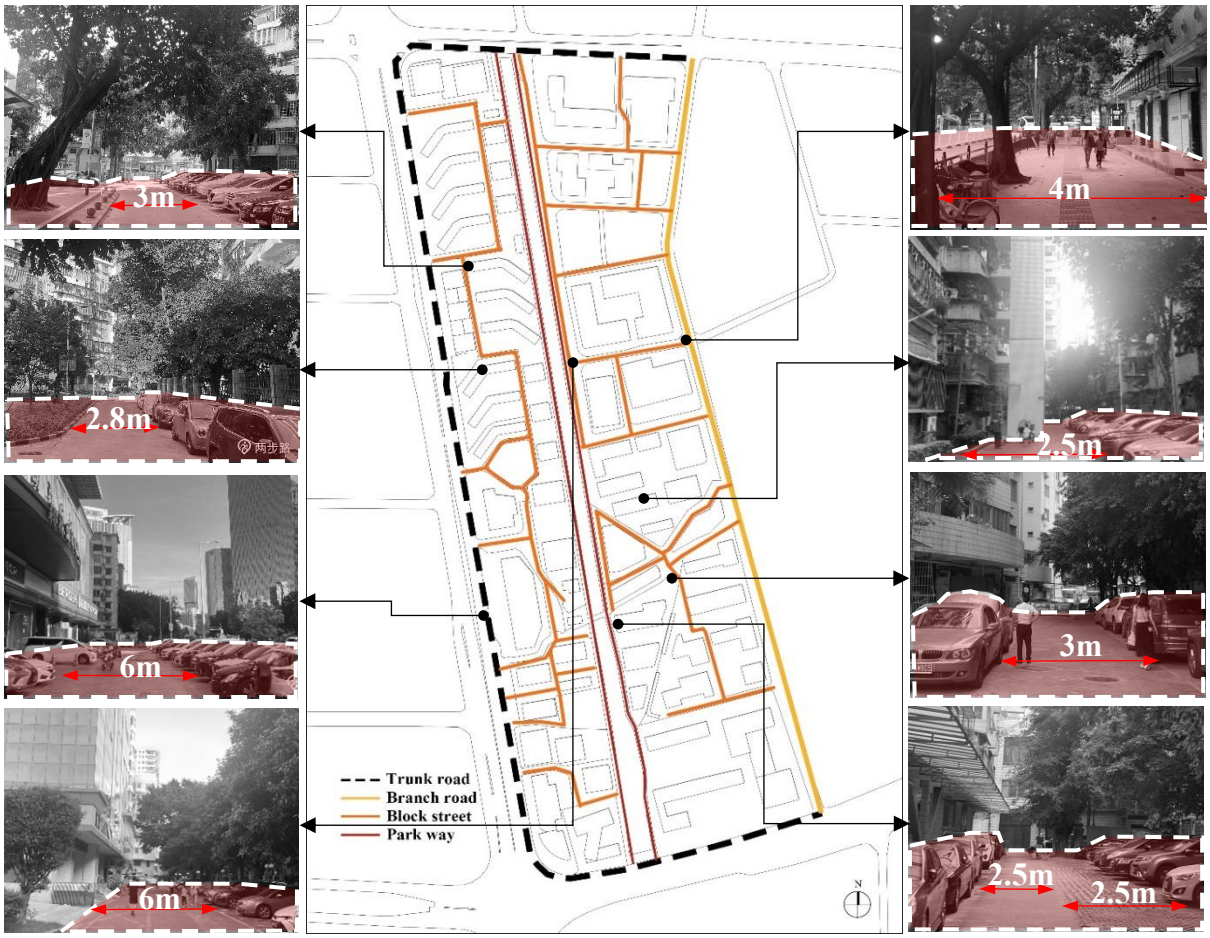


Figure 5-18 Classification and the Status of Streets

(Source: Illustrated by the author)

(3) Evaluation of the Street Space

In general, the community streets are predominantly designed with a focus on accommodating vehicles, while the potential of street space for residents' walking is underutilized. The streets serve primarily as transportation routes, with limited consideration for social activities, recreation, and other essential living functions. Addressing this issue is of utmost importance. Specifically, there are the following shortcomings:

① Parking spaces seem to be omnipresent within the community, occupying motor vehicle ways, green spaces, squares, and even pedestrian walkways, directly interrupting pedestrian flows. ② The community overlooks the needs of cyclists in its design. While bicycles and cars are expected to share motor vehicle ways, the high volume of motor vehicles often forces

pedestrians and cyclists to yield to cars. Additionally, there is a shortage of bicycle parking spaces, leading residents to occupy public spaces for parking. Moreover, some residents resort to pulling electric wires from their homes to charge their e-bikes, posing substantial safety hazards. ③ Certain living block boundary divisions focus solely on enclosure, resulting in numerous sharp-angle spaces (Figure 5-19).

a. Plan of Parking spaces (Source: Illustrated by the author)	b. Photo of Parking spaces (Source: Photographed by the author)

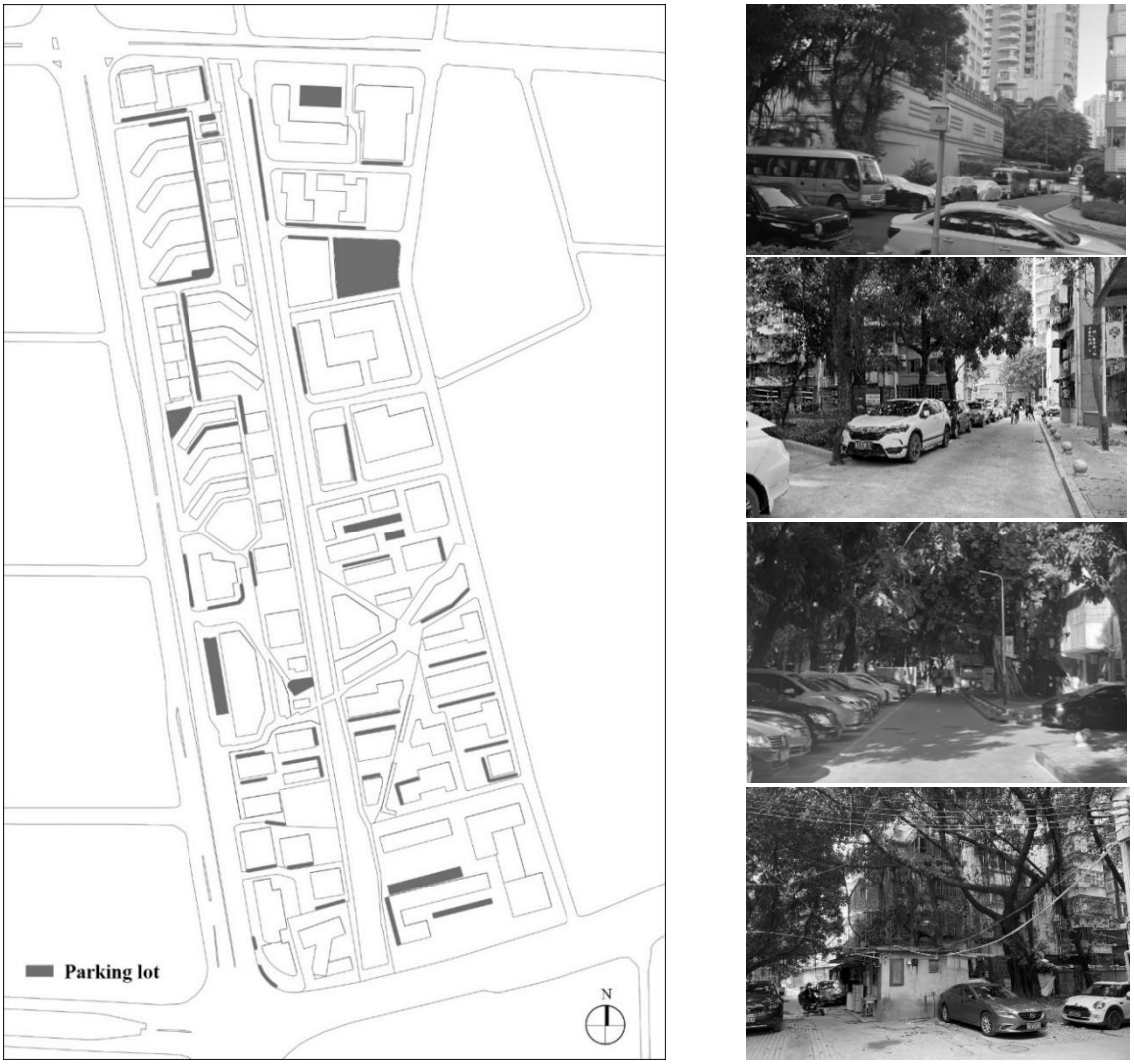


Figure 5-19 Spread of Parking Spaces
(Source: Compiled by the author)

By drawing street cross-sections, further observation can be made to determine whether the street space is conducive to walking (Figure 5-20 and Figure 5-21).

Figure 5-20 Street Cross-Sections Before Improvement of the West Plot

(Source: Illustrated by the author)

Figure 5-21 Street Cross-Sections Before Improvement of the East Plot

(Source: Illustrated by the author)

5.3.3 Landscape Analysis

(1) The Distribution of Green Spaces

Green spaces distribution is determined based on the findings of a physical survey (Figure 5-22). Overall, the green area in comparison to the entire site is relatively small, and the distribution of green spaces in the east and west sections of the community is uneven. There is a significant variation in the green environment among different living blocks. The western plot has a higher concentration of green spaces, particularly in the Derong District. As a contrast, in the eastern section, the green spaces are mainly concentrated in Longkou Garden, whereas the rest of living blocks have scattered green spaces. Moreover, there is a limited amount of wooded road coverage, with only Shipai Creek and the eastern portion of Longkou West Road offering pedestrians some relief from the scorching summer (Figure 5-23).

Figure 5-22 Plan of Green Spaces
(Source: Illustrated by the author)

Figure 5-23 Plan of Wooded Roads
(Source: Illustrated by the author)

(2) Evaluation of the Design of Landscape

In residential areas, the green spaces predominantly feature a combination of flower beds, flower borders, and street trees, resulting in simple functional arrangements. While there are ample green spaces, community participation remains low. For instance, in Derong District, a substantial public area is occupied by green space, but its form hinders its effectiveness as an activity space. The arrangement of flower beds and flower borders separates the green landscape from residents, serving primarily as ornamental plants. As a result, it fails to encourage residents to engage with the natural environment or interact with the community. The low-participation landscape design indirectly diminishes opportunities for residents to interact with the community environment and discourages them from utilizing and staying in the space.

