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## 论文题目

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**Evaluation and Optimized Strategies of Walkability in  
Historic District Based on Data Augmentation**

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# **Evaluation and Optimized Strategies of Walkability in Historic District Based on Data Augmentation**

A Dissertation Submitted for the Degree of Master

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# Abstract

As cities continue to regenerate and develop, the concept of sustainable development has gradually become one of the main themes in the process. People have also begun to place higher demands on the walkability of historic and cultural districts. Relevant research has also evolved from subjective and emotional evaluations to objective and rational quantitative analyses. Nowadays, with the support of information technology in development, various refined quantitative research tools and relevant urban evaluation data have created a fundamental analysis platform to quantitatively evaluate the walkability of historic and cultural streets. In this context, this paper attempts to sort out and develop a quantitative evaluation system for historic and cultural districts based on the concept of data augmented design, and thus develops corresponding optimized design strategies to further improve the walkability of historic and cultural districts.

The first chapter introduces the background of this paper, clarifies the purpose and significance of the research, describes the research objectives and methods, and sets out the research framework and technical route.

The second chapter is the construction of a framework for the quantitative evaluation system and data augmented design of the walkability in historic and cultural districts, through the improvement of the walkability measurement system of historic districts and the support of data to form the basis of subsequent analysis for optimisation and enhancement.

The third chapter uses national and international case studies to obtain an optimised approach for walkability evaluation, the enhancement of multidimensional walkability , the recognition of the relevance of indicators and comprising the selection of targeted evaluation indicators, leading to a specific methodology.

The fourth chapter is an empirical study, in which the Changhua historic and cultural district in Guangzhou is selected for the evaluation of various indicators of walkability, and the information is collected and analyzed with various data tools in conjunction with the traditional data to form a comprehensive evaluation and further classification of the streets based on different attributes. Thus provides a stronger support for the later specific design strategies and optimization.

The fifth chapter presents the specific optimization design for the walkability in Changhua District according to the problems and opportunities analyzed before. With systematic strategies, general design as well as the enhanced measurements for different streets are put forward to achieve simultaneous improvement of multiple indicators related to walkability, aiming at stimulating the comprehensive value of it, so as to make a positive effect of realizing a sustainable development of Changhua District.

The sixth chapter presents the main conclusions, innovations and shortcomings of the thesis.

Through the above research, this paper further improves the analysis of the basis and construction of quantitative evaluation of the walkability in historic district, and it can have a positive effect on the optimization of street regeneration.

Keywords: walkability ; quantitative evaluation ; data augmented design ; Guangzhou Changhua District

# 摘 要

随着城市不断更新发展的进程，可持续发展理念已逐渐成为其中主要的指导思想之一。人们也开始对历史文化街区街道的可步行性提出更高的要求。针对性的研究也历经了从主观感性的评价到客观理性的量化分析。在现代信息技术发展的支持背景下，各种精细的量化研究工具以及相关的城市研究和评价数据创造了充分的分析基础，去对历史文化街区街道的可步行性进行定量的评价。在此大背景下，本文尝试研究并梳理针对历史文化街区街道可步行性的定量评价体系，结合数据增强设计方法，形成相应的优化设计策略，促进历史文化街区街道可步行性的提升。

第一章绪论介绍了本文研究背景、阐明研究目的和意义、说明研究目标和方法，搭建研究框架和技术路线。

第二章是历史文化街区街道可步行性量化评价体系与数据增强设计综合利用框架的构建，通过对历史街区可步行性测度体系的完善和数据的支撑去形成后续优化提升的分析基础。

第三章通过国内外案例的研究得到优化的可步行性评价方式，包含提升多维度的可步行性、认可指标的关联性及选取针对性评价指标，从而形成具体的技术方法论。

第四章为实证研究部分，选取广州昌华历史文化街区进行可步行性的各项测度指标评价，运用数据工具进行信息搜集与分析，结合传统数据形成街道综合评分，划分不同属性街道并为具体的设计策略及方式提供数据支撑。

第五章为针对前文分析中昌华大街具有的问题与机遇提出有关可步行性的具体优化设计，通过系统性策略、整体设计和优化措施促进不同街道有关可步行性多指标的同步提升，展现街区的综合价值，推动街区的可持续发展。

第六章为本文主要的结论、创新点和不足展望。

本文通过上述研究，进一步完善历史街区可步行性的量化评价的依据分析及体系构建，使其在历史街区街道更新优化中发挥引导作用。

**关键词：**可步行性；定量评价；数据增强设计；广州昌华大街

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# Chapter 1 Introduction

## 1.1 Background

### 1.1.1 The importance of enhancing walkability in contemporary society

As the oldest and most fundamental as well as the most economical and environmentally friendly way of travelling, walking still occupies an irreplaceable position in today's integrated urban transport system. Faced with a series of problems such as congestion, noise and pollution caused by the explosive growth of motor vehicles in the past, relieving traffic pressure, reducing urban pollution and enhancing the safety and comfort of people travelling have become important themes for sustainable urban development.

From 1990s, investigations of urban pedestrian environments have been carried out in various countries. In the United State, planning thinking had changed from the car-centred to the bicycle and pedestrian-centred approach, and a series of street design standards had been introduced on the basis of research, and the most notable one is the California Street Design Guidelines for Healthy Communities<sup>[1]</sup>. In Europe, Dutch experts had summarised and proposed the shared streets theory, which had played an important role in optimising the overall pedestrian environment of European urban streets<sup>[2]</sup>. In China, research on pedestrian cities started relatively late, but in recent years the study process has been steadily progressing, with corresponding design guidelines emerging for distinctive urban streets.

With the increasing scale of urbanisation in China, the number of urban residents is also growing, people are beginning to pursue a higher standard of living, and this has led to more requests for motor vehicles and public transport. At the same time, with the advent of the era of social stock growth, people are paying more and more attention to the quality of their living space. The street as an important carrier of people's social life, the quality of it depends to a large extent on its walkability. In the context of the country's latest dual carbon policy - carbon peaking by 2030 and carbon

neutrality by 2060<sup>[3]</sup>, there is a need to effectively control the carbon emissions of urban transport. Nowadays, on one hand, electric vehicles are being vigorously promoted and the public transport system is being continuously optimised. On the other hand, with the increased awareness of the importance of non-motorised traffic contribution in the decarbonisation of urban transport, cities are paying more attention to the walkability and cycling friendliness of their streets to maximise the chances of people travelling slowly, so that the requirements of short distance travel can be met by safe, convenient, comfortable and enjoyable walking or cycling.

### 1.1.2 Conservation and regeneration of historic districts

The historic district is a record of the development process of the city, reflecting the characteristics and appearance of the city in different periods, and has a unique historical and cultural heritage value, which can be seen as the soul of the city.

The concept of the historic district was first introduced in August 1933 with the adoption of the Athens Charter, in which it was stated that "buildings and districts with historic value should be preserved and not destroyed". Further research on the value of historic areas has led to an increased emphasis on their conservation. The concept of Historic urban areas was introduced in the Washington Charter in 1987, which not only considered historic areas as a witness to history, but also identified the traditional cultural values of the towns. In contrast, the concept of historic districts in China was defined relatively late, and the first mention of the proposal to protect historic districts appeared in 1982 Notice of the State Council on the Approval of the State Construction Commission and Other Departments on the Protection of Famous Historical and Cultural Cities in China<sup>[4]</sup>. And in 1986 Notice of the State Council on the Approval of the Report of the Ministry of Construction and the Ministry of Culture on the Request to Publish the List of the Second Batch of National Famous Historical and Cultural Cities was issued by the State Council. And in this notice, the concept of historic districts was clarified for the first time: they include towns, streets and villages that are particularly rich in cultural relics and have significant historical value or

revolutionary significance<sup>[5]</sup>.

With the development of times, new demands are being put forward on the conservation of historic districts. Firstly, there is an overall trend from monolithic protection to comprehensive protection: the transition from the Athens Charter to the Washington Charter has witnessed a shift from the initial monolithic protection of historic buildings to the subsequent development of a comprehensive protection of historic districts. Historic buildings are no longer viewed as individual element, but rather being part of the surrounding environment and leading to a more integrated approach to the conservation of historic areas. Furthermore, the conservation of historic areas has undergone a transformation from static to dynamic state<sup>[6]</sup>: in the context of rapid development of technology, historic areas are still of great importance for the development of cities. Therefore, it is important to preserve the characteristics of historic districts while adapting to the new requirements, so that the inhabitants and visitors can still enjoy the conveniences of modern civilisation in the specific districts. Thirdly, the management of historic districts also appears to be changing from macro to refined: the new urban context brings more possibilities for the management of historic districts through the use of relevant technological techniques. Through the use of more timely information feedback and more objective analysis of the needs of historic districts, the spatial quality of historic districts can be continuously improved<sup>[7]</sup>. So it is particularly important to enhance the walkability of historic areas nowadays, contributing to the simultaneous enhancement of their conservation, the wider cultural transmission, the emphasis on the integrity and sustainability of historic districts, and a better showcase of the city.

### 1.1.3 New perceptions with the application of new technologies and methods

With the rapid development of information technology in recent years, the use of big data has had a positive impact on the disciplines of urban planning and urban design, providing new perspectives and methods to collect, utilise and analyse relevant data to further promote a diverse and vibrant city. The use of new technologies has brought

unprecedented amounts of supporting data, enabling urban planning and design to be considered, analysed and improved at multiple levels, from macro to micro. As the most basic and data-centric carrier in the analysis, the street, combined with the multi-layered data, provides sufficient information to direct the improvement of the spatial environment and quality. The analysis of the walkability of streets belongs to the micro level. By using multidimensional data such as street location, POI number, street image, web evaluation and questionnaire, the accessibility, convenience, safety, diversity, comfort or character of the street can be analyzed. In the process of improving the walkability of the street, the functions can be improved, the quality can be optimised, the characteristics can be presented and the vitality of can be enhanced<sup>[8]</sup>.

## **1.2 Review of related research**

### 1.2.1 Theoretical developments of walkability in foreign districts

In cities of the medieval period, such as Milan (Italy) and Boston (USA), the pedestrian street was characterised by a high degree of walkability due to the moderate size of the population, the small scale of the city, and the fully mixed utilisation of the attribute of the land<sup>[9]</sup>. At the end of the 19th and beginning of the 20th centuries, the gradual decline of the old city led to a search for change and a desire for a new living environment. At the same time, the need for extensive urban restoration and construction after the Second World War and the growth of the automobile industry led to the rise of modern urbanism, represented by Le Corbusier. It is hoped that the problems of urban development can be solved through the use of advanced technology and efficient transport organisation which can increase urban density<sup>[10]</sup>. While the dominant modernist context solved some of the problems of urban development at the time, as cities became wider, faster and more densely populated, their streets seemed to lose their former vitality by becoming traffic containers with an emphasis on movement. Robertson (1994) argues that the advent of the motor car in the 1920s announced the end of the walkable city. Wider, faster

streets divided neighbourhoods and increased the dangers of walking<sup>[11]</sup>. It was not until the 1960s that sociologists, planners and others, represented by Jane Jacobs, began to critique the way cities were built under modern urbanism. She argued that the city street was the equivalent of the city's bloodline and appealed to us to value the role of the street and to restore its functions of communication and exchange, which can bring vitality. As the demand for a return to traditional streets became more apparent, and with the prevalence of New Urbanism in the 1980s, Peter Calthorpe, a leading figure, proposed a renewed emphasis on pedestrian-centred streets by limiting the development of motor vehicles, restoring the medieval road network model and valuing the functional hybrid of urban land<sup>[13]</sup>.

By the end of the 1990s, with the development of the world economy and the advancement of technology, urban planning became more concerned with social and ecological construction, and urban research developed around the goal of improving the living environment and optimising the habitat. The concept of walkability was then formally introduced and walkability research was put on track.

In order to make a more rational evaluation of streets and to establish relevant evaluation criteria, scholars have started to study streets using quantitative methods. The earliest research goes back to Brewer (Cervero 1997) who measured the distance between the edges of street or the distance between centrelines of the street as total lengths and concluded that the connectivity of street is inversely proportional to the length<sup>[14]</sup>. As the research progressed, the quantitative study of streets began to move from a single indicator to a more multifaceted and integrated level.

Michael Southworth (2005) defines walkability in his article *Designing the Walkable City*, where he argues that walkability refers to the built environment providing pedestrian comfort and safety, linking people to different destinations within a reasonable range, to a degree that supports and encourages people to walk as much as possible, and providing visual interest for journeys throughout the street. It contains six elements: (1) Connectivity of path network, both locally and in the larger urban setting, (2) Linkage with other modes: bus, streetcar, subway, train, (3) Fine grained

and varied land use patterns, especially for local serving uses, (4) Safety, both from traffic and social crime, (5) Quality of path, including width, paving, landscaping, signing, and lighting), (6) Path context, including street design, visual interest of the built environment, transparency, spatial definition, landscape, and overall exportability<sup>[15]</sup>. Then the theoretical framework for street walkability has been developed. It serves as the basic comprehensive indicator dimension to facilitate the more complex and comprehensive evaluation of street walkability at a later stage and to further guide the development of the city.

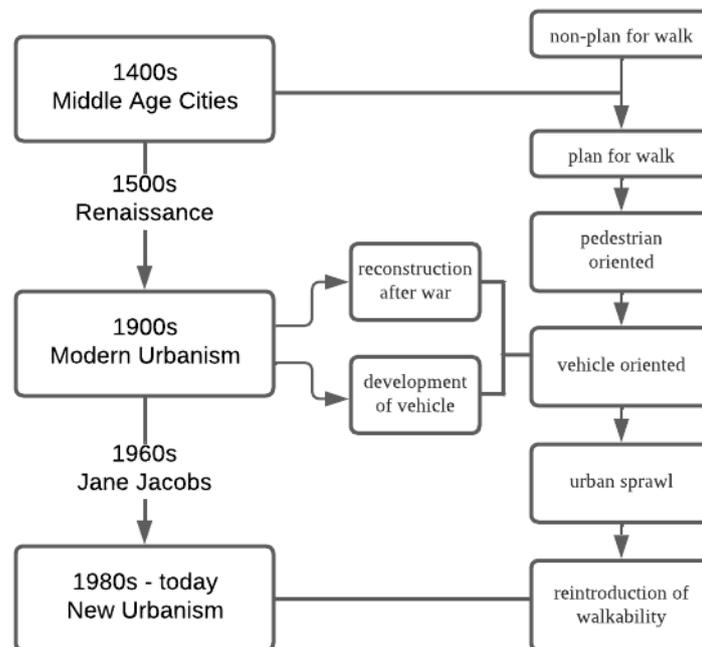


Figure 1-1 The development of walkability (Source: Self-illustrated by the author)

### 1.2.2 Theoretical developments of walkability in domestic districts

In comparison with foreign studies, research on the walkability of districts in China is relatively late. The first study of street walkability in China was conducted by Li Huai Min (2007), who introduced the pedestrian space in Venice, Italy<sup>[16]</sup>. Later, Lu Yintao (2013) studied the relationship between accessibility of pedestrian destination and walkability of street based on a questionnaire<sup>[17]</sup>.