In areas outside residential communities, most landscape space designs also do not consider the actual travel needs of residents (Figure 5-24). As an illustration, in large open spaces, green vegetation is haphazardly placed, causing difficulty for residents to establish their location and direction of travel. On the crucial landscape axis, the Shipai Creek promenade, the design consists of only two rows of street trees, resulting in a monotonous and uninteresting view. This lack of visual appeal fails to attract both residents within the community and visitors from outside.

Figure 5-24 Design of Landscape
(Source: Photographed by the author)

(3) Evaluation of the Vibrant Spaces

The distribution of residents' behavioral activities and vibrant spaces in the community is shown in the figure 5-25， with the following characteristics:

Figure 5-25 Distribution of Vibrant Spaces

(Source: Illustrated by the author)

① The main activities of residents include: walking, chatting, dog walking, equipment exercise, ball sports, jogging, sitting idly, playing chess, parent-child interaction, and shopping. Among them, equipment exercise, ball sports, parent-child interaction, and shopping take place in specific public spaces (such as community parks, community squares, etc.), while the remaining activities can take place in any space within the community (such as streets, around buildings, etc.).

② There are five vibrant space nodes in the community that can gather people (Figure 5-26).

Node 1 within the Derong District boundary serves as the sports square, featuring badminton courts, table tennis tables, a small stage, and a few seats. However, most of these facilities are old and poorly maintained, resulting in low utilization. Presently, they are primarily used by parents and children for parent-child interaction. NNode 2 is the community park, strategically located facing the main entrance of Derong District. It serves as the primary community facade and a key element of the landscape environment. The park boasts a circular garden design that extends along the north and south streets. Equipped with pavilions and seating areas, it has become the favorite spot for children to spend their leisure time after school. Moreover, it acts as the central place for residents to interact, communicate, and foster a vibrant community atmosphere. However, a significant concern arises as the garden is surrounded by motor vehicle ways. Consequently, residents, especially children, must exercise caution when engaging in leisure and entertainment activities. The proximity to passing vehicles necessitates heightened awareness, and parents often raise their voices to caution their children in this area.

Figure 5-26 Vibrant Space Nodes

(Source: Photographed by the author)

Node 3 is the basketball court located within the Tianhe East Street Community boundary. Unfortunately, it is surrounded by high wire fences and plagued by a neglected entrance filled

with garbage and e-bikes. The internal facilities are severely aging, with the basketball court lines already blurred. Moreover, a few teenagers playing basketball have to constantly worry about inadvertently disturbing a group of elderly people playing chess in the corner. Node 4, situated outside the Longkou West Street Community boundary, serves as the children's playground. It features slides, sports equipment, and other facilities, making it the sole pocket park within the entire community. To ensure the safety of children, the playground is thoughtfully surrounded by green plants, providing protection from vehicle interference. Node 5, located in front of the commercial area on the ground floor of Poly Zhongchen Plaza, serves as the most vibrant space outside the residential community boundary. The square is impressively equipped, with a row of rest seats thoughtfully arranged along the edge, effectively separating the street from the square.

③ However, there are also three open spaces in the community that should have been vibrant space nodes but have low popularity (Figure 5-27). Open space 1, known as the Shibai Creek pedestrian promenade, holds a central position within the community and stands out as its most prominent waterfront area. However, the presence of two fences running from north to south serves to "protect" the living blocks on either side, inadvertently isolating residents from the natural influence of Shibai Creek. As a result, residents within the fenced area who wish to access the promenade face limited options, having to pass through only three entrances or navigate through most of the community to reach the promenade's ends, leading to inconvenience and added effort. Furthermore, the promenade's facilities are simplistic, and its width is somewhat narrow, resulting in a single line of sight that fails to captivate residents beyond the fence. Open space 2 is the green area located within the boundaries of Longkou Garden, encompassed by a large parking lot, rendering it more of a parking garden for vehicles. Unfortunately, the obstructed views and the low frequency of usage have contributed to its underutilization. Open space 3 takes the form of an exclusive garden situated between two office buildings. Although it possesses a unique layout, a wall obstructs access for residents, rendering it inaccessible. Consequently, the garden sees limited use, with only a few employees being the primary users.

Figure 5-27 Open Spaces

(Source: Illustrated by the author)

5.4 Regeneration Principles in Old Community

(1) Principle of Adapting to Local Conditions

Thorough consideration of the present circumstances is essential, encompassing a comprehensive assessment of the existing construction status, strengths, and challenges. Specific and tailored guidance should be offered for various public spaces, considering their unique requirements. Furthermore, maximizing the utilization of existing resources is crucial to enhance the pedestrian environment through approaches like reconstruction and expansion. By doing so, we can effectively cater to both regulatory standards and the needs of residents while avoiding environmental pollution that may result from extensive demolition and construction activities.

(2) Principle of People-Oriented

The essence of a "community" lies in its people, as evident from its very definition. Being a collection of living spaces, it is crucial to foster a vibrant "life" atmosphere within. Therefore, when renovating old communities, the primary focus should be on improving "people's lives." In essence, adopting a people-oriented approach means prioritizing individual needs and emotions. In the context of low-carbon orientation, enhancing the pedestrian environment in old communities goes beyond simply improving roads and their layout. It involves contemplating and selecting residents' travel patterns. Unfortunately, most community planning starts with a "car-oriented" mindset, resulting in communities that cater more to cars. As a consequence, parking lots and expansive commercial areas are increasingly replacing public spaces in these communities. A "people-oriented" approach, on the other hand, advocates considering the comfort and convenience of individuals from a human perspective, and it

centers around a planning model dominated by walking. By embracing this approach, we can create communities that truly prioritize the well-being and satisfaction of their residents.

(3) Principle of Integration and Coordination

The development of a city and its potential for growth are closely intertwined with the efficiency of renovating old communities. Hence, it is crucial to strike a proper balance between these two aspects during the renovation process. The goal is not only to enhance the living standards of residents in old communities but also to seamlessly integrate them into the urban fabric. Achieving this requires ensuring the overall integrity of the community, which involves considering both the material and social environments.

Practically, regenerating old communities necessitates a principle of comprehensive coordination. Effective harmony and unity must be achieved between the material environment and the social environment, including the preservation of the community's cultural spirit. This approach ensures that the renovated communities not only improve residents' well-being but also contribute positively to the broader urban landscape.

(4) Principle of Openness and Sharing

The closure of communities results in inadequate micro-circulation of urban traffic, longer travel distances for residents, increased reliance on vehicles, and a gradual decline of internal public facilities. This situation fails to cater effectively to the daily travel needs of residents, compelling them to drive to more distant locations. Additionally, the closure of communities creates a disconnect between the community's green landscape and the city's public spaces, leading to heightened travel requirements for residents. To address these challenges and reduce vehicle dependency, community openness becomes an inevitable choice. When enhancing the pedestrian environment in old communities, comprehensive principles must be upheld. This involves skillfully coordinating and harmonizing not only the physical environment but also the social and cultural aspects of the community. By doing so, the community can strike a balance between accessibility, green spaces, and social connectivity, ultimately promoting a sustainable and people-centric living environment.

5.5 Conclusion

This chapter focuses on the research and analysis of the case study – Shipai Creek

Community on Tianhe North Street. Firstly, a questionnaire survey and interviews were conducted with the residents of Shipai Creek Community, revealing that most residents have a vague and unclear understanding of low-carbon transportation. Subsequently, the material spatial characteristics of the community were analyzed from three dimensions: layout, streets, and landscapes. Issues such as oversized residential blocks, low accessibility to public facilities, high permeability of motor vehicle ways, encroachment of parking spaces on pedestrian walkways, closed-off open spaces, and insufficient green spaces were identified. Finally, five principles for the quality improvement of pedestrian environment in old communities were proposed: adaptability to local conditions, people-oriented approach, integration and coordination, and openness and sharing.

Chapter 6 Practice for Improving Pedestrian Environment in Shipai Creek Community

Presented in this chapter are an analysis of existing challenges and improvement strategies for Shipai Creek Community on Tianhe North Road, Guangzhou. The plans are tailored to meet the community's needs in three dimensions: layout form, transportation, and landscape. Through the implementation of these targeted approaches, the goal is to revitalize and contribute to the sustainability of the community (Figure 6-1).

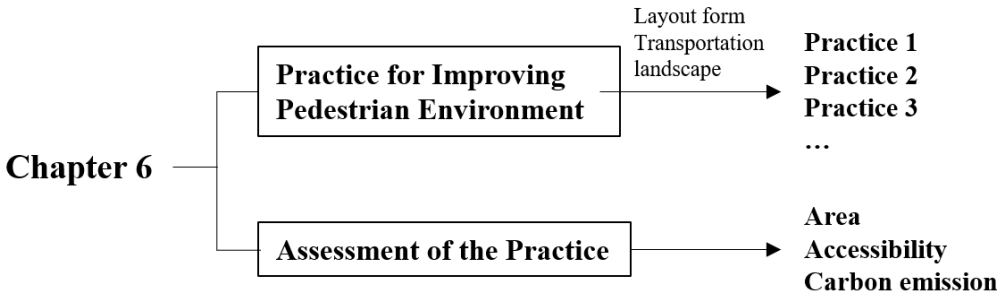


Figure 6-1 Framework of Chapter 6

(Source: Illustrated by the author)

6.1 Enhancing the Layout Form

6.1.1 Demolition of Small Vacant Buildings

Through research, it has been found that there are several small-scale service buildings in Shipai Creek Community. Most of these buildings serve as logistical facilities or parking spaces for bicycles and electric scooters. Due to the aging of these small buildings, their functions and designs are no longer in line with the development of the community and do not meet the needs of the residents. Consequently, they have become "nail households" in the community, resulting in hidden energy consumption and hindering sustainable development. In view of this, the first step in the renovation process is to demolish these small vacant buildings and integrate their functions into other logistical buildings or nearby office spaces (Figure 6-2). As a result of the demolition, the land could be used for recreational activities by the residents.

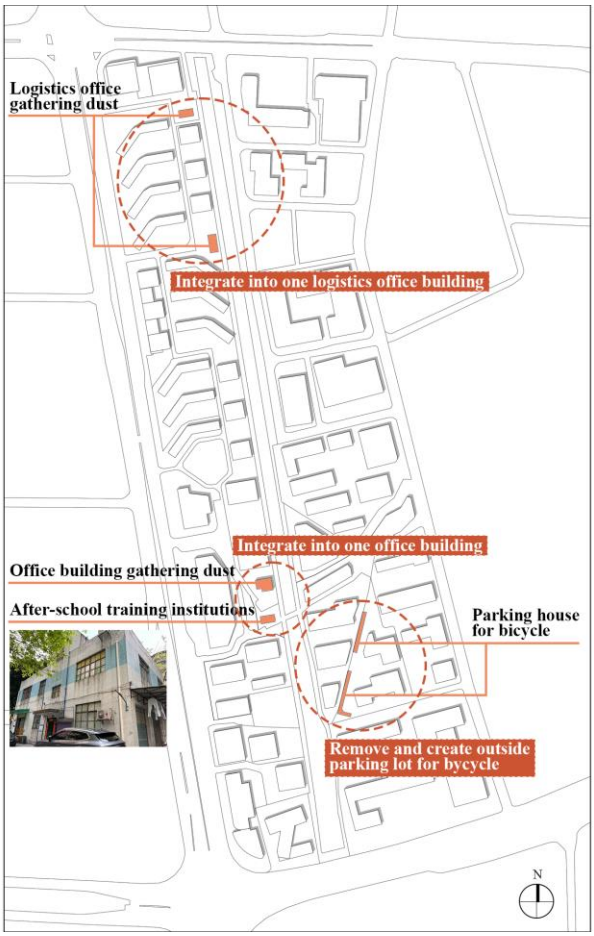


Figure 6-2 Demolition of Small Unused Buildings

(Source: Illustrated by the author)

6.1.2 "1+1+2" Organization of Vibrant hubs

Based on the land use characteristics of Shipai Creek Community, including the central Shipai Creek promenade and the distribution of public facilities along the eastern street, it is necessary to establish two outward-facing vibrant hubs within the community as a first step. This includes a landscape-oriented vibrant axis centered around Shipai Creek and a service-oriented vibrant axis centered around public facilities. Both vibrant axes are open to the city for public use (Figure 6-3). In addition, vibrant hubs of varying sizes and shapes are situated within the residential blocks on both plots in order to satisfy residents' need for activity spaces. A vibrant axis is formed by connecting these vibrant hubs with a series of streets, primarily serving the residents living within the residential blocks (Figure 6-4).

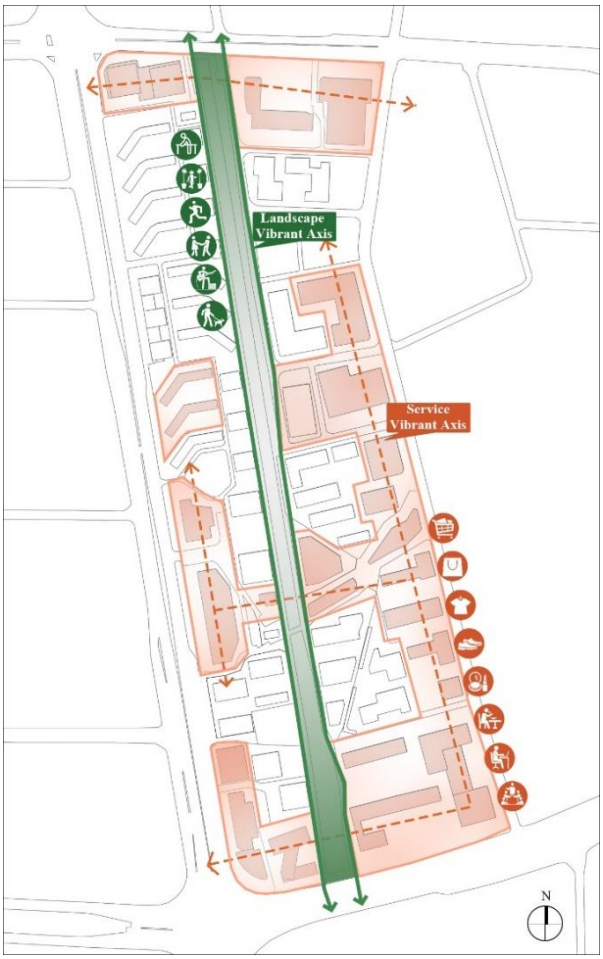


Figure 6-3 “1+1” Vibrant Axis
(Source: Illustrated by the author)

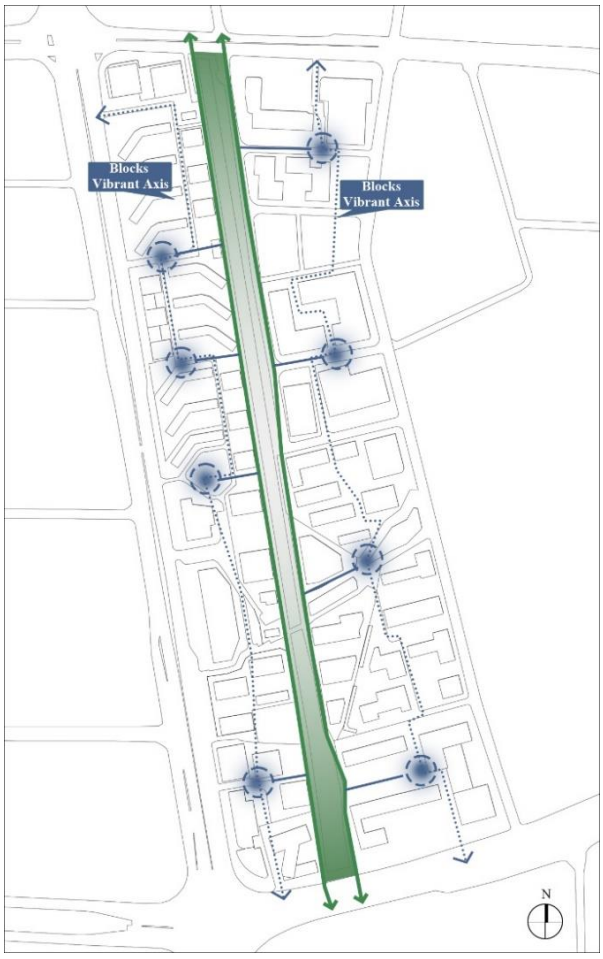


Figure 6-4 “+2” Vibrant Axis
(Source: Illustrated by the author)

The three types of vibrant hubs are strategically arranged within the community, creating a "1+1+2" organization of vibrant hubs that provides a complete and continuous spatial framework for walking within the community. The landscape-oriented vibrant axis encompasses the most significant vibrant nodes in the community, connecting them to the living block-oriented vibrant hubs through the pedestrian walkway and emphasizing their connection to the service-oriented vibrant axis on the ground level. Enhancing the connection of public facilities through elevated pedestrian corridors

6.1.3 Opening-up and Organization of Ground Floor Areas

Ground floor area is regarded as the transitional space between buildings and their surroundings, engaging directly with residents and contributing significantly to the quality of urban spaces. Shipai Creek Community experiences varying levels of vacancy in public buildings. There are two commercial buildings that are widely spaced and disconnected, with nearly half of the shops remaining unoccupied. In order to activate the pedestrian atmosphere, the proposed improvement plan proposes to open up and reorganize the ground floor of the buildings.

According to the survey of the functional configuration of the community, there are few cultural, educational, and recreational facilities, and ground-floor businesses experience low foot traffic due to poor planning. In the initial plan, all accessible ground floor area are divided into designated functional zones, such as commercial areas, cultural areas, and recreation areas (Figure 6-5 and Figure 6-6). Based on the needs of the residents as well as the characteristic of the existing commercial establishments, a detailed layout of each functional area is then developed. Furthermore, it is imperative that each functional zone provides adequate space for future adaptations, in order to accommodate future development possibilities.

Figure 6-5 Openness and Organization of Ground Floor Areas

(Source: Illustrated by the author)

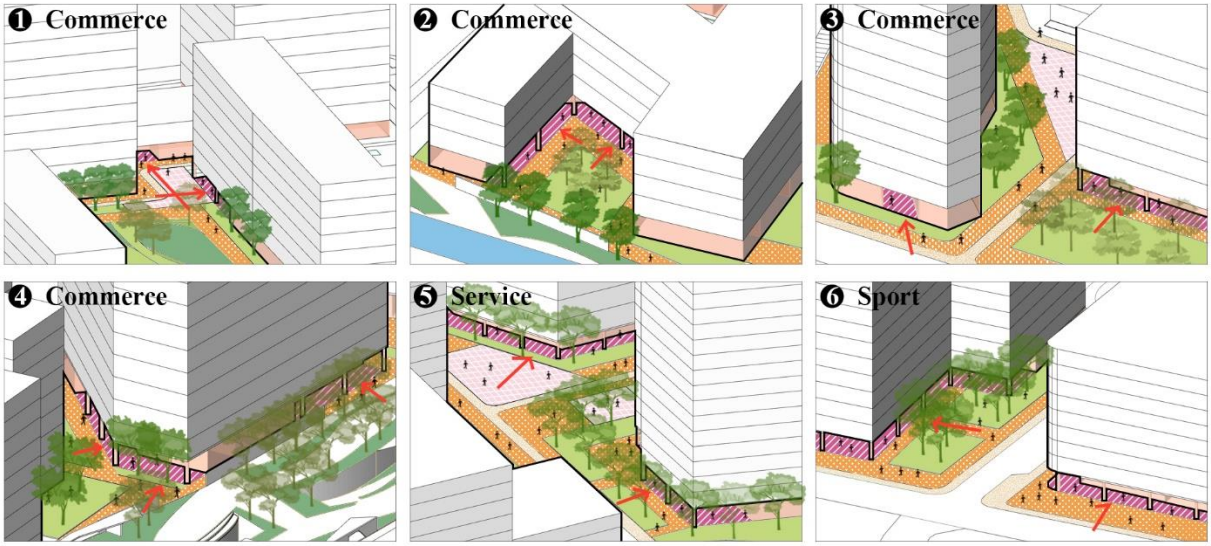


Figure 6-6 Perspectives of Ground Floor Areas

(Source: Illustrated by the author)

6.1.4 Restructuring of Residential Living Blocks

It is proposed to open up and redefine the irregular boundaries of the residential living blocks, which were originally defined based on the layout of the residential areas. This will result in smaller-scale living blocks that are more conducive to pedestrian movement (Figure 6-7). It is planned to separate the new residential blocks with the existing road enclosure, and to extend the existing roads in accordance with the original road pattern. After the restructuring, the residential blocks will range in size from 68m to 197m, catering to a more pedestrian-friendly environment.