Yang Junyan et al. (2019) attempted to quantify the walkability of streets using multivariate data from four aspects: accessibility, safety, convenience and comfort<sup>[18]</sup>.

Lu Mao-Kai (2019) analysed the mediating effect of self-efficacy between settlement built environment and residents' walking activities , and to figure out the moderating role of socio-demographic characteristics in this process through modelling. Shen Leihong and Jiang Yinghong (2020) sort out the main problems of uneven distribution of rights-of-way in urban streets and their causes, and make suggestions for the repair and improvement of urban streets, taking into account the development trend of urban street design<sup>[19]</sup>. By analyzing the influence of the built environment on walking behavior, Han Zhengda (2020) proposes countermeasures for the construction and renovation of a pedestrian-friendly environment in urban residential areas from planning and design level<sup>[21]</sup>. Liu, B.C. and Xiong, W. (2020) evaluated the pedestrian street network in the study of Tongzhou, the sub-centre in Beijing in terms of four dimensions: connectivity, convenience, safety and comfort, based on the need for a 15-minute living circle. Based on geographic big data sources such as night-light remote sensing data and Tencent Street View data, Qianqian Wang (2020) integrated two influencing factors, the purpose of the trip and the walking environment between the departure and destination, into the walkability evaluation to explore new ideas for the study of the walkability of streets in ancient cities from the perspective of tourists. As a result, related research in China has achieved relatively rapid development in a short period of time, transitioning from an early study of relatively single indicator relationships for street walkability, to an evaluation system based on complex relationships, and then gradually realising the use of multivariate data to quantify walkability.

While academic research on the evaluation of the pedestrian environment has made promising progress, the construction of a healthy environment, which is closely related to walking, has also received widespread attention at government.

Provinces and municipalities have actively introduced policies and plans to strengthen slow-traffic system. And in 2021, the outline of the 14th Five-Year Plan of the National Economic and Social Development of the People's Republic of China and Vision 2035 explicitly proposed the construction of slow-travel networks such as bicycle paths and

walking paths, further demonstrating the importance that the country attaches to green mobility. In the same year, Beijing also issued the "Work Plan for the Improvement of the Quality of Beijing's Urban Slow Walking System in 2021" to implement the improvement of the urban slow walking system into a specific work plan. In Shanghai, the "Shanghai Slow Transport Planning and Design Guidelines" were issued to promote the construction of a complete urban slow transport network. It is believed that more cities will introduce relevant policies one after another to speed up the construction of urban slow-traffic networks.

### 1.2.3 Evaluation methods for the application of walkability in the district

In general, the evaluation of street walkability has evolved from a single indicator to multiple and complex review tools, and specific evaluation methods have evolved with the development of information technology from subjective attempts to quantitative research, which can be divided into two main categories: the first is based on the traditional approach to walkability evaluation, which includes walkability evaluation research based on the audit of indicator systems and walkability evaluation research based on the perception of walking behaviour; the second is based on multidimensional data for walkability evaluation research.

In the early stage, respondents' intentions were usually collected in the form of a questionnaire, on the basis of which a quantitative analysis was carried out. For example, Ewing and Clemente (2013) developed an urban design evaluation system in which respondents were asked to quantify five dimensions, including enclosure, human scale, transparency, tidiness, and imageability, through a combination of street images and a questionnaire<sup>[24]</sup>. Then in the context of the rapid development of computer technology, we ushered in the new data era. Quantitative analysis methods such as location-based data, review data, street-view data, physiological sensor data, etc. are beginning to develop at a rapid pace. The maturation of communication and sensor technologies will bring us huge amounts of new data, which will allow us to analyse the behavioural activities taking place in the city on a large scale and at a

granular level.

Table 1-1 Quantitative research on street quality ( (Source: Self-illustrated by the author)

Typical methods and representative studies of quantitative research on street quality			
Method	Author	Thesis title	Content of Research
Subjective evaluation based on questionnaires	Ewing and Clemente 2013	Measuring urban design: Metrics for livable places	Quantitative evaluation of the five dimensions of the city with questionnaires
	Yao <sup>[25]</sup> et al. 2016	Urban function connectivity: Characterisation of functional urban streets with social media check-in data	Points of interest from social networking sites and their check-in data are used to understand the functional density and mix of streets. Points of interest can also be used to measure the walkability of a street
Quantitative research based on location data	Ruddle <sup>[26]</sup> et al. 2011	Using Google Street View to audit neighborhood environments	The study based on Google Street View maps is consistent with the results of the empirical study and the evaluation based on street view data is reliable

Quantitative research based on street view data	Li <sup>[27]</sup> et al. 2015	Assessing street-level urban greenery using Google Street View and a modified green view index	Quantitative assessment of street greenery using street view maps
	ZhouYin <sup>[28]</sup> et al. (2017)	Large-scale evaluation of the Street Walk Index - Methodological improvements and application in Chengdu	A large-scale study of street walkability in Chengdu using POI data, street map data and computer recognition techniques
Quantitative research based on physiological sensor data	Aspinall <sup>[29]</sup> et al. 2015	The urban brain: analysing outdoor physical activity with mobile EEG	Using an electroencephalograph to observe changes in brain waves during walking activity in different walking groups and environments
Quantitative research based on 3D building data	Harvey <sup>[30]</sup> et al. 2017	Streetscape skeleton measurement and classification	Using machines to reconstruct streets in three dimensions and applying the collected data for quantitative studies

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Quantitative research based on multivariate data	Yang Junyan et al (2019)	Research on Spatial Characteristics and Optimization Strategies of Urban Street Walkability Based on Multi-source Big Data - A Case Study of Nanjing Central City	An attempt to quantify the walkability of streets in terms of accessibility, convenience, comfort and safety using multivariate data
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#### 1.2.4 A summary of the current state of research

Through a review and analysis of the theories and methods of evaluating the walkability of streets at home and abroad, we can understand that the perception of the importance of a walkable street has gone through a process of upward spiral. With the new context and needs of the times, car-orientation was once the primary consideration in street design, until the return of the human-centred concept that gradually awakened a renewed quest for pedestrian-friendly streets. Based on the theoretical research of walkability that has been continuously upgraded and improved in foreign countries, a series of discussions and analyses have gradually been carried out in China, from the study of single indicators to a more complex and systematic evaluation mechanism, from the traditional evaluation method to the multidimensional data, trying to combine the development and application of modern technology to carry out quantitative analysis of walkability through multidimensional data. The studies of these predecessors have provided us with a wealth of important basic information and enabled us to become fully aware of the development, evaluation and enhancing methods of walkable streets. This has paved the way for additional research to follow. At the same time, we can also find some shortcomings and

deficiencies in previous studies, as the evaluation system of street walkability in China is mainly focused on the larger scale of urban roads, and there is relatively less mention of the systematic evaluation and the basis of selecting indicators of streets in historic districts. Therefore, this paper hopes to explore and experiment in this area.

### **1.3 Purpose and significance of the study**

#### 1.3.1 Purpose of the study

(1) Based on the literature review, this paper takes a typical representative of the historic district in Guangzhou, Changhua District as the research object, and obtains a specific evaluation index system and measurement method for the walkability of the historic district. Through data-based analysis of the pedestrian characteristics and spatial environment elements of Changhua District, realizing the interpretation of the influence mechanisms of the walkability, construction of a more scientific and objective walkability index system, and establishment of a corresponding measurement method for the classification of streets with different characteristics in historic districts from human-oriented perspective, then based on it to propose specific measures and related recommendations to improve the walkability of different streets.

(2) The research combines qualitative description and quantitative analysis of the historical and cultural district of Changhua District and further realizes the analysis of pedestrian behavior characteristics by conducting questionnaire interviews on the walkability of the district, supports the optimization of walkability indicators, and obtains a comprehensive evaluation of walkability, so as to realize a refined analysis of the district and discover the existing problems.

(3) Based on the evaluation results obtained from the analysis, corresponding improvement suggestions and measures are proposed to realize the optimal design of the walkability in district.

#### 1.3.2 Significance of the study

(1) Theoretical significance: To conduct a comprehensive evaluation of the walkability

of historical and cultural districts in cities by using the constructed evaluation measurement system for the walkability of historic districts, to improve the data of walkability studies in different cities, and to actively promote and support the realization of a unified comprehensive evaluation system for the evaluation and comparison of the walkability of domestic cities in the future as a data base.

(2) Practical significance: to obtain basic information on the walkability of the historic and cultural district of Changhua District in Guangzhou through research, to obtain comprehensive evaluation results of the walkability based on this analysis, to discover and analyze the problems and opportunities; to propose corresponding improvement suggestions for the problems that arise in the actual use process, and also to serve as a basis for the relevant design and management departments to formulate policies and measures, and as an accumulation of experience to assist the relevant planning and design.

## **1.4 Content and methodology of the study**

### 1.4.1 Content of the study

The research in this paper reviews the development and application of walkability theory and its evaluation methods and tools. To study the characteristics of walkability within the streets of historic districts, a quantitative evaluation system is formed by combining multidimensional data analysis with the selection of walkability evaluation indicators, based on which a classification of streets with different attribute is achieved in order to facilitate the specific design strategies and guidelines, also the optimal design of street walkability. The details are as follows.

(1) As the theoretical developments and specific applications of walkability from urban planning to street design have been studied, summaries and draws on the characteristics of these developments can be obtained, a framework for research on the walkability of historic district is developed.

(2) Through the construction of a customized index system and measurement

method, a detailed evaluation framework is constructed in terms of connectivity, convenience, safety, history, comfort and diversity to form a comprehensive analysis of the walkability in the study area.

(3) Based on the constructed walkability index system, data collection was conducted for the study area. Questionnaire survey data, self-collected streetscape image data, pedestrian network data, POI business data, network evaluation data, etc. for the streets are included. Constructing the data base for the study of the walkability in historic district as a foundation for the classification of the streets.

(4) Design strategies are developed for different streets as an effective reference for enhancing the walkability of the street. By optimising the specific design of the more malleable streets, the resource and value of the site could be exploited to meet the requirements of different people.

#### 1.4.2 Methodology of the study

(1) Literature review method: by reviewing journals, papers, books and materials related to street walkability and the spatial quality of streets in historic districts, the theoretical basis and evaluation system of street walkability research in historic districts were obtained.

(2) Questionnaire method: a questionnaire is used to obtain evaluations from people of different genders (male, female), ages (old, middle-aged, young) and types of status (resident, visitor, businessman, passer-by, worker, etc.) on a five-point Likert-type scale. The descriptions of specific walkability indicators are used to rate perceptions on a scale of 1-5, as a basis for the weighting of the different indicators and as a reference for the classification of the different attribute of the street.

(3) Field research method: through the field research of the pedestrian environment of Changhua District, the streetscape images of the district were collected as basic data for the analysis of the spatial environment and quality of the streets in the district. At the same time, the relevant documents of the upper plan were combined and analysed to form a basic knowledge and optimisation orientation of the walkability.

(4) Empirical analysis of data augmented design method: using Changhua district as the research object, a series of data analysis was conducted to quantify the walkability of the streets in order to promote specific and optimised design in the later stages. The data was obtained by using street view images from Gaode Map, microblogging data, public review data and CAD calculations, combined with image data, questionnaire record and statistical data for integrated qualitative and quantitative analysis, as a foundation for classifying streets with different attributes to promote further optimisation strategies and designs.

## **1.5 Framework for Research**

The framework of the study is structured in four main parts, the first part serves as a basic study to explain the background related to the walkability of historic districts, based on which the second part constructs the evaluation system, combining the methodology of data augmented design. The third part specifies the specific evaluation approach, quantitatively evaluating the district in terms of both environment and vibrancy, using the composite score as a basis for classifying the street in order to propose a concrete enhancement measure. Finally the empirical part uses Changhua district as an empirical example, using the evaluation approach developed in the previous section to carry out specific analysis and research to support the corresponding optimisation strategy and design at a later stage.

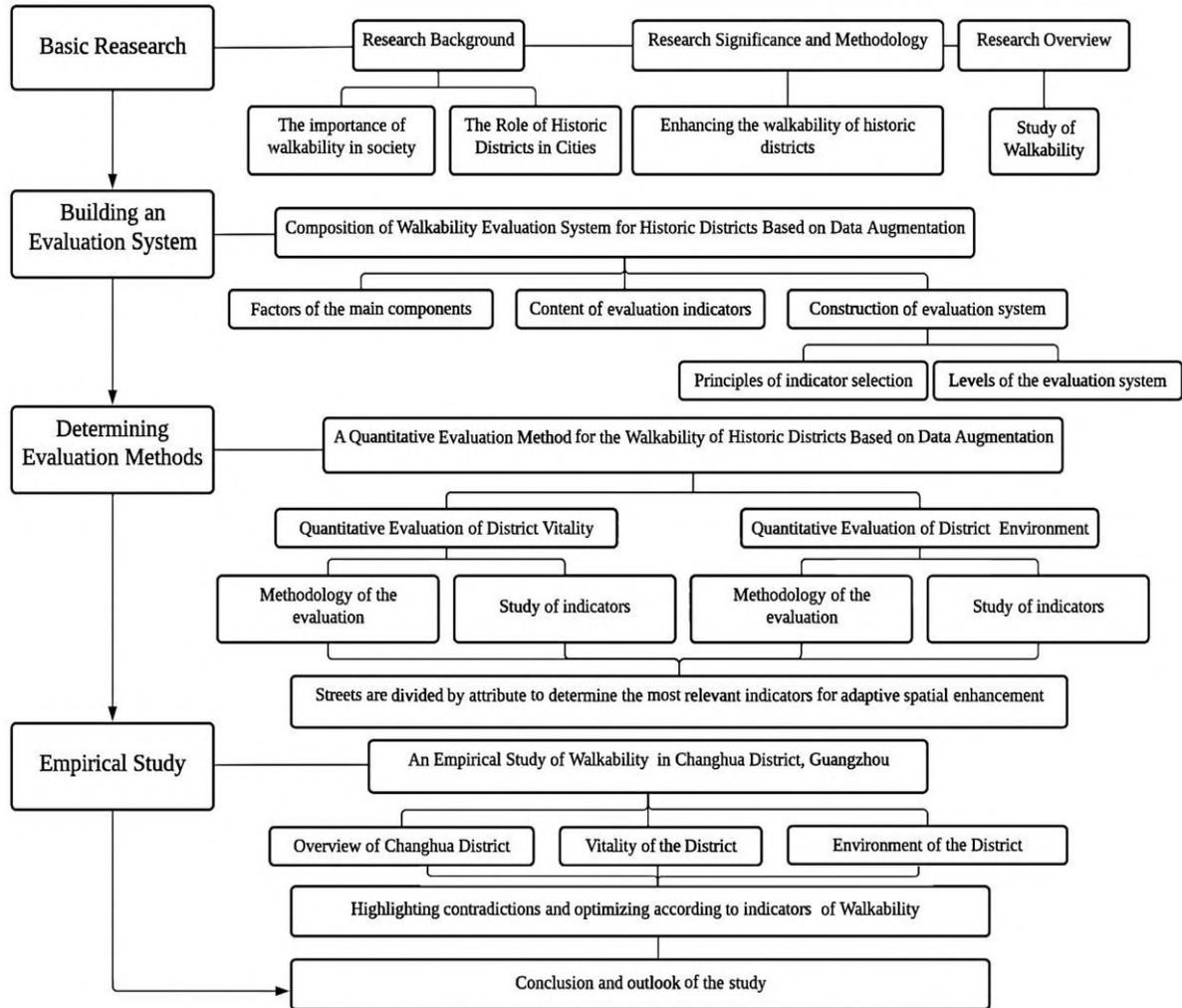


Figure 1-2 Framework of analysis (Source: Self-illustrated by the author)