Figure 6-7 New Division of Living Blocks

(Source: Illustrated by the author)

6.1.5 The Elevated Pedestrian Corridor Enhances Connectivity of Public Facilities.

The public facilities in Shipai Creek Community are located along the streets. However, they are divided by the obstruction of Shipai Creek from the east to the west, and by the interruption of streets and residential buildings from the north to the south. Consequently, relying solely on ground-level transportation links between public facilities is not sufficient to provide a complete pedestrian pathway. To reach the next location, residents must cross multiple streets back and forth when they wish to use different public facilities within the same travel process. As a solution to this problem, the plan incorporates elevated pedestrian corridors between public facilities, strengthening the connection between them and emphasizing the characteristics of the service vibrant axis (Figure 6-8).

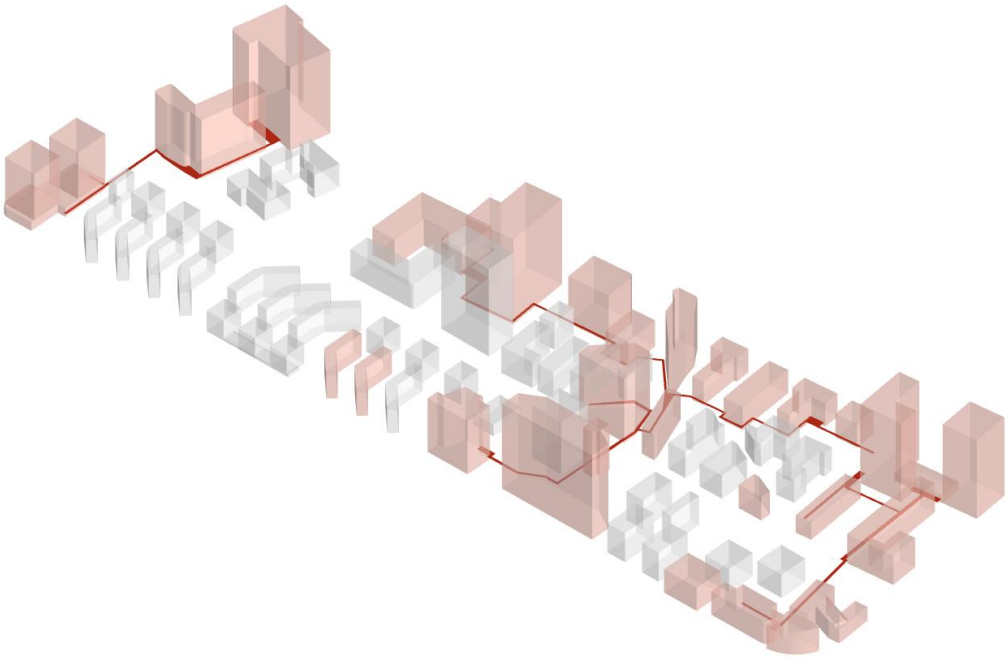


Figure 6-8 Pedestrian Corridor on 2nd Floor Among Public Facilities

(Source: Illustrated by the author)

6.2 Improving the Transportation

6.2.1 Integration of Pedestrian Flows and Street Network

In Shipai Creek Community, pedestrian walkways are an essential part of the walking concept. In the renovation plan, pedestrian walkways are envisioned as having the highest penetration rate. As a result, the existing motor vehicle routes that traverse residential blocks are incorporated into the pedestrian flows, creating "car-free living blocks" for the convenience and safety of residents.

The pedestrian walkways are designed in a grid-like pattern, converging from the east and west towards Shipai Creek. The living blocks are connected by cross-linking streets from south to north. The dead-end streets are designed to connect to the living block streets at one end, while at the other end, they lead to the Shipai Creek promenade. In addition, several new pedestrian pathways have been added to Shipai Creek, forming a complete loop between the east and west side pedestrian walkways (Figure 6-9).

Figure 6-9 Pedestrian Flow
(Source: Illustrated by the author)

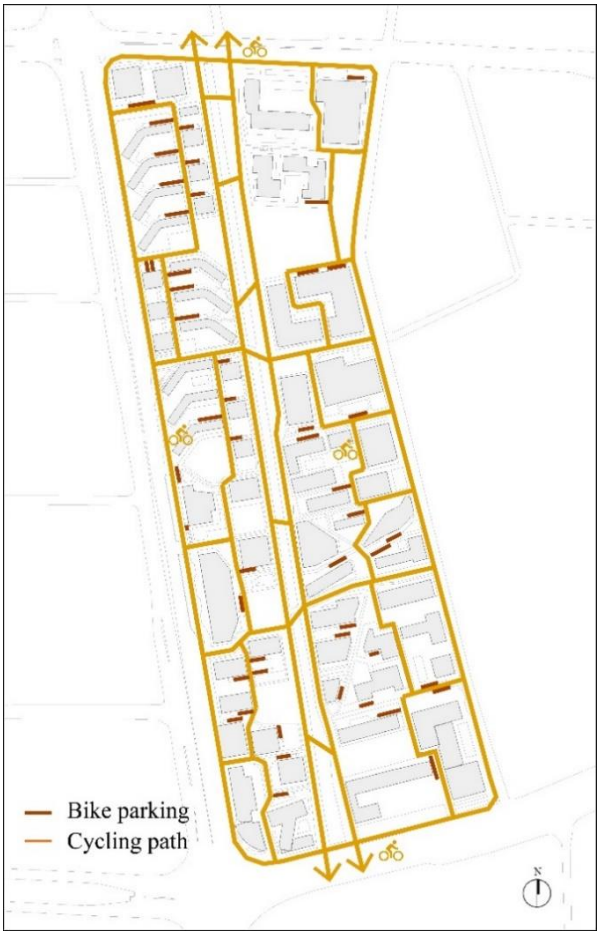


Figure 6-10 Riding Flow
(Source: Illustrated by the author)

6.2.2 Integration of Cycling Flows and Street Network

Shipai Creek Community currently lacks dedicated bicycle lanes, resulting in mixed traffic of bicycles, electric scooters, pedestrians, and e-bikes. However, due to the small size of the pedestrian walkways, bicycles and pedestrians frequently collide. Bicycle lanes are surrounded by pedestrian walkways in the renovation plan, and each residential building has designated parking spaces for non-motorized vehicles. Cycling flows are placed within several interconnected loop systems, creating an overall radial pattern emanating from the residential block. It is intended to direct non-motorized traffic to trunk roads and establish a good connection with bus stops. Residents' commuting routes are integrated into a continuous network of streets (Figure 6-10).

6.2.3 Integration of Vehicle Flows and Street Network

Pedestrians and cyclists in the community have been given priority by reconfiguring the motor vehicle routes into two north-south loops that are connected to the trunk roads in the area. In the residential living blocks, there are no cross-through motor vehicle ways, but a section of motor vehicle way extends towards the edges of the blocks from the main streets to meet basic needs such as goods transportation and temporary parking (Figure 6-11). Sizes of different streets are shown in figure 6-12.

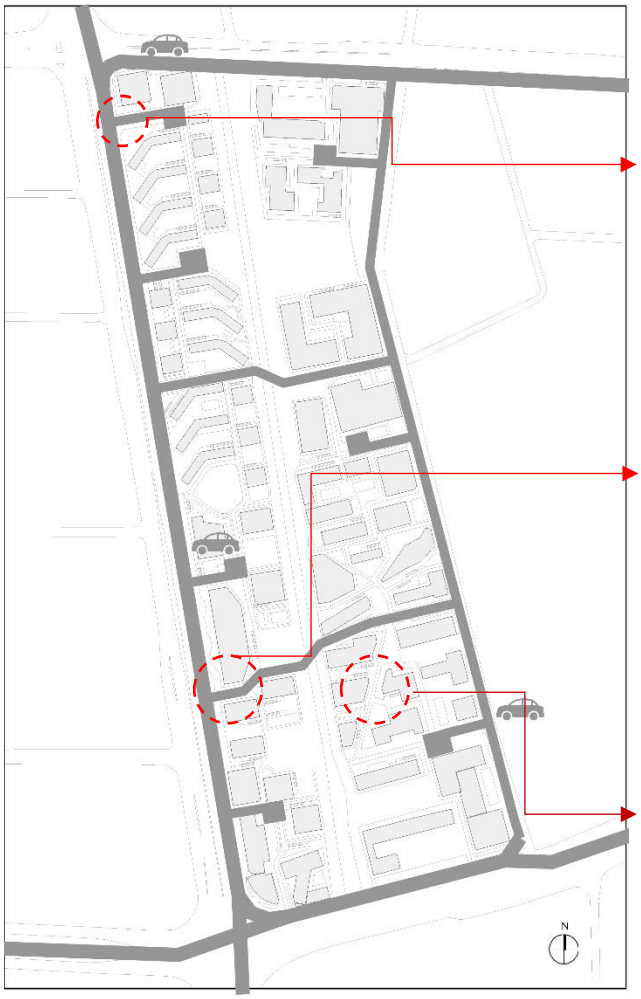


Figure 6-11 Driving Flow
(Source: Illustrated by the author)

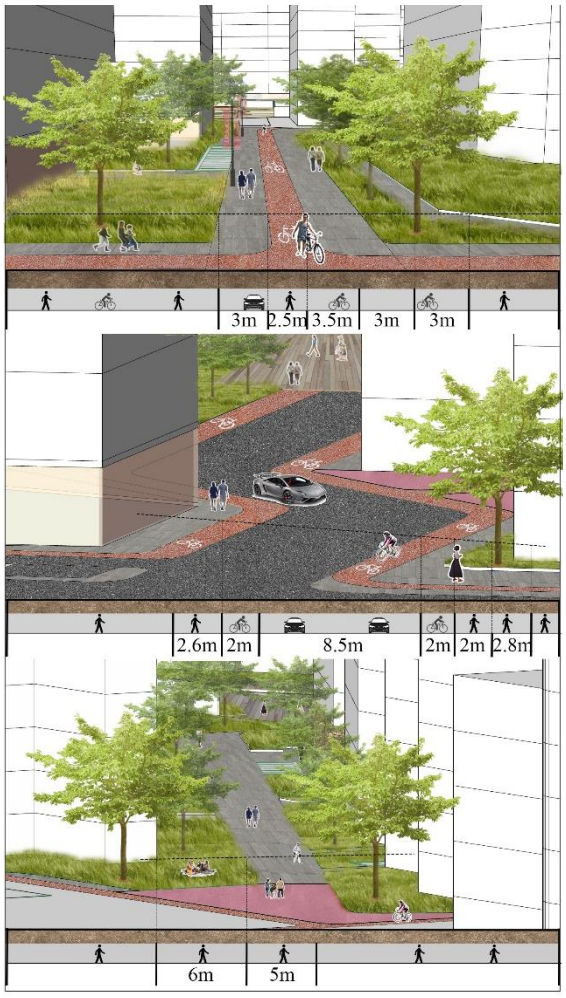


Figure 6-12 Sizes of Different Streets
(Source: Illustrated by the author)

6.2.4 Placing Living Block Vibrant Spaces at Intersections

In living blocks, vibrant spaces are strategically located at the intersections of community

streets, adjacent to block roads. As a result of the improvement plan, a continuous network of vibrant axes runs along the living blocks from south to north, providing residents with an opportunity to enjoy a harmonious community life right at their doorsteps. It is possible for residents to immerse themselves in a variety of spatial atmospheres while walking. Intersections can take both regular and irregular forms, which influence the design of these vibrant spaces (Figure 6-13). Corners with excessively large or small turning angles can be transformed into more perpendicular or near-perpendicular shapes by the addition of vibrant spaces.

Figure 6-13 Vibrant Spaces of Living Blocks

(Source: Illustrated by the author)

The vibrant spaces host a wide variety of community activities: The first benefit of these programs is that they serve as catalysts for integrating walking into the daily lives of residents. In the improvement plan, several dynamic locations within the community will be selected for the establishment of carbon credit exchange stations equipped with display screens, VR experience rooms, gift counters, and other amenities (Figure 6-14 and Figure 6-15). A mobile application will transmit daily travel data to the display screens, allowing residents to view their carbon credit rankings and walking mileage at any time. In the long run, residents will be able to accumulate carbon credits that can be exchanged for household items, service experiences, and gift certificates, among other things.

Secondly, these spaces are an important part of the living blocks' leisure program. The research has shown that elderly and children in the community require activity spaces where they can engage in activities such as chess, chatting, and small games that require safe spaces with resting facilities. Therefore, the improvement plan incorporates a number of landscape ornaments that provide residents with a variety of opportunities for interaction, relaxation, chess-playing, recharging, dining, reading, etc. (Figure 6-16)；

Finally, owing to the lack of a marketplace function in the community, the improvement plan has chosen the vibrant space surrounded by public facilities on the east side to accommodate a mobile market. On a variety of holidays and time periods, the market will supply goods. For example, it can provide fresh food from Monday to Saturday and second-hand items on Sundays. Additionally, during festivals and holidays, it can serve as a themed market offering related goods.

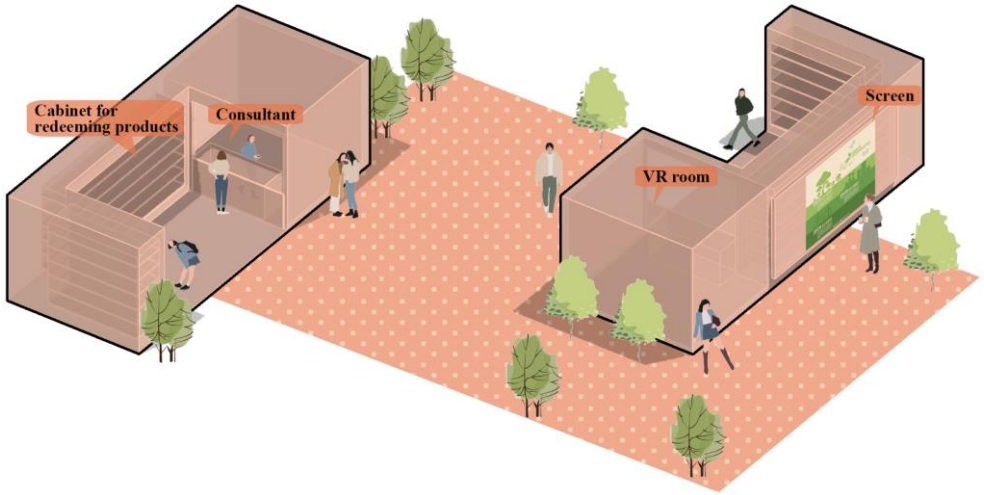


Figure 6-14 Carbon Credits Exchange Stations

(Source: Illustrated by the author)

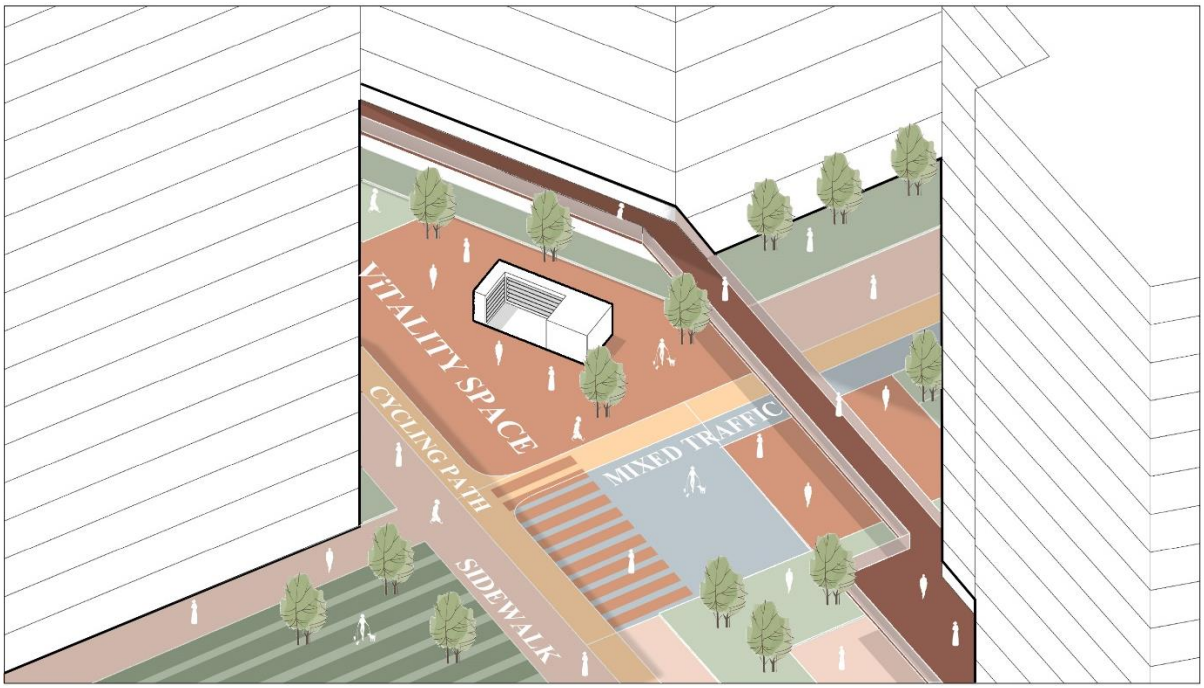


Figure 6-15 Perspective of Carbon Credits Exchange Stations

(Source: Illustrated by the author)

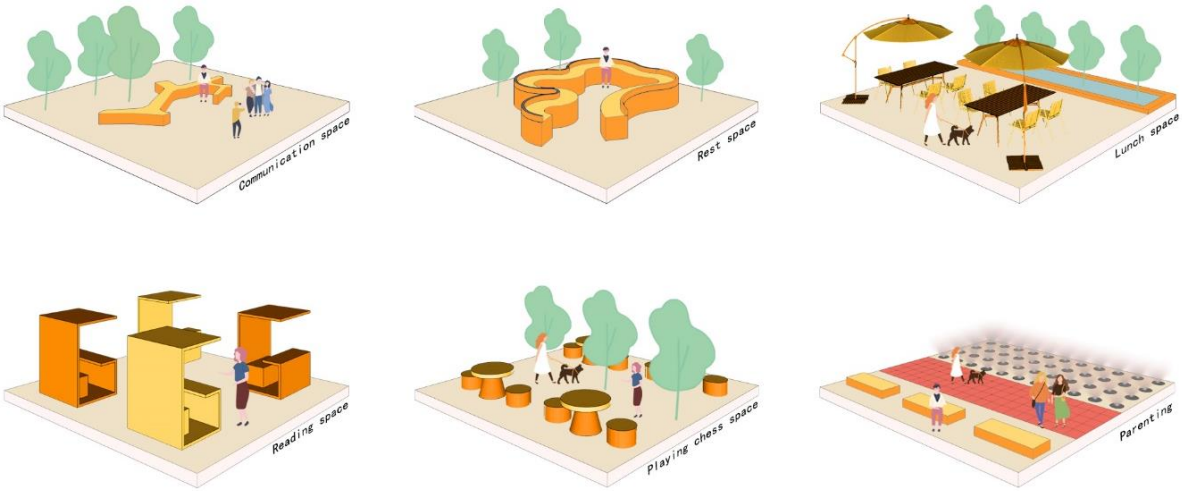


Figure 6-16 A Series of Landscape Ornaments

(Source: Illustrated by the author)

6.2.5 Classification of Streets Based on Three Flows

Using the three flows as a guide, the improvement plan categorizes the streets into six levels. These levels include the trunk road connecting to the city, with a speed limit of 40-60 km/h, providing segregated lanes for pedestrians and vehicles. The community's main roads have a speed limit of 30 km/h, also featuring segregated lanes for pedestrians and vehicles. The end lanes extending from the main arterial streets into the community have a speed limit of 5 km/h, allowing for mixed traffic of pedestrians and vehicles. The block road crossing the living blocks are designed for pedestrians and cyclists. The pedestrian walkways scattered within the living blocks are exclusively for pedestrians. Finally, the scenic roads crossing the Shipai Creek allow for a shared lane for vehicles, with a speed limit of 5 km/h, promoting a mixed traffic environment (Figure 6-17).

Figure 6-17 Classification of Streets

(Source: Illustrated by the author)

6.2.6 Externalization of Parking Spaces

The purpose of this improvement plan is to eliminate on-site parking spaces in order to provide more space for pedestrians and cyclists, to improve traffic flow, to improve air quality, and to enhance the residential environment within the community. Ultimately, this will reduce vehicle traffic within the community and discourage residents from using private vehicles. A portion of the existing peripheral parking spaces will be retained or redefined to be closer to the main streets, bus stations, or commercial and office areas. To some extent, this will meet the parking needs of residents and visitors while preventing the introduction of motorized traffic into the community (Figure 6-18). There are also a limited number of street parking spaces available along the community's main streets. To provide residents with more parking options and flexibility, community managers may also wish to consider opening some underground parking facilities to residents, implementing parking fees that are appropriate, managing

parking permits, or implementing a reservation system.