## Chapter 2 Quantitative Evaluation System for Walkability

### 2.1 Research on the characteristics of walkability in historic districts

#### 2.1.1 Spatial characteristics of historic districts

As a place of "spatial identity" in the city, the historical and cultural atmosphere of a historic district can embody its richest qualities, revealing multiple layers of intrinsic values, both material and immaterial, combined with the distribution and adaptation of various modern businesses, to form a sense of history and place that is specific to the new period. In this way, the diverse urban culture can be further displayed and the urban context can be continued. Therefore, from the perspective of the relationship

between the spatial characteristics and the spirit of the historical and cultural district, it is possible to sort out a context for the spatial ideology of the district and the city, showing three unique spatial qualities, namely the assimilation of a sense of history and locality, the revival of the culture of local market, and the construction and refraction of social relations. Therefore, the streets of the historic districts, both in the physical environmental space and in the relational social space, are rich in the creation of cultural meanings in their unique historical and cultural space. And the spirit of place in the historic district is fully expressed<sup>[31]</sup>.

### 2.1.2 Concerns and needs of pedestrian

With regard to the walkability of a district, on one hand it can be understood in terms of the built environment or land use characteristics, evaluating whether it is conducive to the needs of the residents in the district to walk for leisure, exercise or recreation, access services or travel to work. On the other hand, it is possible to evaluate what exactly constitutes a pedestrian-friendly environment, looking at specific indicators in terms of the concerns and needs of pedestrians. Using the latter approach, a related study by Transport for London<sup>[32]</sup> found that walkability could be categorised into seven main factors based on pedestrian concerns and needs, as described in the table below.

Table 1-2 7C index ( (Source: transfer-illustrated by the author)

7C index	Definition
connectivity	Parameter linked to pedestrian environment(such as interface, joint work...)
convenience	Parameter linked to appropriate/useful/suitable concepts
comfort	Linked to easy, pleasant, protected, relaxed, sheltered, untroubled concepts
conviviality	Linked to sociable parameters
conspicuous	The extent to which the pedestrian environment is obvious, clear, discernible, distinct and perceptible
coexistence	The extent to which the pedestrian and other transport modes can exist at the same time and place with order and peace
commitment	The extent to which there exist engagement, liability and responsibility towards the pedestrian environment.

### 2.1.3 Summary

In general, under the goal of enhancing the walkability of historic districts, the characteristics of historic districts themselves should be preserved and inherited to the greatest extent, and the basic requirements of people for the walkability of districts, in which parameters, such as conviviality, linked to sociable parameters, it is equal to diversity; it should be the main factor to be considered in the evaluation index if it can promote the expression of the characteristics of the historic district.

## **2.2 Construction of the evaluation system for the walkability of historic districts**

### 2.2.1 Basis and content of the selection of indicators

Based on the spatial characteristics of the historic district, such as the assimilation of

history and locality, the revival of the culture of local market, and the construction and refraction of social relations, and taking into account of people's perceived needs for continuity, convenience, comfort, sociality, iconicity, coexistence, and safety to form a general foundation of relevant elements of walkability in historic district. In addition, Cui Ying et al. (2015) combined existing research to propose a walkability evaluation index system and data survey method that takes into account accessibility, safety, convenience, comfort and aesthetics for the environmental characteristics and walking needs of historical and cultural districts<sup>[33]</sup>, and Lv Haiping (2021) by identifying the problems in the existing evaluation of historic buildings, a set of indicators and methods for the evaluation of the conservation and use of historic buildings was constructed<sup>[34]</sup>. Therefore on the basis of the previous analysis, a framework for systematic walkability evaluation of historic districts can be developed as follows.

The comprehensive system for evaluating the walkability of a district consists of six main indicators. Each indicator contains two dimensions, the physical environment and pedestrian perception, which are then expanded to the next level of detailed quantitative evaluation indicators. In the case of connectivity, the degree of connectivity with other modes of transport, the density of the pedestrian network and the width of the specific pedestrian street are evaluated quantitatively. This is ultimately reflected in the texture of the road network. As to the convenience mainly focus on the service facilities, including the the aspect of accessibility and completion with the consideration of street furniture and facilities. Safety encompasses the pedestrian environment and the perception of pedestrian safety, as reflected in the level of congestion, lighting and wayfinding systems that help to achieve a basic guarantee of the physical environment of the street. History focus on the character of the open space and the associated street elements, they work together to create the historic and cultural atmosphere of the district. The overall orientation is achieved in terms of the specific spatial environmental conditions and the transmission of the historical and cultural spirit of the place. Comfort focuses on the interface of the place,

including the cleanliness of the street, the shade, the visibility of the sky, etc, and is mainly reflected in the perception of specific street elements by people. As to diversity, it contains the specific functions of the street and its attraction to the people, in terms of the different points of interest, the evaluation of the specific people and the interactivity of the environment, which together form the different attributes of the place.

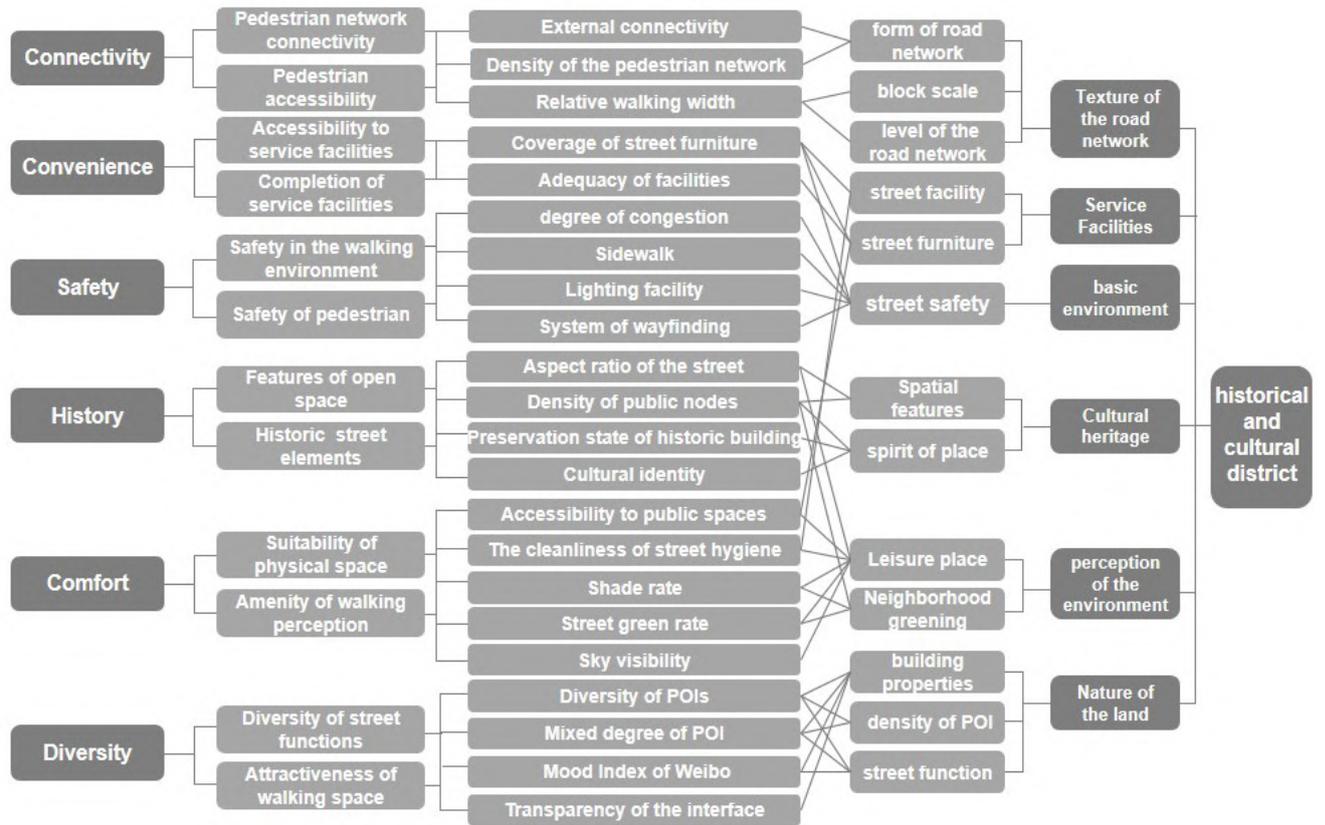


Figure 2-1 Framework of evaluation system for the walkability in historic districts (Source:

Self-illustrated by the author)

### 2.2.2 Quantitative evaluation of district vitality

Street vitality is often expressed through the diversity of amenities surrounding the street. Walkable neighborhoods require a 20-minute walking distance or 800 meters to accommodate the activities that people need on a daily basis. These activities include shopping malls, restaurants, banks, medical centers, fitness centers, elementary and secondary schools, libraries, parks, etc. The prerequisite for this is to

enhance the mix of land uses, increase the diversity of the neighborhood, and shape the vitality of the street. In terms of street vitality factors in historic districts, a vital street can be understood as a street with popularity, where people are attracted to the street by certain factors. Therefore, street vitality indicates the probability of attracting people to the street. In the Walk Score concept, the density and variety of daily facilities available to residents in a street are used as indicators.

In the evaluation of walkability of Chinese cities published by the Natural Resources Association (2017) using point of interest (POI) distribution for a quantitative study of street vitality. They concluded that streets are more likely with the greater the number and variety of points of interest, the more likely it is to attract people to visit. Therefore, in evaluating the street vibrancy of historic districts, we will use this method as the basis for quantitative evaluation. Because of the rich historical heritage and humanistic atmosphere in historic districts, the classification and weighting of points of interest in historic districts need to emphasize the historical buildings and related cultural facilities in historic districts compared with traditional streets, and focus mainly on people's perception of the environment and experience of space, which can be regarded as a further demand for walkability of the district in the spiritual aspect. Therefore, when evaluating the street vitality of historic districts, the evaluation indexes will be redesigned according to the special characteristics of historic districts. Based on the analysis of the previous indexes, the main vitality factors for the evaluation of walkability are history, diversity and comfort.

The quantitative evaluation indicators of district vitality consist of three primary indicators: history, comfort and diversity, with each primary indicator containing a corresponding secondary indicator and its specific quantitative evaluation method, resulting in a composite evaluation as a symbol of the degree of street vitality. To clarify the access to indicators and data processing and calculation methods of each index, which mainly includes street view pictures, street view picture scoring and GIS analysis.

Table 2-1 Quantitative evaluation of district vitality (Source: self-illustrated by the author)

Walk Score Index for historic districts				
Index	Specific indicators	Access to indicators	Data processing and calculation methods	Quantitative Interpretation
History	Street height to width ratio	Street View Pictures	X=H/D	
	Small open spaces	Street view picture scoring	Based on criteria for street image scoring	
	Preservation of historic buildings	Street view picture scoring	Based on criteria for street image scoring	
	Cultural Identity	Street view picture scoring	Based on criteria for street image scoring	
Comfort	Problems of motor vehicle parking	Street view picture scoring	Based on criteria for street image scoring	
	Sanitation and cleanliness of streets	Street view picture scoring	Based on criteria for street image scoring	
	Green view rate of streets	Street View Pictures	X=S green/S total	
	Shading rate	Street View Pictures	identify the proportion of green space in the street picture corresponding to the location of the street interval 50m in the base, and calculate the average value of the street	
	POI diversity	GIS	Number of POIs within 50m of the street	
	POI Mixing Degree	GIS	Number of certain POI points within 50m of the street as a proportion of the total number of POI points	

Diversity				S building represents the area of the sky in the street interface and S wall is the area of the wall in the street interface
	Interface	Street View Pictures	$X = S \text{ building} / S \text{ wall}$	
	Transparency			

### 2.2.3 Quantitative evaluation of district environment

With regard to the environmental factors of the streets in historic districts, in addition to having facilities that attract people to move around, the intrinsic environment of a walkable neighborhood is particularly important. A good pedestrian environment can make pedestrians happy to generate walking activities on the street for a long time. Only when both the street vibrancy and the street environment are met can an interesting and walkable street be created; if one of these components is missing, the street may become walkable but uninteresting, interesting but difficult to walk, or uninteresting and difficult to walk. None of this meets the requirements for a walkable street. The Natural Resources Association has attempted to evaluate the street environment in the 2019 edition of the China Urban Walkability Assessment. By combining streetscape maps with human subjective judgment of the presence or absence of street crossing facilities, street furniture, non-motorized segregation facilities, and the occupancy of pedestrian paths, the corresponding indexes are constructed, and the physical environment of the street is considered as the basis for the protection of people's walking space.

The quantitative evaluation of the district environment is also based on three primary indicators, including connectivity, accessibility and safety. Each secondary indicator corresponds to a specific quantitative evaluation method to form a composite evaluation of the district environment. The indicators are obtained through open data, CAD calculation, street view pictures as well as street view picture scoring, and then the final walk score is calculated using specific formulae and scoring criteria.