Figure 6-18 Parking Spaces Moved to the Periphery

(Source: Illustrated by the author)

6.2.7 The Application of Curb Extensions

A number of advantages can be achieved by creating street extension spaces on the peripheral streets on both the eastern and western sides of the community. To begin with, it helps alleviate some of the parking demand. Second, these extension spaces can be utilized as public spaces in order to increase the capacity of the street and introduce various functions. It is possible to set up small rest areas in these extension spaces, which will provide pedestrians with a place to relax and rest. They can be used as temporary parking spaces for bicycles and electric scooters, providing residents with convenient parking options. The area can also be

designated for the access of shared bicycles, allowing residents to use them as a means of transportation to reach nearby subway stations (Figure 6-19). Furthermore, these spaces can be utilized as waiting areas for bus stops (Figure 6-20). Extension spaces at intersections can serve as a reminder to drivers to reduce their vehicle speed by reducing the dimensions of the street, thereby improving the safety of residents.

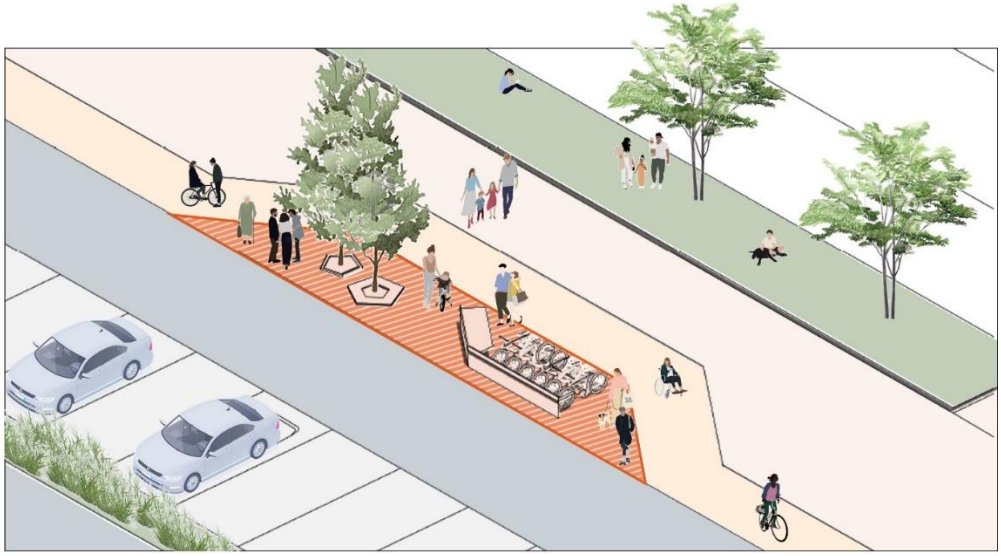


Figure 6-19 Curb Extensions as A Small Plaza

(Source: Illustrated by the author)

Figure 6-20 Curb Extensions as A Bus Station

(Source: Illustrated by the author)

6.3 Designing the Landscape

6.3.1 Expansion and Design of Shipai Creek Promenade

A significant feature of the renovation plan is Shipai Creek, an open space that attracts residents to walk and is located in the center of the community. The regeneration in Shipai Creek aims to achieve two main objectives. The first objective is to increase the amount of usable space, accommodate more recreational activities, and meet the leisure travel needs of residents. A second objective is to expand ecological shorelines, improving the microclimate and establishing a prominent face for Shipai Creek Community (Figure 6-21 to Figure 6-23). The specific design steps are as follows:

(1) Opening the closed fences that separate the living blocks from both sides of Shipai Creek, incorporating the streets adjacent to the buildings into the Shipai Creek promenade.

(2) Preserving the existing vibrant spaces near Shipai Creek and adding new community activity spaces on the eastern and western sides. These activity spaces, along with the pedestrian walkway, are integrated into the design of a landscape-oriented activity axis.

(3) Redesigning the straight Shipai Creek into a curved shape while adding green space and waterfront platforms along the pedestrian walkway.

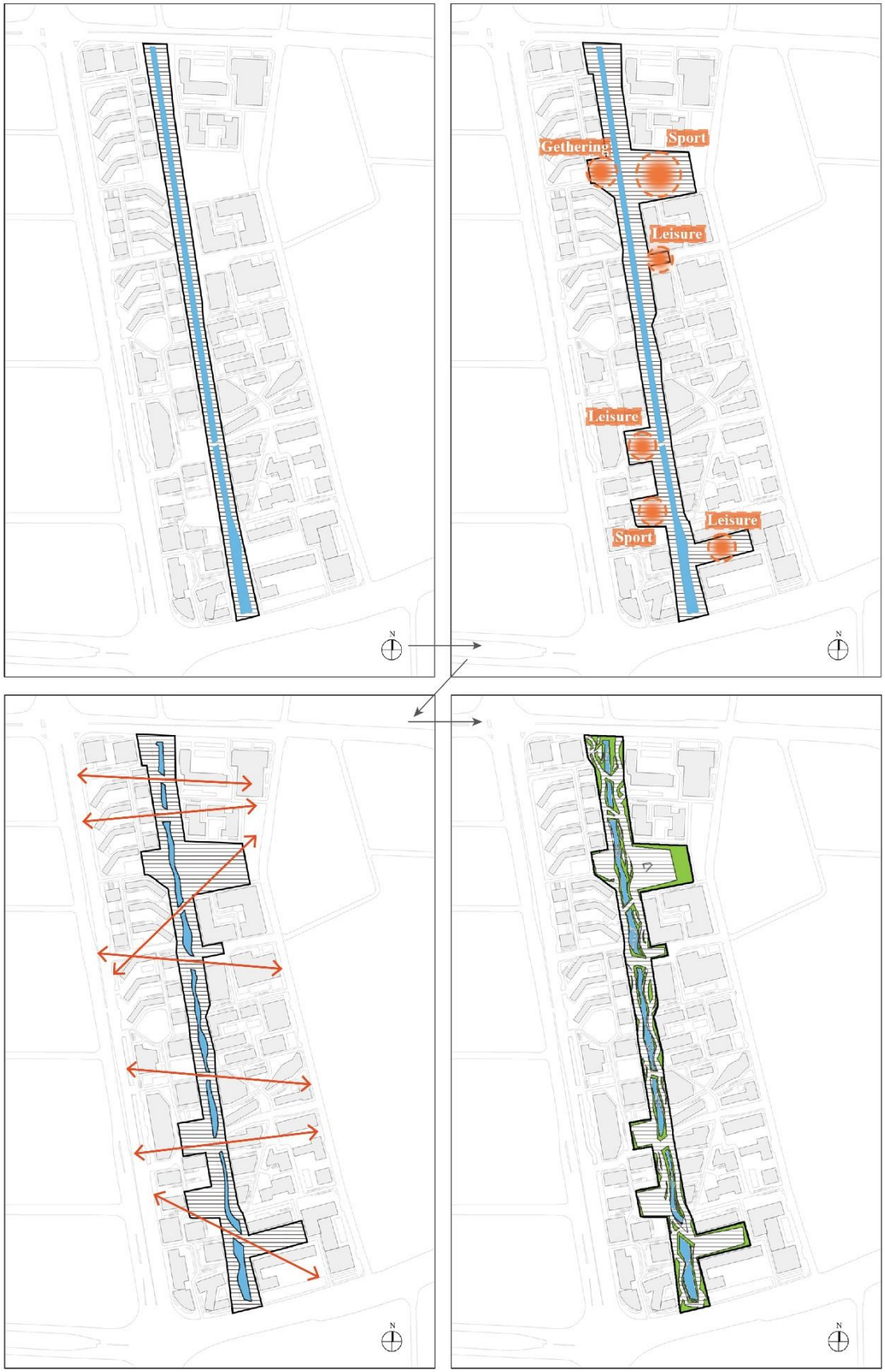


Figure 6-21 Design Process of Shipai Creek Promenade

(Source: Illustrated by the author)

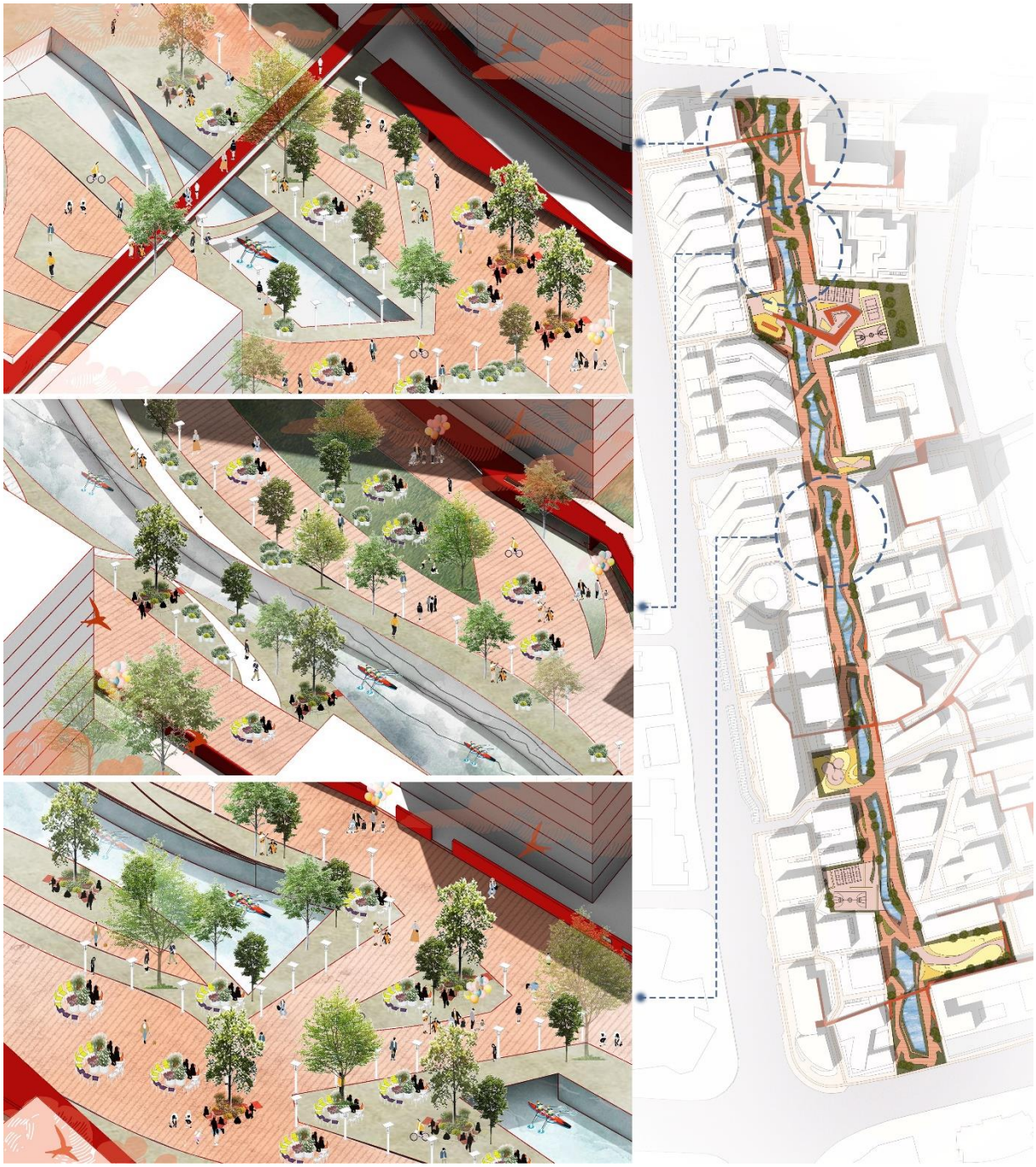


Figure 6-22 Shipai Creek Promenade (a)

(Source: Illustrated by the author)

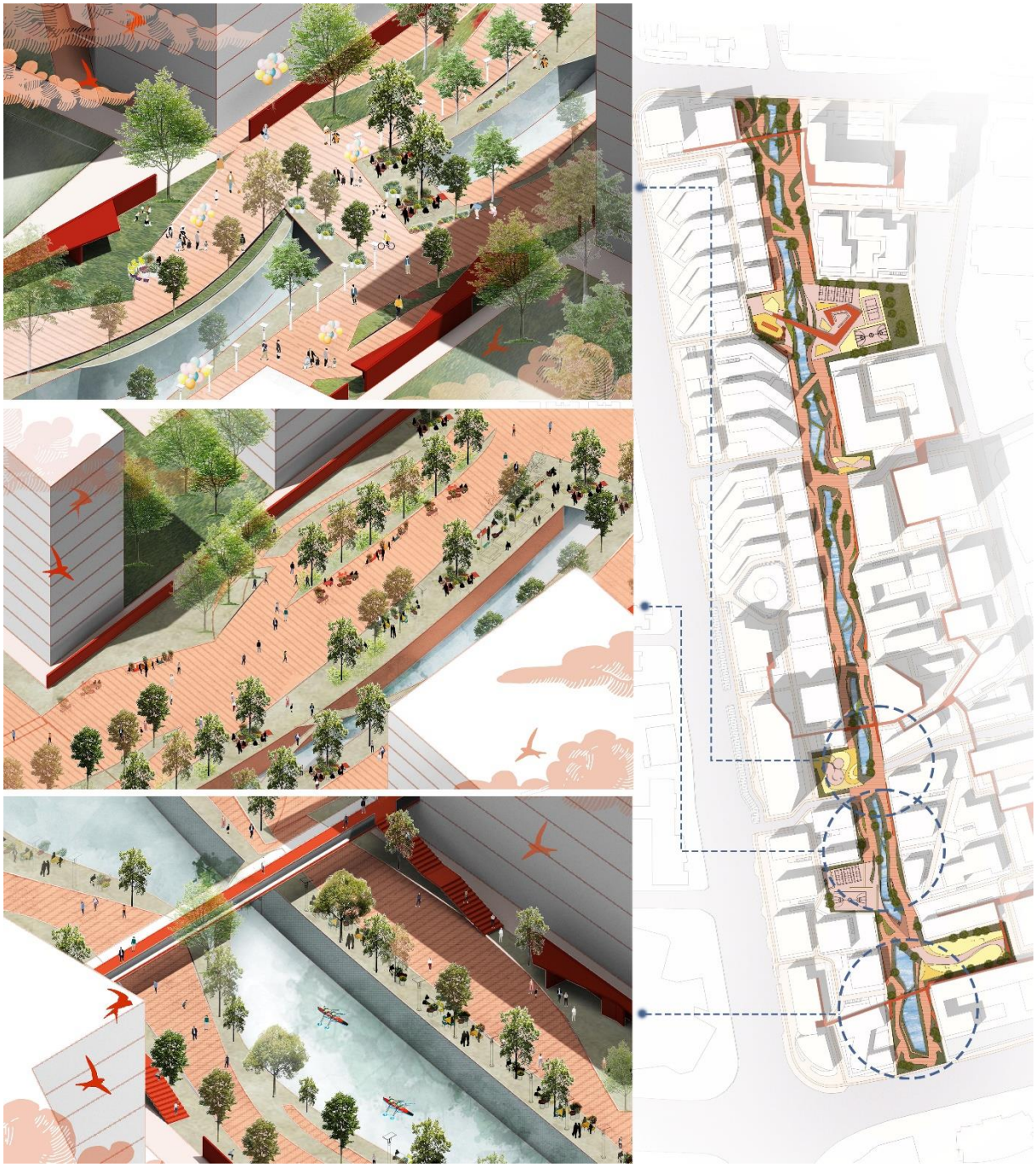


Figure 6-23 Shipai Creek Promenade (b)

(Source: Illustrated by the author)

6.3.2 Designing Community Vibrant Spaces to Meet Different Needs

In addition to the existing functions, the six vibrant community spaces have been adapted to meet the needs of the surrounding environment, offering a variety of themes and functions. There is one gathering plaza, three leisure plazas, and two sports plazas. A small performance space is available for community events at the gathering plaza, which features a stage and

seating. Leisure plazas are situated near office buildings and feature landscape elements and comfortable seating, offering an opportunity for office workers to relax and unwind. Sports plazas include facilities such as basketball courts, badminton courts, and table tennis tables, encouraging physical activity and participation in sports (Figure 6-24 and Figure 6-25).

Figure 6-24 Vibrant Spaces of Community (a)

(Source: Illustrated by the author)

Figure 6-25 Vibrant Spaces of Community (b)
(Source: Illustrated by the author)

6.3.3 Utilizing Flexible Enclosure Walls

The fences on both sides of the Shipai Creek promenade were originally intended to separate private living blocks from the open public space. The tall solid fences created a sense of visual isolation and enclosure, reducing the allure and vitality of the pedestrian pathway. Moreover, they restricted interactions and social connections between community residents and the surrounding environment, potentially preventing the development of a strong sense of community. Thus, in the improvement plan, the concept of public-private separation is retained, but instead of rigid fences, soft enclosure walls are used to provide a more flexible and adaptable approach (Figure 6-26). There is a natural transition between the living blocks and the Shipai Creek promenade created by these walls. Furthermore, the use of various sizes and shapes of holes enhances the aesthetic appeal of the pathway, making it more enticing for pedestrians to explore.

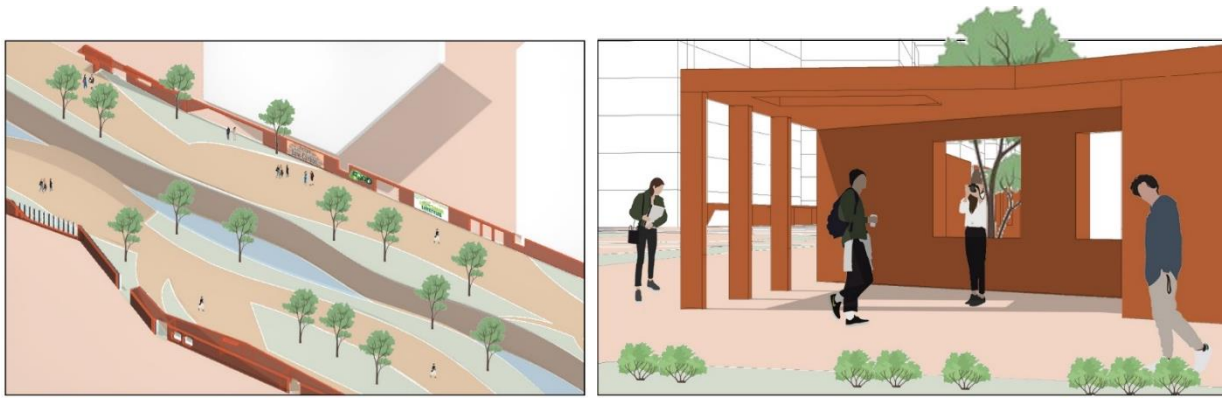


Figure 6-26 Flexible Walls on Both Side of the Creek
(Source: Illustrated by the author)

6.3.4 Strengthening the Guiding Role of Green Spaces on Streets

Through several effective strategies, the proposed improvement plan attempts to resolve the issue of scattered green spaces in the community. To begin with, additional green spaces will be incorporated into the residential clusters in order to improve the quality of life for residents. Secondly, arbor and shrub plants will be selected and distributed to enhance the community's carbon sink capacity. The existing wooded roads will also be augmented by additional plantings, resulting in a more pleasant and continuous canopy (Figure 6-27).

Moreover, the open spaces will be strategically used to identify road directions and guide the movement of residents, improving the flow of pedestrians. In addition, it is anticipated that these green areas will serve as natural barriers between buildings and roads, creating a safer and greener environment for pedestrians (Figure 6-28).

Figure 6-27 Wooded Roads
(Source: Illustrated by the author)

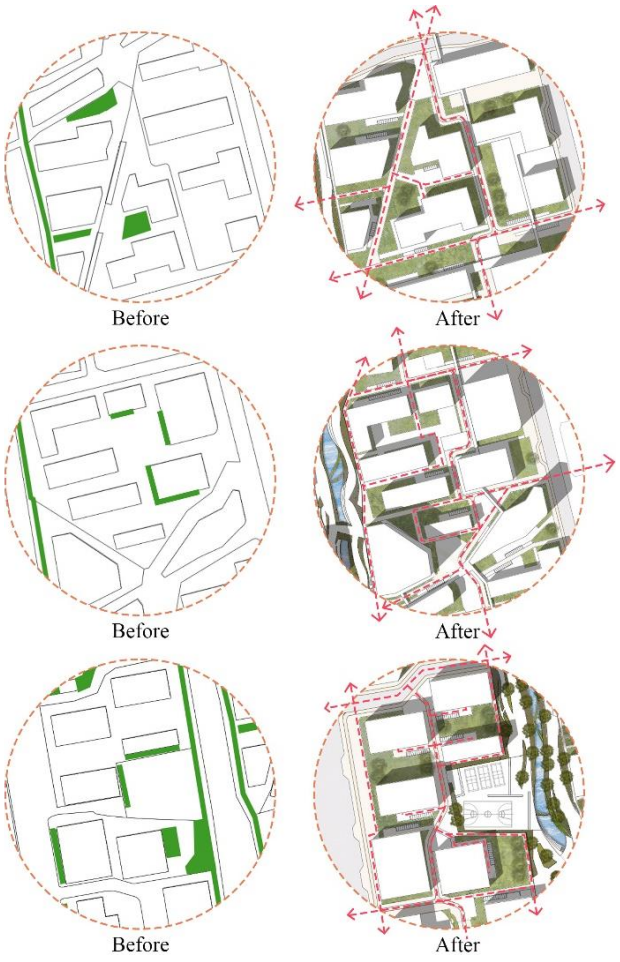


Figure 6-28 Organization of Green Spaces in Living Blocks
(Source: Illustrated by the author)

The complete plan after the improvement is shown in figure 6-29.