Table 2-2 Quantitative evaluation of district environment (Source: self-illustrated by the author)

Walk Score Index for historic districts				
Index	Specific indicators	Access to indicators	Data processing and calculation methods	Quantitative Interpretation
Connectivity	Density of the pedestrian network	Open Data	Length of footpath per unit area	
	Relative walking width	CAD Calculation	$X = \frac{S}{S + \text{asphalt road}}$	pedestrian space value represents the area occupied by pedestrian-only lanes in the street interface, and S tarmac value represents the area occupied by motor vehicle lanes in the street interface
Convenience	Completeness of facilities	Street View Pictures	$X = 1 - \frac{\sum(\text{Amount of Ni-type facilities})}{\text{Total N facilities}}$	The amount of Ni facilities represents the number of traffic safety facilities (e.g., pedestrian barriers) within the street coverage area, and the total amount of N facilities represents the sum of all traffic safety facilities within the street coverage area.
	Coverage of furniture	Street view picture scoring	Based on criteria for street image scoring	
Safety	Sidewalk	CAD Calculation	Proportion of total length with pedestrian-only lanes to the centerline of roadway	Indicates the potential probability of an accident occurring in a mixed traffic situation
	Lighting facilities	Street view picture scoring	Based on criteria for street image scoring	
	Wayfinding system	Street view picture scoring	Based on criteria for street image scoring	

### 2.2.4 Basis for scoring

In the scoring criteria the primary indicators include history, comfort, convenience and safety, while the detailed secondary indicators are scored quantitatively based on the

street view images, with each indicator corresponding to a specific comparison score on a scale of 0-1, corresponding to ten levels of different degrees of selection to obtain the respective score.

Table 2-3 Basis for scoring (Source: self-illustrated by the author)

Criteria for street image related evaluation index			
Index	Specific indicators	Basis for scoring	Assignment of points
history	Comprehensive value of historic buildings	Whether the building is well integrated with the surrounding open space, the condition of the building preservation, the potential for rational use and cultural identity (based on the expert evaluation in the latest conservation plan)	0-1
comfort	Sanitation and cleanliness of streets	Whether the streets are neatly paved and free of litter	0-1
	problem of motor vehicle parking	Whether there is parking along the street and the degree of impact on walking	0-1
convenience	Coverage of furniture	The presence of street furniture within a comfortable walking distance	0-1
safety	Lighting facilities	Adequate lighting	0-1
	Wayfinding system	Adequate wayfinding system	0-1

## 2.3 Constituents and influence mechanisms of data augmented design

### 2.3.1 Constituent factors

Long, Ying and Shen Yao (2015) proposed the concept of Data Augmented Design (DAD), which aims to support the generation of urban design solutions through the effective analysis of data and to achieve more rational decision making in space<sup>[35]</sup>. From a larger perspective, the data augmented design can be seen as a new planning and design methodology in the context of the existing planning and design system. It refers to a project-driven approach to planning and design through quantitative urban analysis in the context of the rapid development of new data. In practice, data analysis,

modelling and forecasting can be used to provide support tools for research, analysis, design, evaluation and tracking throughout the planning and design process, and to improve the science of design as well as to stimulate the creativity of the planners and designers by means of data empirical methods. It is simpler and more straightforward than traditional planning and design methods, making full use of both traditional and new data to achieve enhanced planning and design at some stage of scheme generation or assessment, and can be easily extended to a large number of sites, while taking into account the uniqueness of the site. What DAD actually enhances is a precise understanding of urban entities, an accurate grasp of the complex relationships between their organisation and their effects, and the practical implementation of the positive impact of spatial creation<sup>[36]</sup>.

### 2.3.2 Influence mechanisms

From a more detailed level, urban design at the meso-micro scale can be aided by the use of data augmented design approaches to obtain more refined and targeted data, such as the analysis of human characteristics, commercial layout and the state of public activity, to demonstrate the features of people's behaviour in different space and the interaction between people and space. Flexible feedback can be achieved in short periods of time to drive timely optimisation of the space.

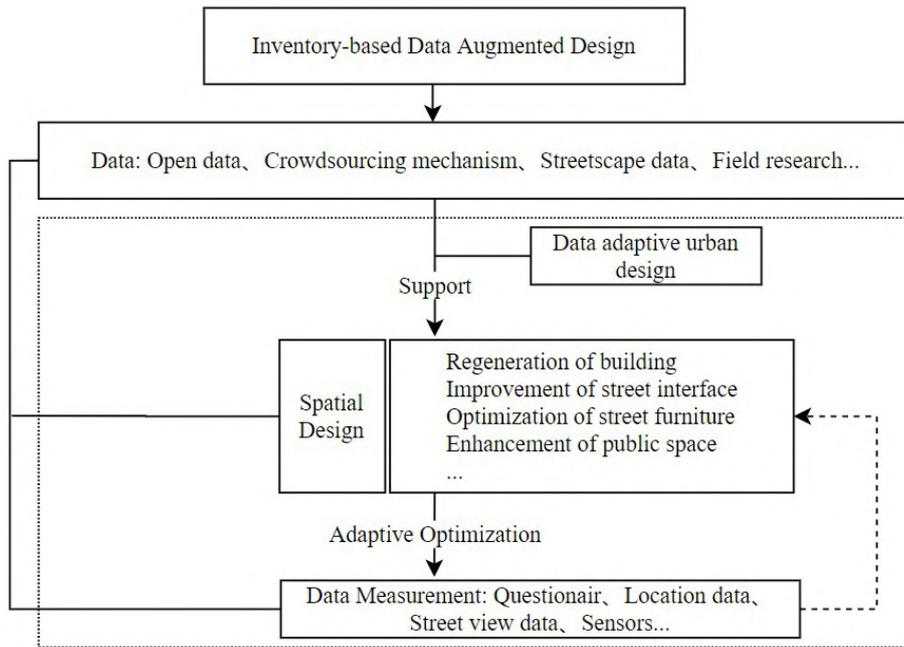


Figure 2-2 Data augmented design in meso-microscale (Source: Transfer-illustrated by the author)

There are two types of interaction mechanisms between people and space: one is a one-way relationship, where the space is designed and transformed according to the needs of people, and the other is a dynamic two-way relationship between people and space, through the combination of relevant indicators and the analysis of data platforms to achieve timely interaction and feedback adjustment between people and space.

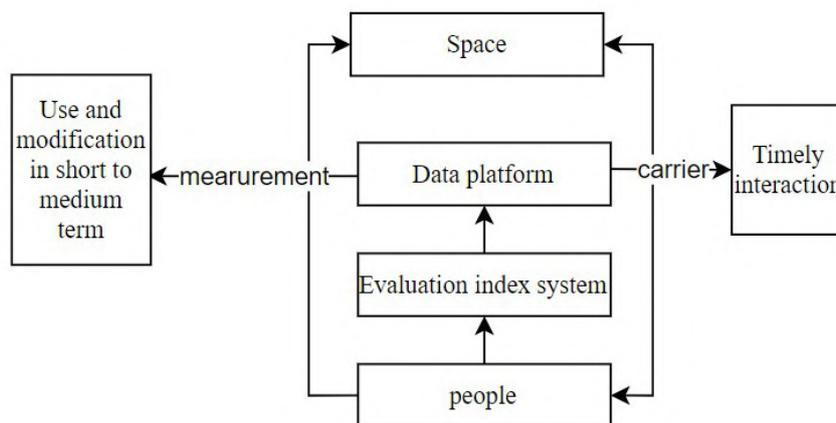


Figure 2-3 Two mechanisms of interaction between people and space (Source: self-illustrated by the author)

## Chapter 3 Research on Relevant Cases and Methodology

### 3.1 Relevant case studies

#### 3.1.1 The city of Lübeck in northern Germany



Figure 3-1 General view (Source:<https://www.shplanning.com.cn/Home/News/detail/id/252.html>)

The city of Lübeck in northern Germany is the first city in northern Europe to be listed as World Heritage Site. Data from the 2010 survey shows that household car ownership and bicycle ownership in the Lübeck region are 0.9 and 1.6 respectively, and 28% of households no longer have their own personal car. Walking accounts for 28% of people's travel patterns<sup>[38]</sup>.

The use of cars is decreasing, while the use of public transport, cycling and walking is increasing. This indicates that there is already a high level of acceptance among local citizens to live by non-motorised modes of travel. And this successful reversal of public perception is due to more than 20 years of comprehensive urban planning and policy implementation by the local authorities.

In 1991 Lübeck joined the "European Cities Climate Alliance". In 2008, the decision "Lübeck without congestion 2015" was launched. In 2010, the "Action Plan for Climate Protection" was adopted. Like other German cities, Lübeck has moved towards an

integrated urban green transport system since the turn of the millennium. Rather than restricting the freedom of choice of private cars or meeting the endless demand for private transport, an integrated urban green transport system of "rail-cycling-walking" is gradually being developed. By offering a variety of transport options, the reliance on car as a means of transport will be curbed. And the features of the walkability in Lübeck mainly include four aspects:

(1) Multi-scale connectivity of the pedestrian network

Lübeck still retains the context of medieval historic town and therefore has a good foundation in terms of pedestrian network connectivity and permeability.

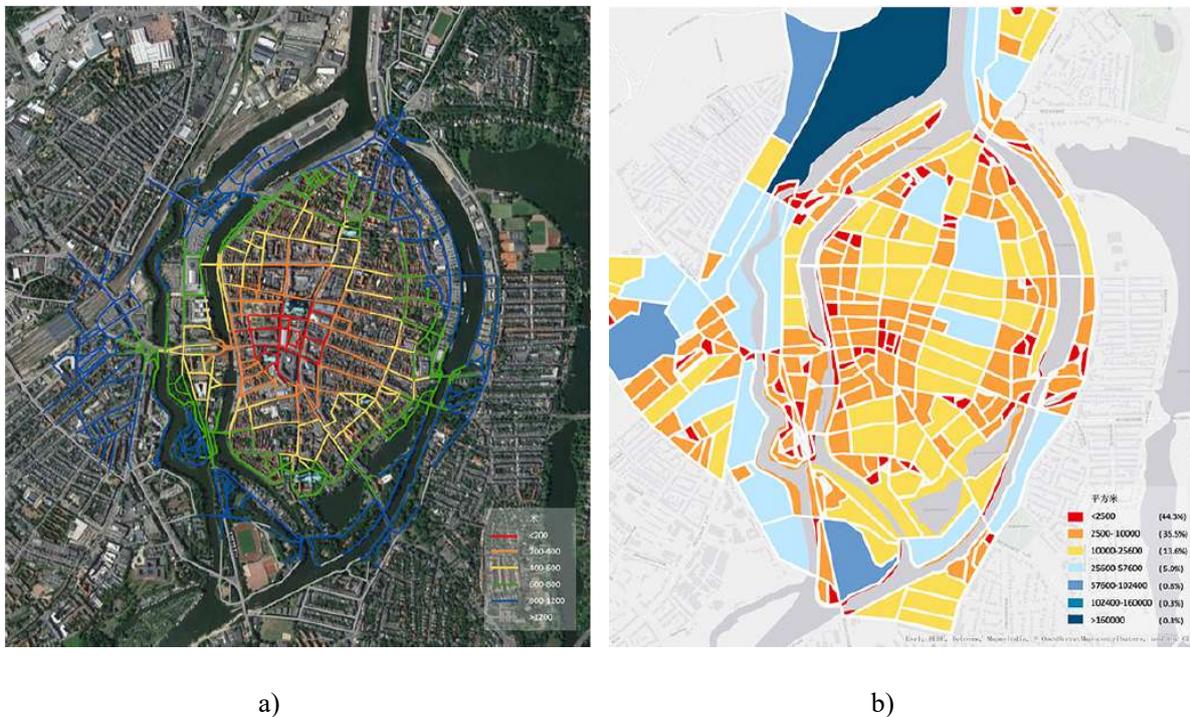


Figure 3-2 Pedestrian network. a) Network metric distance analysis from the central market and; b) Analysis of block sizes (Source:<https://www.shplanning.com.cn/Home/News/detail/id/252.html>)

(2) Convenient connections to other transport modes

Lübeck's regional public transport plan, which has now been updated to version 3, has sub-objectives that include: further enhancement of the close connection between bus stops and the surrounding area, which should be ensured within a walking distance of 5-8 min.

Coordination between rail transport, urban and regional transport should be enhanced; the historic city centre can be reached from all major destinations in the city in a maximum of no more than two transfers in 30 min. A high level of vehicle punctuality is ensured in terms of acceleration measures for public transport; the design of vehicles and stations pays attention to safety and comfort; accessibility measures for vehicles and stations, and accurate electronic information signs.

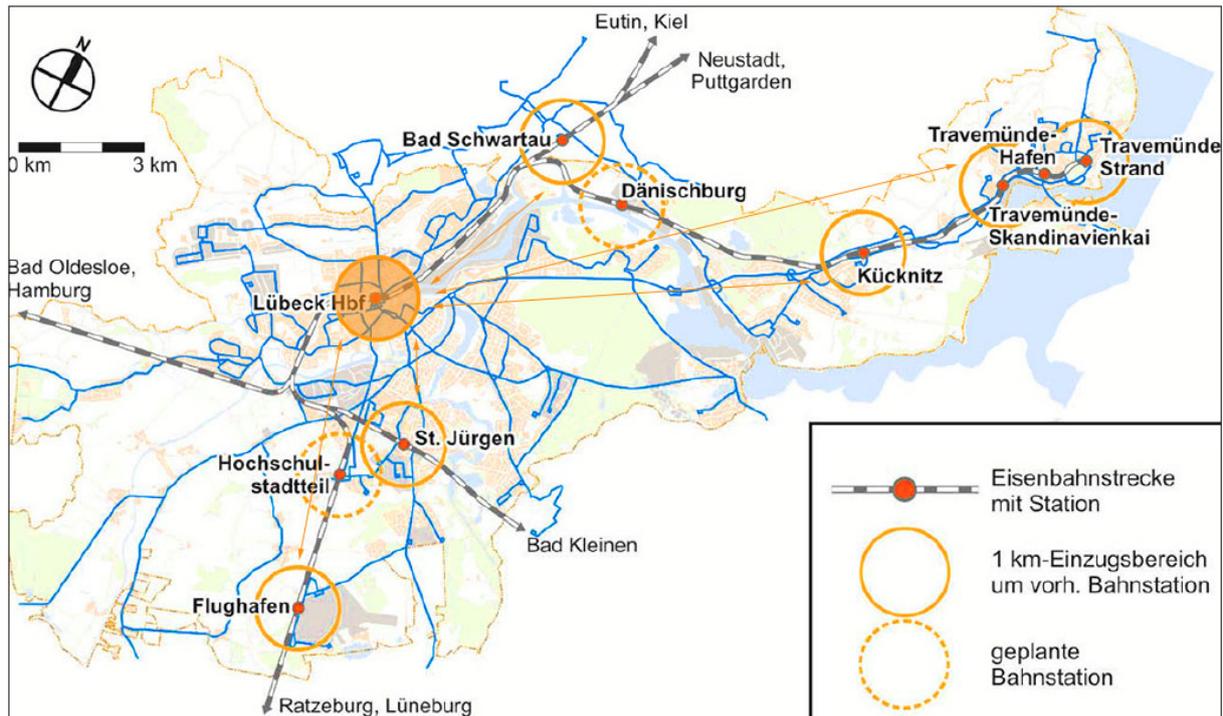


Figure 3-3 Map of the intercity railway stations in relation to the urban area of Lübeck (Source: transfer-illustrated by the author)

### (3) Refined and diverse land use patterns

Residents can reach most local services within 10-20min walking distance to meet their daily needs. The intensity and diversity of land use is planned at the outset of development. Plot subdivision is introduced from planning and design and mixed land use is encouraged.

### (4) A high quality pathway environment

Attention is paid to the quality of the path environment, which includes the scale of the street space, the presence of street trees and other landscape elements, views,

visible activity and permeability, scale and the coordination of architectural styles, making the landscape along the path attractive to pedestrians.



a)



b)

Figure 3-4 Plan and intention for the transformation of the waterfront (Source: transfer-illustrated by the author)

### 3.1.2 The historical city centre of Delft, Dutch ‘Binnenstad’



Figure 3-5 General view of Binnenstad (Source: from website)

Delft is an historical city in South Netherlands with a population of 103.1634

inhabitants. the historical city centre of Delft, Dutch 'Binnenstad'. The city centre is very vibrant due to cluster of commercial functions and activities. It attracts people from all around Delft and is accessible by walking, cycling and public transportation. Delft's city centre has approximately 12.000 inhabitants, and is substantially pedestrianized; traffic has been slowed down to support walkability and bikeability. The basic spatial features and configuration of the city including car-free areas and streets, pedestrian hubs, public transportation and a bicycle network in the field area.

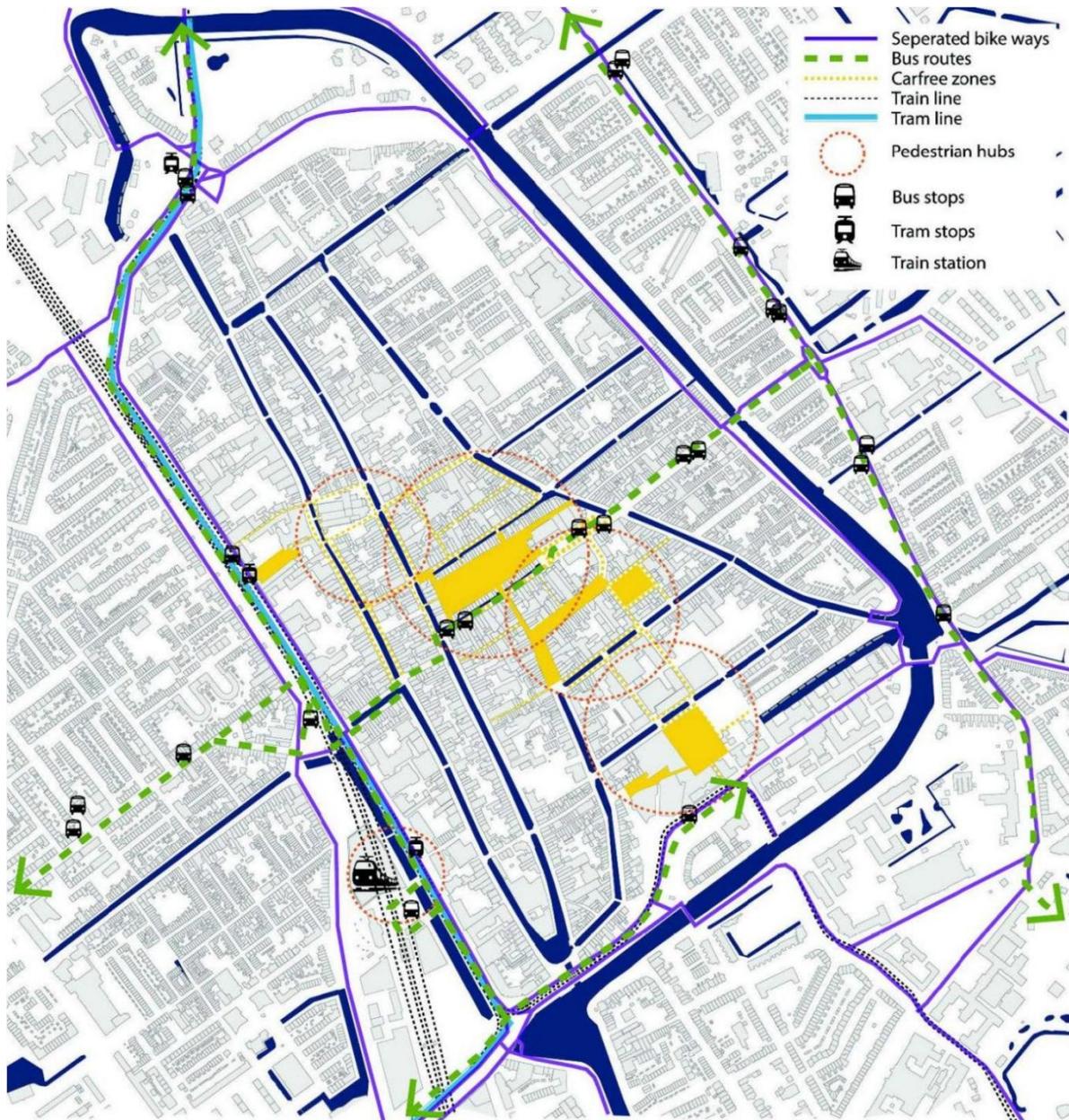


Figure 3-6 Public, bicycle and pedestrian transportation network in the city centre of Delft.

(Source: from website)

The record and analysis of 10 Go-Along walk with mobile methodologies considering pedestrian perception in 2020. It conducted the observation of accurate situation and then showed the walking preference of different people. The routes of the 10 participants and their evaluations of the street can be clearly expressed with the green word means positive attitude while the red one means negative reviews. The evaluation mainly includes five aspects: safety, traffic safety, accessibility, comfort and pleasure/attractive. It paid attention on the personal perception and specific feelings of people as the reflection of different walking experience.



Figure 3-7. Go-Along walking routes with participants in Delft (Source: from website)

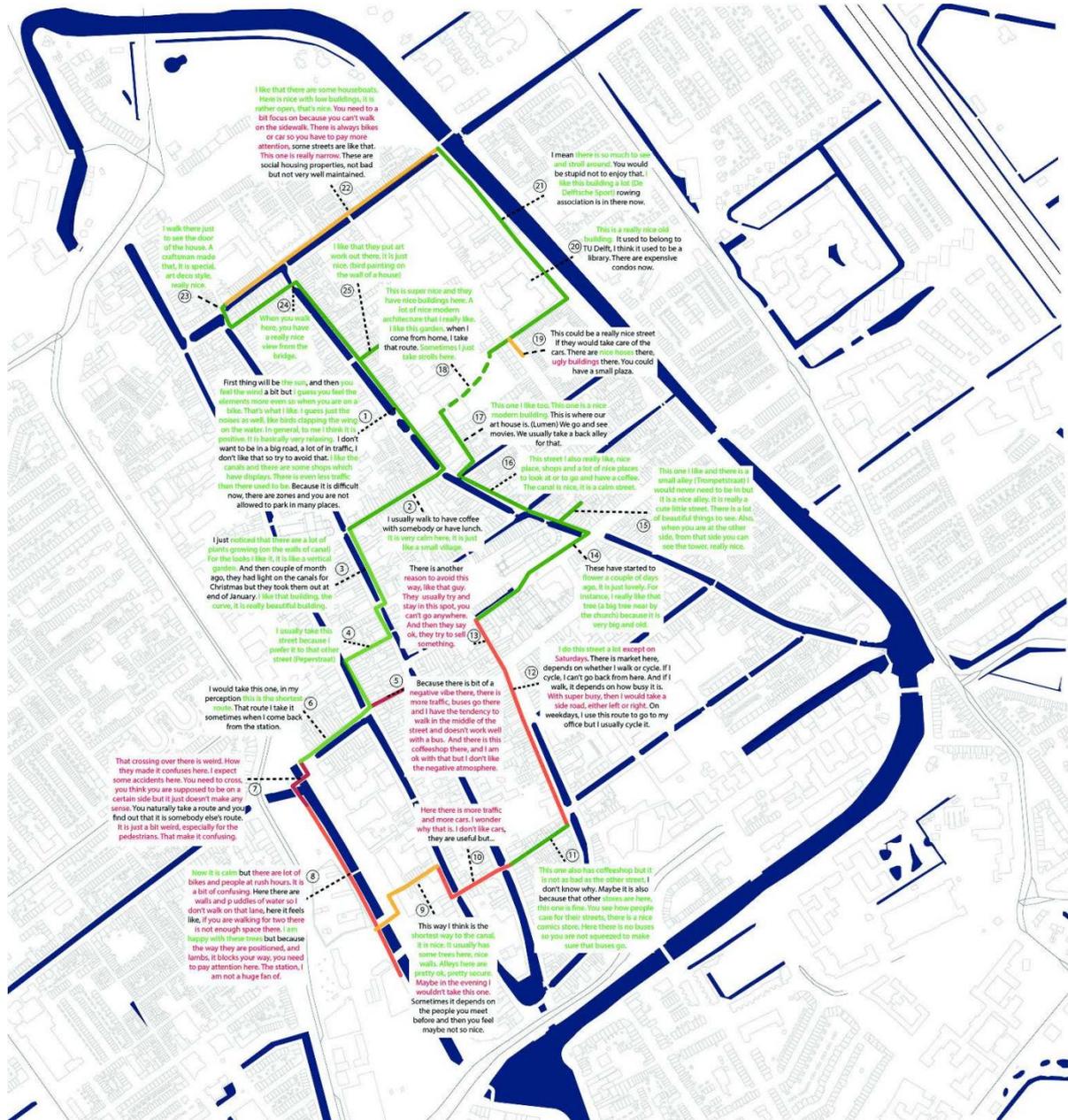


Figure 3-8. An example of visualized Go-Along walk in Delft with one of the participants.

(Source: from website)

Then based on the evaluation of the participants, 8 alternative design scenarios were built for them to choose the preference. With different floor covering on the street or the insertion of different functional devices as intuitive pictures for people to choose their preference.



Figure 3-9 Vestpoort current situation (L) and design alternatives (M/R) surface of the ground was changed, green elements were added and the street became only for pedestrians.(Source: from website)



Figure 3-10 Markt-2 current situation (L) and design alternatives (M/R) different urban furniture, green elements were added. Exhibition was located to make the place more alive and attractive.(Source: from website)



Figure 3-11 Vrouwenregt current situation (L) and design alternatives (M/R) surface of the ground became smoother and more continuous and the street became car-free.(Source: from website)

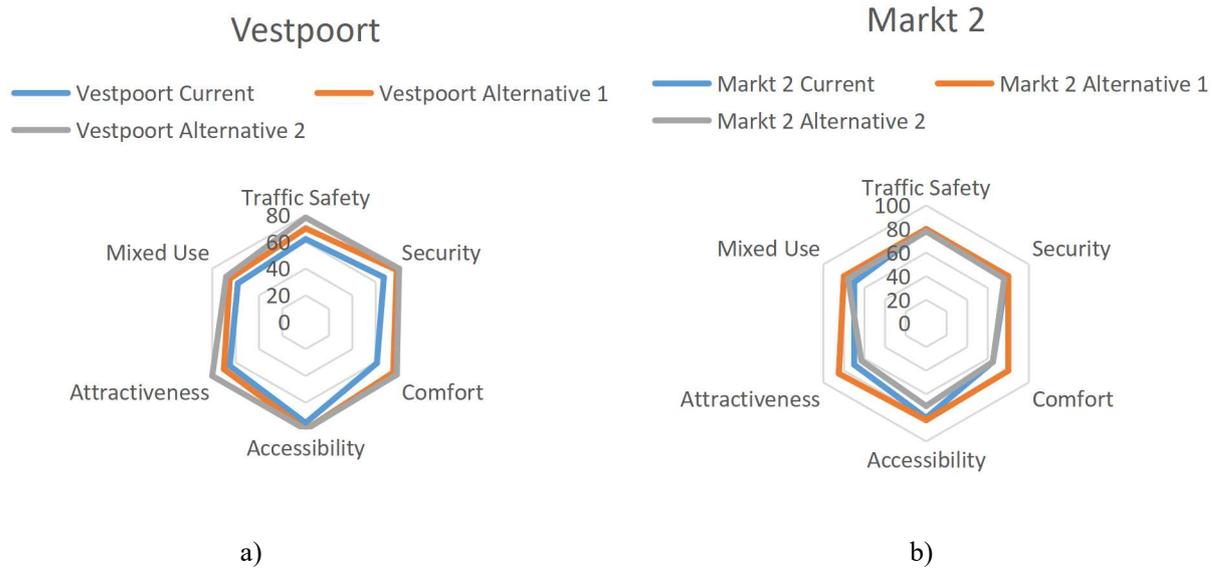


Figure 3-12 The score of each index after regeneration (Source: transfer-illustrated by the author)



Figure 3-13 The score of each index after regeneration (Source: transfer-illustrated by the author)

These results point out that the inter-relations between measures of improving walkability ,all indexes can work as a holistic system. The indexes can affect each other and normally the comprehensive evaluation will have a promotion even with the only improvement of one index.

### 3.1.3 Hengfu historic district in Shanghai

The Hengshan Road - Fuxing Road Historical and Cultural District is located on the south side of Yan'an Middle Road and the west side of Chongqing South Road in Xuhui District, Shanghai. The southeast part of the district is adjacent to Xujiahui, a

sub-centre of the city. It is the largest conservation area in Shanghai, with a total area of 7.66km<sup>2</sup>, and has a profound historical and cultural heritage, being the birthplace and carrier of Shanghai school culture and urban context. The Shanghai Street Design Guidelines (2016), which propose a distinction from roads to streets, emphasising the return from motorised traffic space to pedestrianised living space. Thus new requirements for a more refined, humanised and intelligent planning, design and management from road to street level are put forward. In the context of these policies, a series of improvements and renovations have been carried out in the Hengfu District from 2007 in order to meet the requirements of refined urban management<sup>[39]</sup>.



Figure 3-14 General view of Hengfu District (Source: from website)

#### (1) Characteristics and problems of the district

The rapid changes in the Hengfu Historic District are accompanied by a series of characteristics and problems: the continued disorderly spread of commercial shops along the streets; the conflict between the decoration of shop façades and the historic landscape; the haphazard placement of street furniture; the ageing of the local people; and the frequent changes in residents or users. According to the Hengfu Historic and Cultural Area Conservation Plan, most of the sites and buildings in the area are

protected objects. It is therefore not appropriate to adopt measures of demolition and redevelopment, but rather to focus on guiding regeneration and transformation, tapping the comprehensive value of the resources in the area.