Figure 6-29 Plan After the Improvement

(Source: Illustrated by the author)

6.4 Evaluation After the Improvement

Perspective before and after the improvement is shown in figure 6-30 and figure 6-31.

Figure 6-30 Perspective Before the Improvement

(Source: Photographed by the author)

Figure 6-31 Perspective After the Improvement

(Source: Illustrated by the author)

6.4.1 Changes in Area

In regards to the quality improvement of pedestrian environment in Shipai Creek Community under the guidance of low carbon, the plan consistently prioritizes walking as fundamental objectives. Through a series of spatial transformations, the plan aims to enforce residents' rights to walk within the community. Compared to the current situation, Shipai Creek Community has made the following positive changes to promote low-carbon transportation.

①The pedestrian walkway area has increased by 18000m^2 compared to the previous state.

②The non-motorized motor vehicle way has increased by 11000m^2 compared to the previous state.

③The number of non-motorized vehicle parking spaces has increased by 408 compared to the previous state.

④The green spaces has increased by 53000m^2 compared to the previous state.

⑤The wooded roads area has increased by 12000m^2 compared to the previous state.

⑥The length of the ecological waterfront has increased by 122m compared to the previous state.

⑦The water surface ratio has increased by 33.82% compared to the previous state.

6.4.2 Accessibility Analysis

The accessibility of public facilities and bus stops has significantly improved compared to the current situation. Specific axis analysis is as follows:

①Axis integration (Figure 6-32): The highest integration value after the upgrade is 2.23, the lowest is 0.50, and the average is 1.25. These values have generally improved compared to the integration values of the current community street network. The integration level of the streets surrounding the community remains relatively high, with the Shipai Creek promenade having the highest integration level. Other street segments also show improved integration, making it more convenient to access various public facilities.

②Axis depth value (Figure 6-33): The maximum depth value after the upgrade is 11.89, the minimum is 3.44, and the average is 5.66. The minimum and average depth values have decreased, indicating an overall improvement in the convenience of the community. Compared

to the current situation, the accessibility of public facilities within the community has greatly improved, achieving the intended goals.

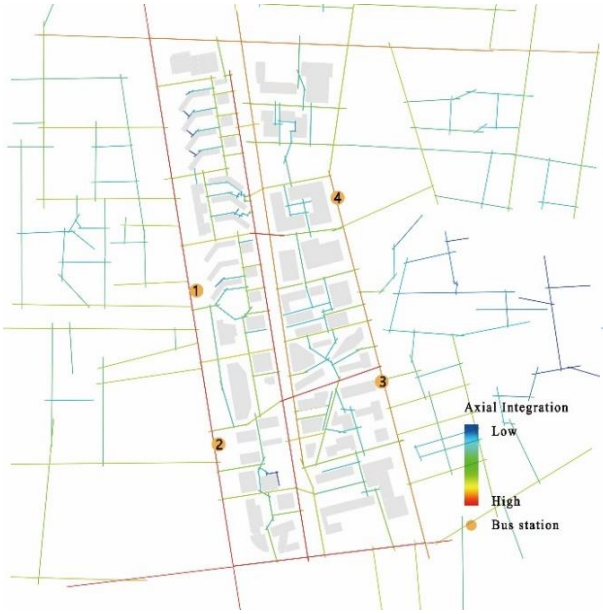


Figure 6-32 Axial Integration
(Source: Illustrated by the author)

Figure 6-33 Axial Mean Depth
(Source: Illustrated by the author)

6.4.3 Assessment of Carbon Reduction and Carbon Sink

The purpose of this paper is to study community environmental renewal from the perspective of low-carbon transportation, so the carbon reduction benefit assessment measures are also initially evaluated from the perspective of transportation carbon emissions. The assessment scenario is based on Kun Wang's super-enhanced scenario, which is a carbon emission scenario achieved by adopting more powerful and effective carbon reduction strategies[82]. The super-enhanced scenario is envisioned as an idealized state where residents' leisure travel can be accommodated inside the community.

The model used to calculate carbon emissions is the Kaya model, which has been optimized by Chen Fei and other scholars[83], and the formula is as follows:

$$CO_2 = n * \frac{mileage}{the\ quantity\ of\ cars} * \frac{E}{mileage} * \frac{CO_2}{E}$$

Where, n is the number of cars, $\frac{mileage}{the\ quantity\ of\ cars}$ is average car mileage (km/per

car), $\frac{E}{mileage}$ is energy consumption of a car per mile traveled (kg/km), $\frac{CO_2}{E}$ is conversion factor (kg/kg).

The survey of travel behaviors of residents in Shipai Creek Community has determined that there are 1255 residents engaging in leisure travel, which is reflected in the number of vehicles they own. Average car mileage in Guangdong is about 1.6 km/per car[84]. The average energy consumption of a car is about 0.051kg/km[85]. Conversion factor under super-enhanced scenario is about 60%[82]. The improvement plan is estimated to reduce CO_2 emissions by approximately 61 kilograms per year.

Regarding the advantages related to carbon sequestration, this research aims to revamp the community's landscape on a local scale by boosting greenery to improve the community's carbon sequestration capabilities. It is important to note that, in contrast to the straightforward afforestation technique for carbon sequestration, the approach employed in this study not only successfully lowers atmospheric CO2 levels but also revitalizes the community's walking environment through specific spatial interventions. This invigorates residents' motivation to walk and indirectly lessens carbon emissions from transportation, resulting in a range of benefits.

6.5 Conclusion

There are a total of three dimensions and 16 improvement processes involved in enhancing the quality of the pedestrian environment in Shipai Creek Community under the low-carbon orientation. It is in response to the previous chapter's research on low carbon concepts and walking environments. The chapter concludes with a preliminary assessment of the benefits of the upgrading program in terms of area, accessibility, and carbon reduction.

Conclusion and Discussion

Conclusion

A major focus of this study is the current limitations of the use of low-carbon practices within old communities, as well as the poor conditions of pedestrian environment within these communities. Using the concept of low carbon and summarizing international low-carbon community development examples, this study presents strategies for improving pedestrian environments in old communities. Through environmental improvements, the goal is to revitalize the vitality of old communities, to encourage residents to adopt low-carbon lifestyles, and to promote the path towards sustainable development. A significant number of research outcomes have been achieved in this study by building on previous research.

(1) This study serves as a bridge between the concept of low-carbon development and the revitalization of old communities. It establishes an implementation framework for creating walkable environments, focusing on two key pathways: reducing carbon sources and increasing carbon sinks. The study delves into the subject from three dimensions: enhancing layout patterns, optimizing transportation, and designing the landscape to achieve the objective of a pedestrian-friendly community. The research follows a logical sequence of defining construction goals, proposing improvement strategies, and validating them through practical demonstrations.；

(2) Based on problem analysis of the site, it is observed that several factors hinder pedestrian activities in old communities, such as excessively large living clusters, scattered and poorly connected public facility layouts, parking spaces encroaching upon sidewalks, and open spaces enclosed by tightly-knit fences. Unlike newly constructed low-carbon communities, addressing these issues requires tailored renewal strategies, rather than applying standardized greenery or parking space indicators；

(3) This study deduces that in the context of reducing carbon sources, suitable pedestrian-friendly layout forms in old communities should adhere to the following objectives: a mixed-use land utilization pattern, high accessibility to public facilities, appropriately scaled living blocks, and the establishment of vibrant activity centering on attracting pedestrian flow.

Therefore, the strategies proposed for enhancing the pedestrian environment in old communities include functional replacement and supplementation, opening up enclosed boundaries and reorganizing living clusters, activating activity centers, and strengthening the spatial connections of public facilities.

Regarding the appropriate pedestrian-oriented transportation, the implementation goals should involve a continuous and convenient slow traffic network, a well-connected road hierarchy system, and people-oriented street designs. Hence, the targeted strategies for improvement encompass perfecting the slow traffic network, designing in accordance with street positioning, reviewing and adjusting the existing road hierarchy system, relocating parking lots from the interior to the periphery, and emphasizing human-centered road space design.;

(4) In the context of increasing carbon sinks, the suitable pedestrian-oriented traffic organization should adhere to the following objectives: creating a continuous and cohesive landscape environment, establishing clear landscape boundaries, incorporating artistic and playful designs, and providing necessary supporting facilities. Therefore, the strategies proposed for enhancing the pedestrian environment in old communities include landscape creation based on community characteristics, designing vibrant spaces and facilitating facilities to meet activity demands, reimagining enclosed boundaries, and ensuring a continuous and diverse arrangement of green spaces.

Discussion

This study has several limitations: Firstly, in terms of research methods, this study is primarily relied on field surveys, and the evaluation of the pedestrian environment in the old community is predominantly based on qualitative analysis, which may introduce some subjectivity. Secondly, concerning the research content, it mainly focus on exploring the goals of creating a pedestrian-friendly community under the low-carbon concept, with limited integration of carbon emission reduction studies. As a result, it is challenging to accurately simulate and assess the current carbon emissions and the potential carbon reduction achieved through the planning measures, leading to only an estimated ideal state.

In future research, there is a need to delve deeper into the relationship between the

pedestrian environment and carbon emission reduction. Apart from investigating the objectives of creating a pedestrian-friendly community, it is essential to simulate and assess the actual impact of pedestrian activities on carbon emission reduction. By establishing models, the potential of pedestrian-oriented measures to reduce carbon sources and increase carbon sinks can be analyzed, providing concrete carbon reduction rationale and strategies.

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