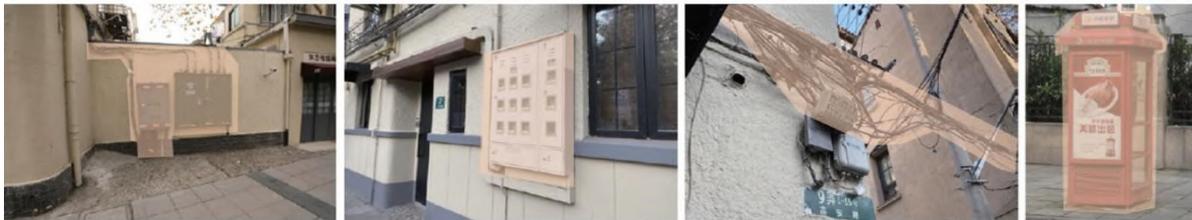


Cluttered living surfaces, windows and doors of varying sizes

The style of windows and doors is not in harmony with the building

Cluttered external air conditioning units and pipework

Incongruous advertising signs and cluttered backgrounds



Facilities such as equipment boxes and exposed pipework need to be removed and rectified

Figure 3-15 The problems in the site (Source: transfer-illustrated by the author)

## (2) Analysis of comprehensive data and division of streets

With the integration of human characteristics data, spatial function and quality data, and physical building environment and health data, quantitative assessment of existing streets could be conducted to have a better division and correspondent optimized design.



Figure 3-16 The statistics of life service POI number in each residential blocks (up) and land use pattern (down)

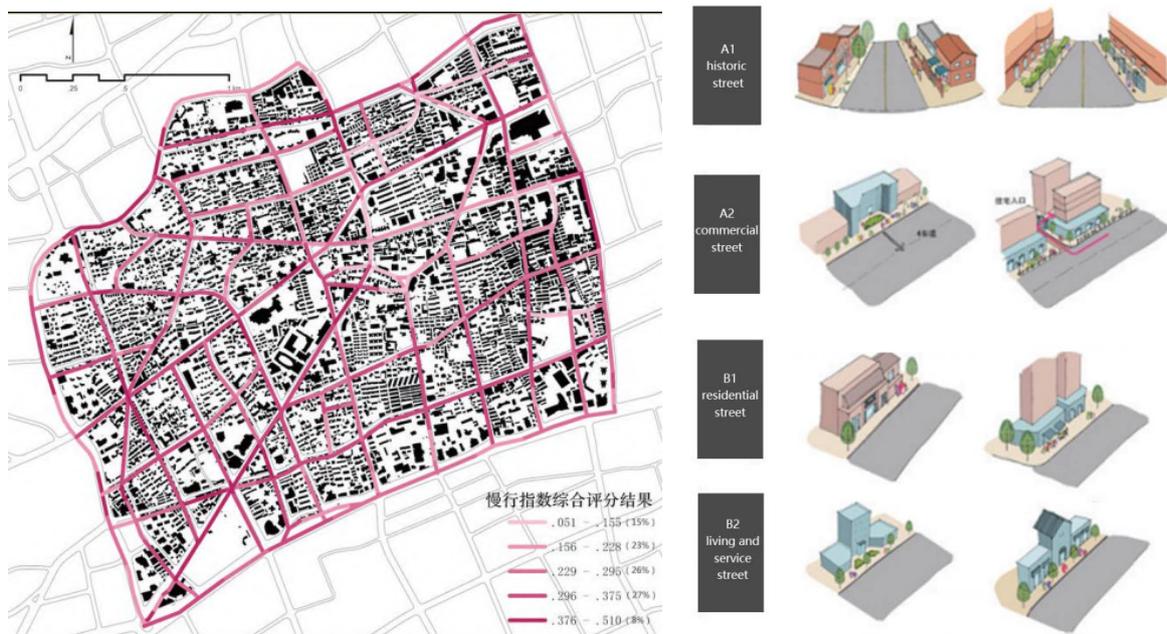


Figure 3-17 Results of the composite slow traffic index score and division of streets (Source: transfer-illustrated by the author)

### (3) Generation of specific and optimized design

Based on street slow walking index scores, questionnaire analysis of residents' perceptions of slow walking and open environmental space on streets, evaluation of the implementation of the 3-year action plan for street renovation, streets are guided into Class A streets (no drastic changes in core streets) and Class B streets

(neighborhood-level streets can be dynamically adjusted). On the basis of the division of streets, a set of benchmark design solutions was proposed for Class A streets, shaping a system of three axes of Class A1-A3 streets within design area, and implanting three types of nodes for slow moving, traffic and creative spaces.

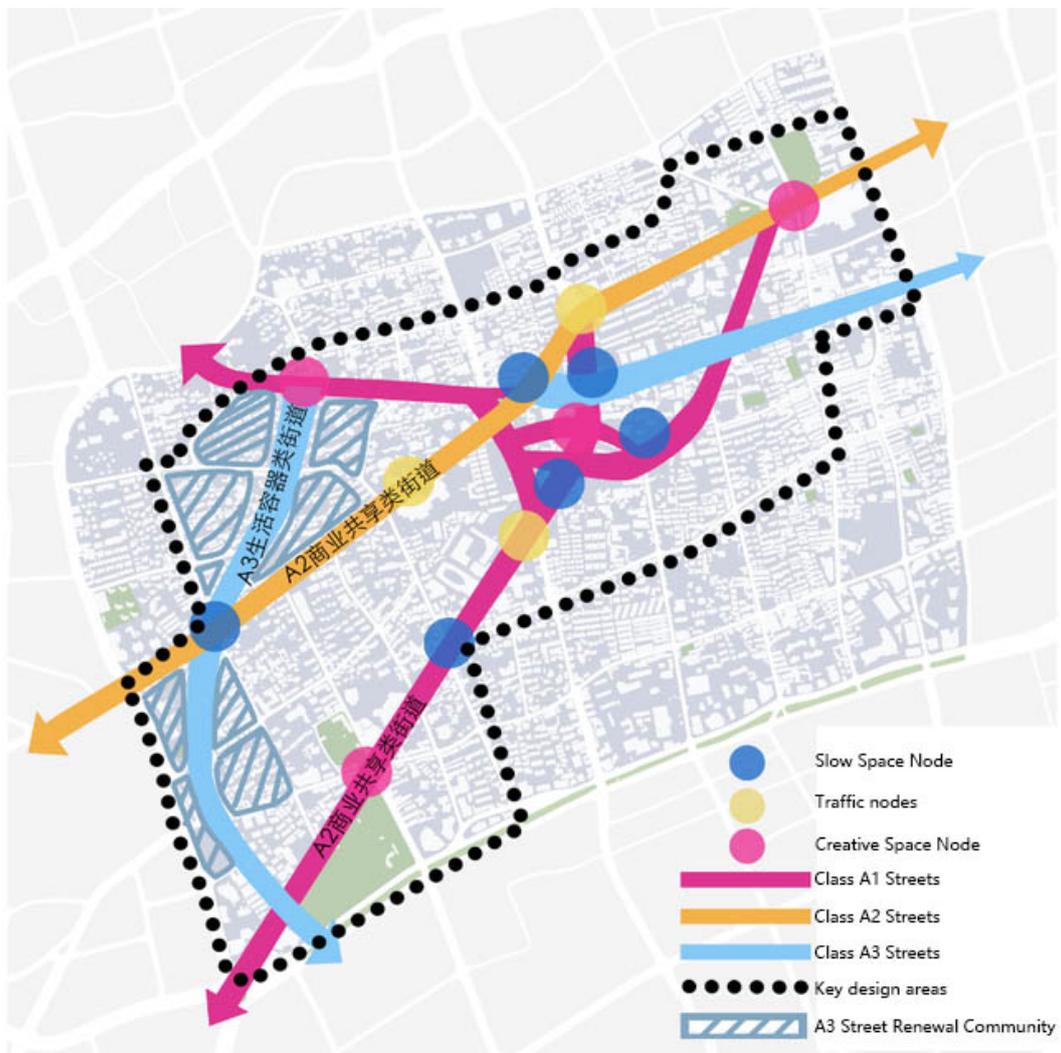


Figure 3-18 Classification of street (Source: transfer-illustrated by the author)

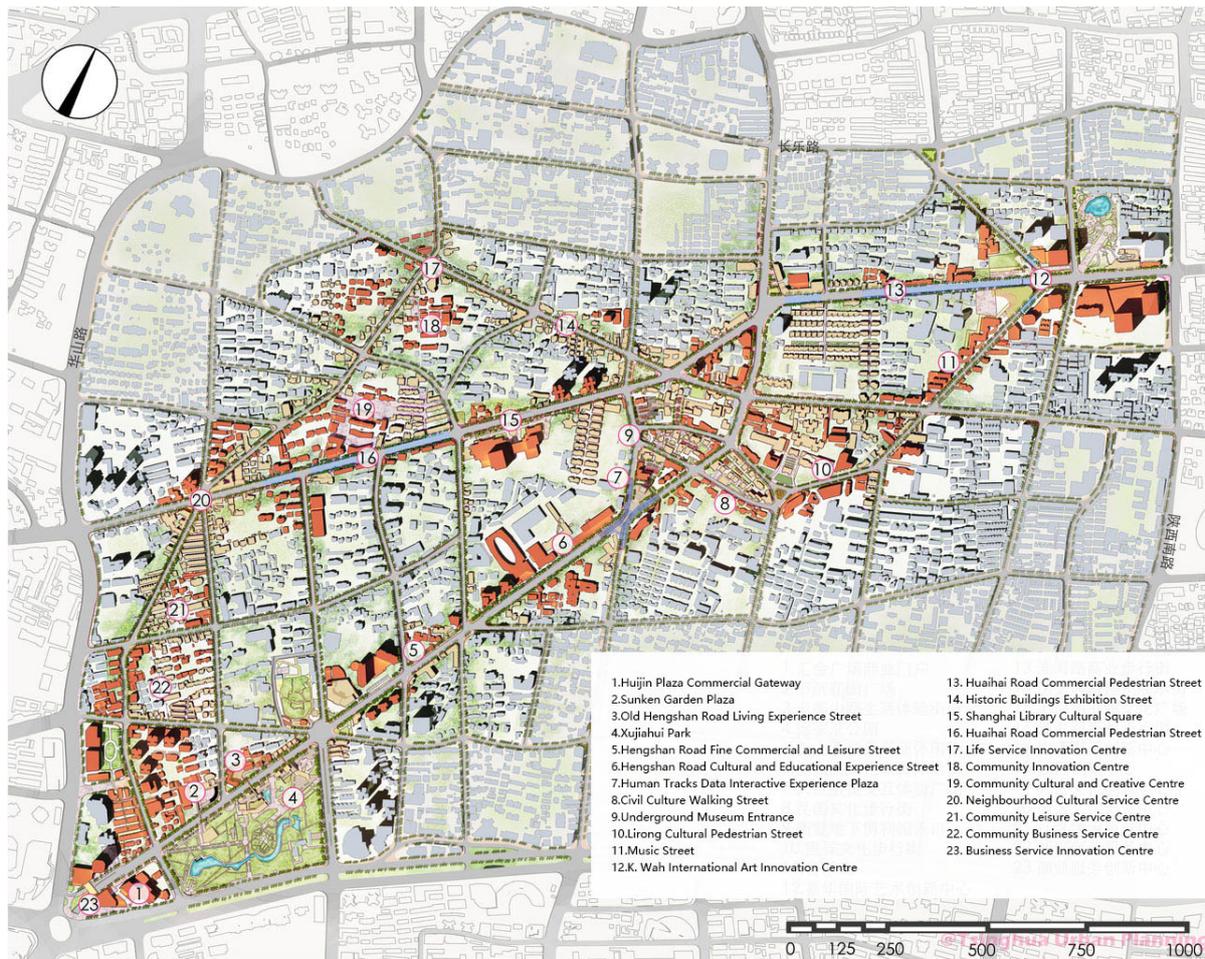


Figure 3-19 Optimized design (Source: transfer-illustrated by the author)

### 3.1.4 Conclusion

#### (1) Enhancement of multi-dimensional walkability

A multi-dimensional enhancement of the walkability of streets from large to small scale can include multi-scale pedestrian networks, transport connections, land use and environmental quality. In the systematic management of street-friendly walkability, the quality of the street environment is enhanced, the street is invigorated and the demand for pedestrian-friendly streets can be met.

#### (2) Recognition of correlations between indicators

In the process of evaluating the walkability of streets, positive correlations were found between indicators. Most of the time when one indicator improves in a positive way, other indicators will change in response, resulting in an improved overall assessment.

Therefore, the selection of key indicators in practice, to optimise the street environment or street vibrancy can have a more positive impact on the overall evaluation of the street.

(3) Selection of specific evaluation indicators

Suitable indicators are selected for quantitative evaluation according to the scope of the site, including the consideration of essential features and the needs of the evaluation. This allows for a more refined and specific analysis to be carried out to improve walkability and create pedestrian-friendly streets in a special conditions.

### 3.2 Methodology

According to the scale and characteristic of historic district, selecting the most relevant indicators to evaluate the walkability. Then choose appropriate way to have a quantified evaluation. Based on the accurate data of site, classifying the street according to different characteristics and generating corresponding strategy and design.

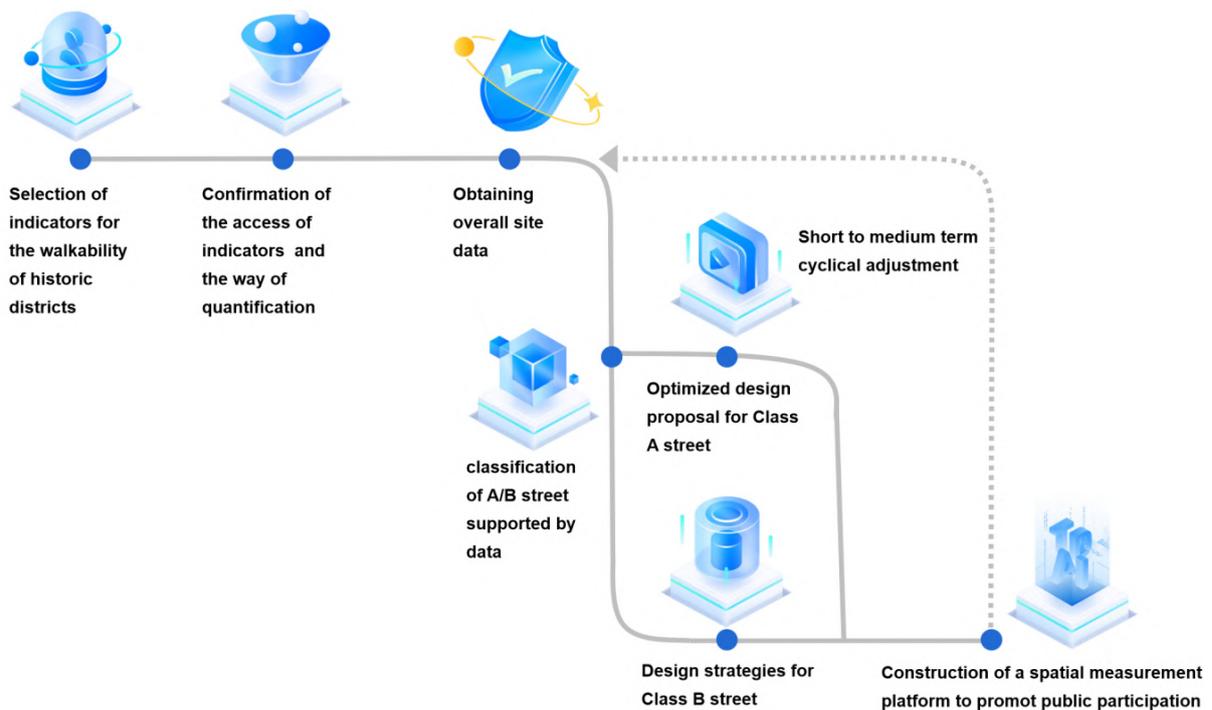


Figure 3-20 Methodology (Source: self-illustrated by the author)

## **Chapter 4 Analysis and Quantitative Evaluation of Walkability in Changhua District**

### **4.1 Analysis of Changhua Historic District**

#### 4.1.1 Why Changhua District

Changhua district is a historic and cultural representative located in Liwan, Guangzhou, and belongs to the important part of conservation. As one of the seven distinctive areas of the Xiguan Historic District, it has the opportunity to link up with the surrounding historical and cultural resources and have a further development, Based on this, it is also necessary to fully exploit its own characteristics to create a differentiated attractiveness. Furthermore, as the most traditional tourist resource in Guangzhou, Changhua district, the upgrading of the slow-traffic system in it can first better match the ratio of road resource allocation and travel demand, satisfy the requirement for slow-traffic spaces with higher quality to develop tourism and commerce, further release the economic value of the district, and have a positive impact on the simultaneous enhancement of the rich historical and cultural heritage in the district as well as its historic environment. However, currently the physical environment within the district still needs to be enhanced. For example, the improvement of streets and public spaces, the timely renewal of historic and cultural buildings and so on. These measures help to further explore the unique values within the district, improve the pedestrian environment and present the traditional characteristics of the district, and at the same time enhance the quality of residential life.

Therefore, it is feasible and necessary to analyse the walkability of the districts in detail through multidimensional data. By combining upper planning, the distribution of businesses, the characteristics and activities of people, the perception and evaluation

of the physical environment, and quantitative statistics and analysis, the walkability of each street can be analysed in a specific way, thus strengthening the pedestrian character of the street and helping to enhance the walkability of the district to show the unique aspect and bring out its value.

#### 4.1.2 Context

##### (1) Location

The object of this thesis study is mainly focus on Changhua District. As a significant part of historic and cultural conservation area in Guangzhou, it is located in Liwan District and belongs to historic district of Xiguan.

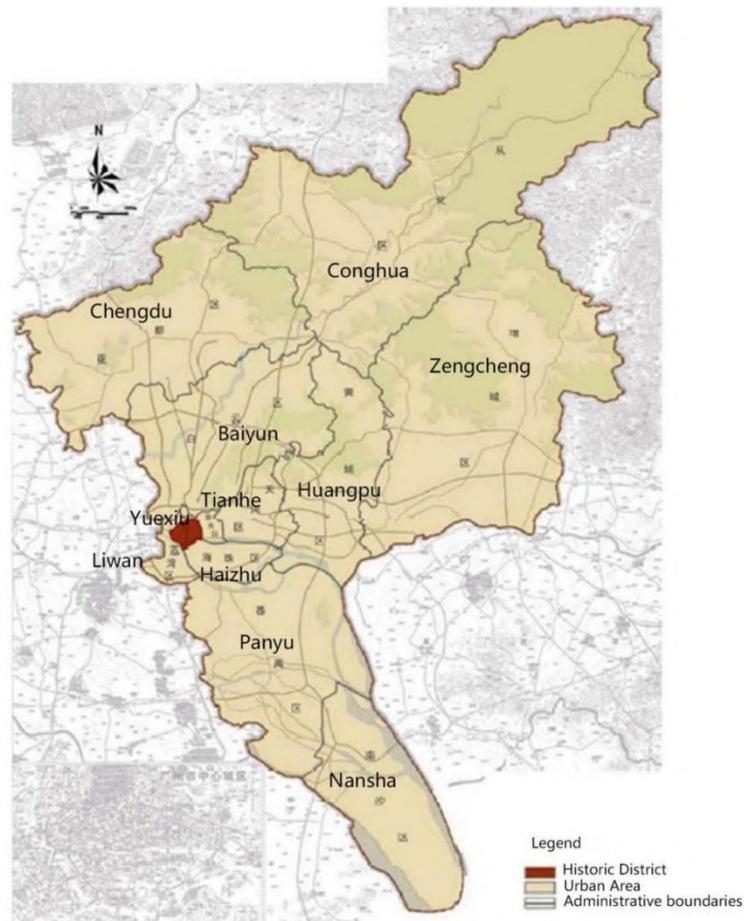


Figure 4-1 Location of historic area in Guangzhou (Source: transfer-illustrated by the author)

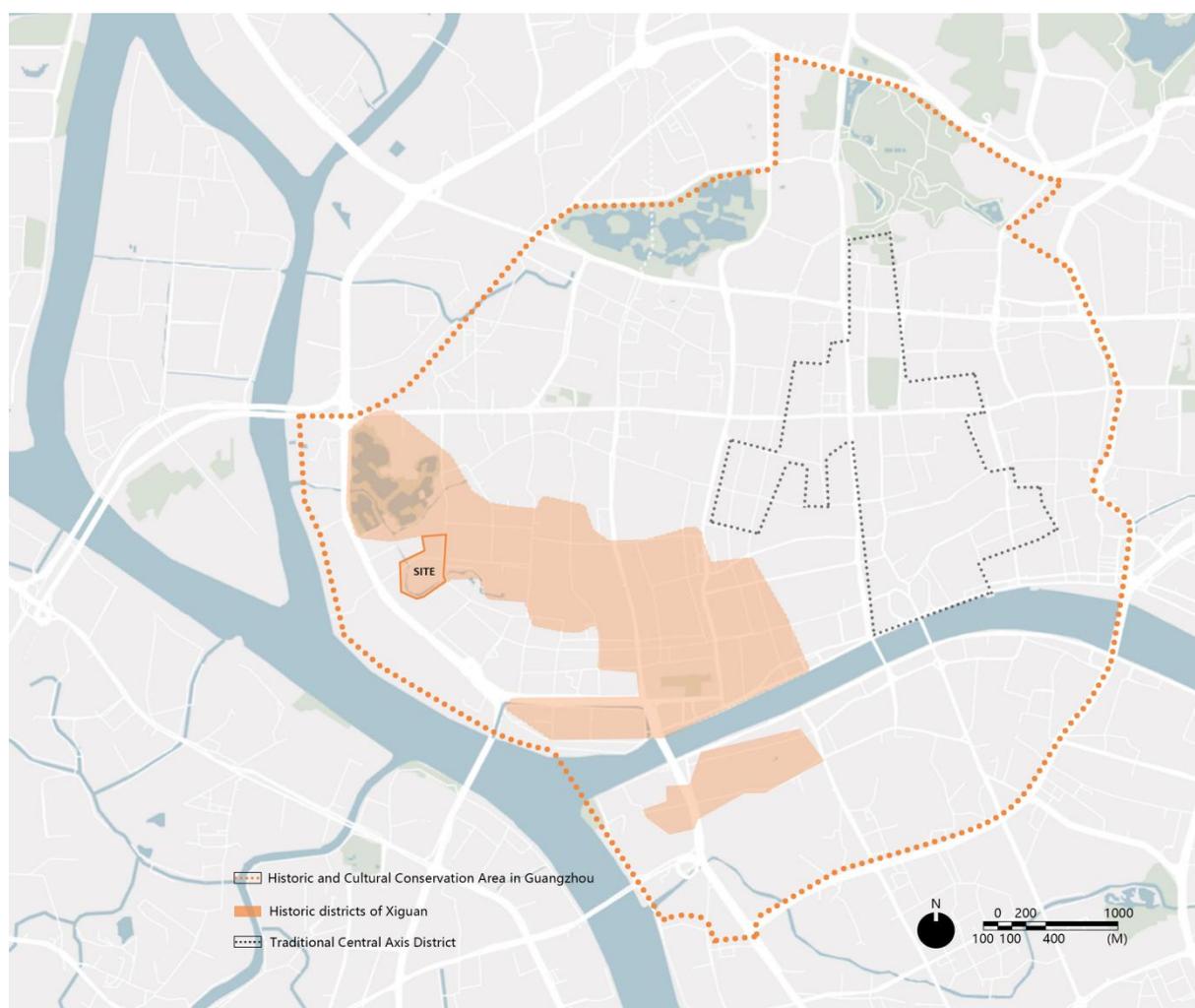


Figure 4-2 General plan of historic and cultural district in Guangzhou (Source: self-illustrated by the author)

## (2) Regeneration

Changhua District has changed dramatically with the changes of Guangzhou, from the urban swamp around the Ming to the early Qing Dynasty, to the late Qing Dynasty when the residential area in the east was extended to the periphery of the site, and to the early years of the Minguo when it was fully developed into a residential area.



Figure 4-3 The map of Guangdong Province in 1907(Source: website)

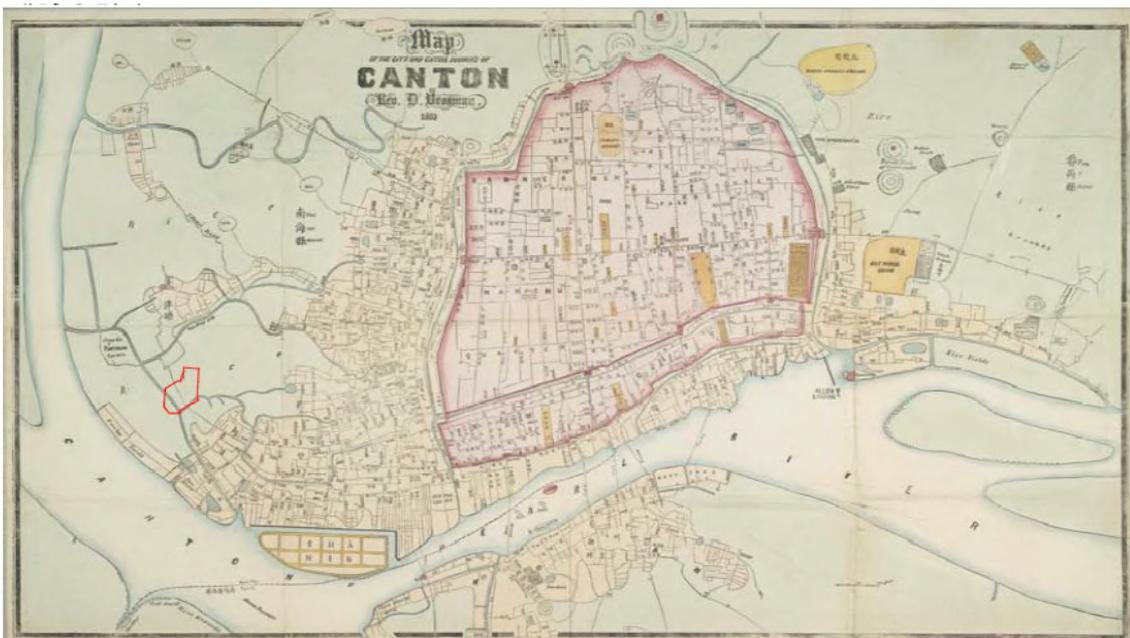


Figure 4-4 The map of Guangzhou in 1860 (Source: website)



Figure 4-5 The map of Guangzhou in 1937 (Source: website)

### (3) Urban resource

Changhua district belongs to the famous Lizhiwan Xiguan Folklore Area of Guangzhou, combining with Chen Clan Ancestral Hall Folk Craft Cultural Tourism Zone, West Gate Urn City Historical and Cultural District, Yueyun Creative Culture Zone, Hua Lin Zen Culture and Trade Tourism Zone, Shamian Commercial Port and European Style Island as the outstanding seven characteristic historical districts of Xiguan, fully demonstrating the traditional history and culture of the area. Changhua District is adjacent to the famous veranda street, Enning Road and Longjin West Road. At the same time Duobao Road as one of the main roads connecting the north of the site. Ruyifang station and Changshou Road station as the main public transport to bring various pedestrian to the area.

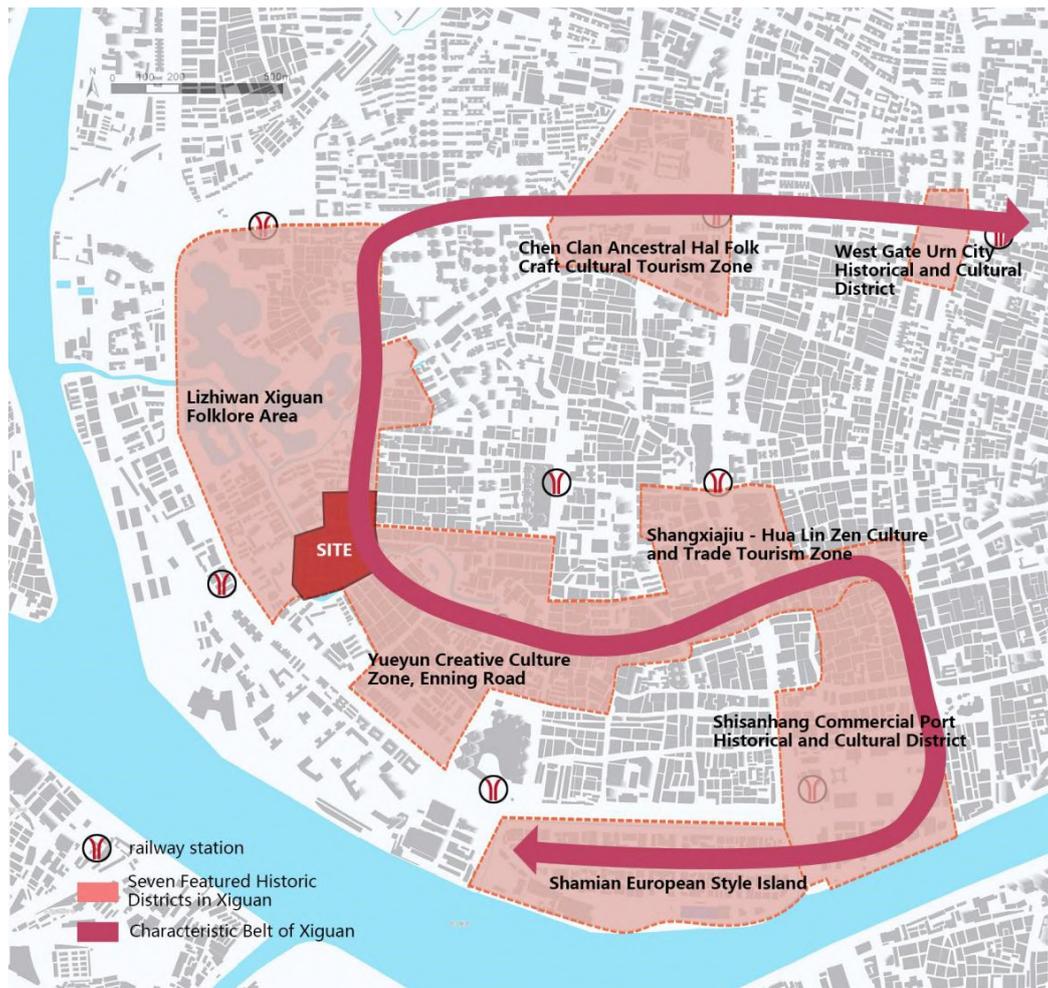


Figure 4-6 Changhua District as important historic resource (Source: self-illustrated by the author)

Changhua district is an important node in the slow traffic system of Guangzhou. It's part of the old city of Liwan and the most traditional tourist resource of tourism corridor, requiring maximum preservation of local characteristics and historical culture, as well as space conducive to walking, cycling and outdoor activities. Through the creation of a regional slow traffic system, Changhua district, as one of the key nodes, makes full use of the surrounding historical and cultural resources to enhance the slow traffic attractiveness, while driving the further improvement of the slow traffic system within the district.



Figure 4-7 slow traffic plan (Source: self-illustrated by the author)

#### (4) The problems and comprehensive resource in Changhua District

The study area of Changhua district is defined in the Guangzhou Historical and Cultural City Conservation Plan (2014). Specifically, the range of area is north to Fengyuan Zhongyue, east to Enning Road, and bounded by Changhuachong in south-west part. The conservation planning area is 6.05 hectares, and it contains 33 elements of tangible cultural heritage and 35 elements of intangible cultural heritage. As to the values and features of Changhua District, It's a typical example of the residential life and social relations of military and political celebrities in the Republic of China, an important sample of the evolution of the Xiguan area from an isolated palace to a modern settlement and a living museum of modern housing in Guangzhou. Furthermore, Changhua district has other strengths, it's surrounded by abundant historic and cultural resource, such as Yong Qing Fang; the streets are rich in natural

resources along with waterfront spaces and greenery; and the street fabric presents regular grids, surrounded by Enning Road and Duobao Road. As to the hybrid function, the district includes residence, business, public services and warehousing forming a relatively quiet and comfortable environment.

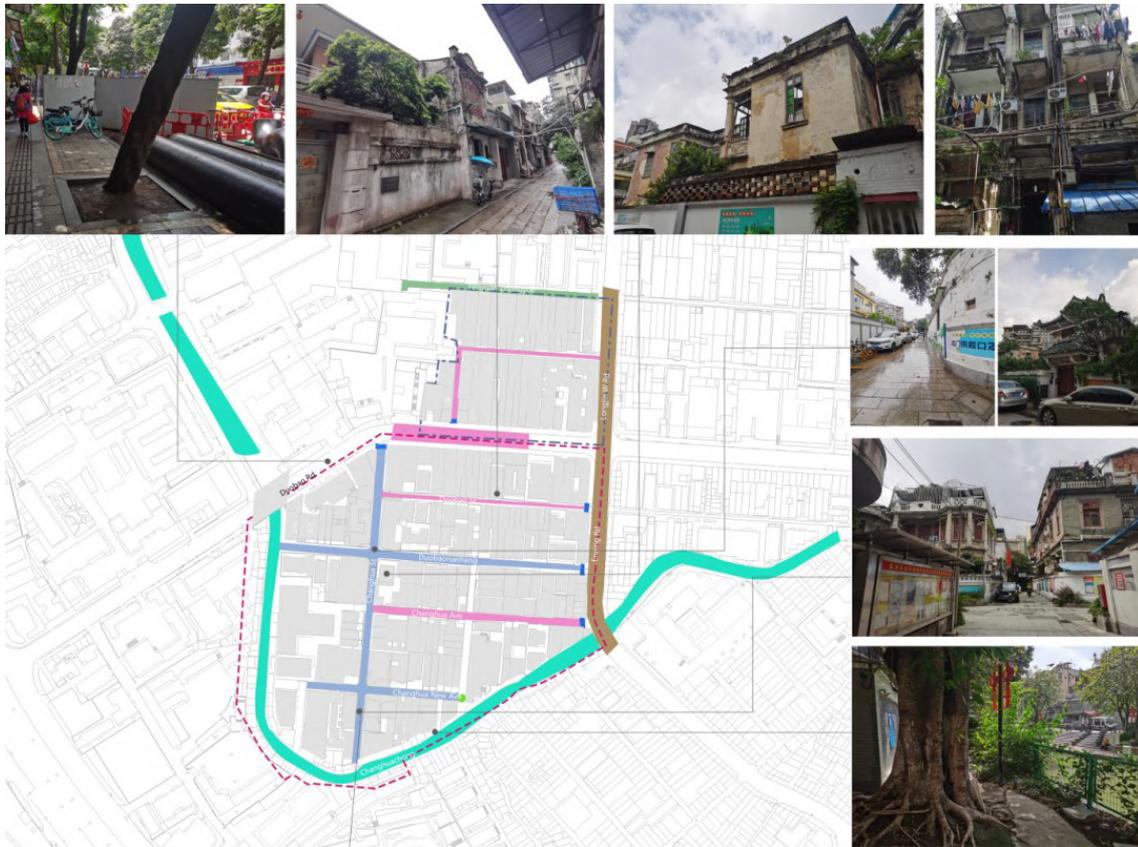


Figure 4-8 Surrounding environment of Changhua District (Source: self-illustrated by the author)

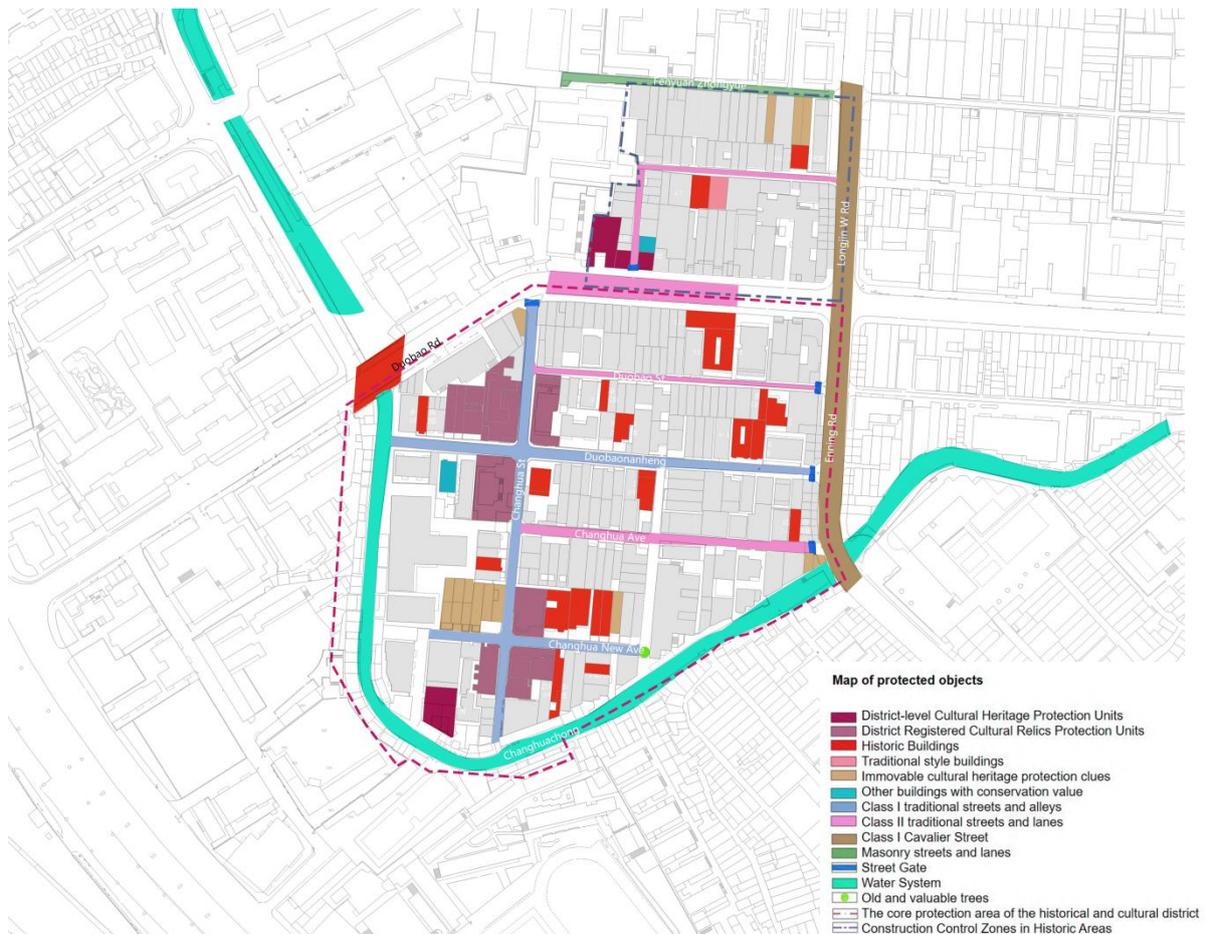


Figure 4-9 The historic value in Changhua District (Source: transfer-illustrated by the author)

#### 4.1.3 Planning relates to walkability

According to Protection and Utilization Plan for the Historic and Cultural District of Changhua District, Guangzhou, Guangdong Province (2021-2035), detailed planning and guidelines have been set up for Changhua District to better protect and perpetuate its abundant historical and cultural heritage, the traditional pattern and landscape of the district, and to present the outstanding national and local cultural traditions, ensuring the scientific conservation and sustainable use of the historic and cultural district. The improvement of the walkability of the streets in the district can serve as a fundamental guideline, integrating with the specific indicator evaluation system analysed in the previous section, and implemented into specific spatial generation to better satisfy the local requirements. At the same time, through the extension and enhancement of walkability, it is possible to achieve an appropriate

attraction to the people nearby, to fully demonstrate the traditional flavour of the streets and enhance their vitality. Furthermore, realizing a better connection with external public transportation can increase the chance of people's slow-traffic behavior.



Figure 4-10 System of main roads around Changhua District (Source: self-illustrated by the author)

### 1. Planning of the slow traffic system

According to the plan of Lingnan Cultural Centre District (Liwan Area) and the green walking system, the existing street in the old city is sorted out and optimised, continuing the pedestrian-oriented status quo while integrating with the historic and cultural resource in the district.



Figure 4-11 Main street and nodes (Source: self-illustrated by the author)

#### (1) Slow-traffic street space

Strictly protect the width, paving and appearance of the 2 cavalry streets, 8 traditional streets and 5 pockmarked streets in the district. Continuing the slow-traffic function of the streets, the streets will be paved and decorated to create five pedestrian streets, including Fengyuan Zhongyue, Duobao Street, Duobaonaheng, Changhua Avenue, and Changhua Street.

#### (2) Waterfront Walkway

Develop a waterfront slow walking space along Changhuachong. Create a leisure and tourism-oriented slow walking space by providing a water-friendly shoreline, increasing waterfront greenery and connecting with public space along the river.

#### (3) Slow pedestrian space

Create a pedestrian slow space along both sides of Duobao Road, Longjin West Road and Enning Road, renovate the pavement, remove obstacles to slow traffic, and achieve the separation of pedestrian and bicycle.

#### (4) Public space

Optimise the signage facilities of the slow walking system, and install name plates of road, information signs and other guidance facilities at the connection joints between the slow walking space and various public spaces as appropriate.

### 2. Green space system planning

#### (1) Planning principles

Maintain the existing road vegetation and green nodes within the district, the scale of green space should be appropriate to the scale of the original public space; use street space and trees as the main source of greenery in the open space, as well as plan small-scale pocket parks with a balanced distribution.

#### (2) Community parks and squares

There is one community park and square should be preserved, it's the community park by Changhuachong, covers the area of about 1700m<sup>2</sup>.

#### (3) Road planting and planning of the green street environment

Continuing the current road planting on Duobao Road, a complete greening network is formed by linking various green squares and open spaces through road greening. Encourage the arrangement of street planting in the streets with a high density of traditional buildings, and under the premise of ensuring smooth fire escapes.



Figure 4-12 Conceptual green space system (Source: self-illustrated by the author)

### 3. Guidelines for building renovation

Protect and revitalise the buildings in the district by category. Combining the spatial characteristics of the traditional buildings in the district, under the premise of conservation, encourage the introduction of various types of social capital to participate in the rational use of historical and cultural heritage by means of acquisition, replacement of property rights, vacating and relocating, etc., to optimise the internal space of the buildings and meet modern living needs. Social and market forces are encouraged to participate in the renovation and revitalisation of buildings to enhance the vitality of the district, giving priority to the revitalisation and utilisation of protected buildings with public property rights and encouraging the functional upgrading of protected buildings with private property rights.

(1) Cultural heritage conservation units and units registered for protection are given priority as cultural displays and public services in accordance with the Cultural Heritage Protection Law and other relevant laws and regulations.

(2) Under the protection requirements, historic buildings and traditional style buildings (including clues) are allowed to undergo necessary internal renewal and transformation to meet modern lifestyles and to allow the injection of new functions that can promote the vitality of the neighbourhood.

(3) For general residential buildings, appropriate changes to the residential function can be made to give a new commercial or cultural business value, taking into account the characteristics of the area.

(4) In compliance with the Regulations of Guangdong Province on the Management of Water Resources Projects, the Regulations of Guangzhou Municipality on Water Management, and the Technical Specification for River Management of River-related Construction Projects (DB4401/T19-2019), etc., buildings and structures involved in new, altered or expanded construction in the area shall not encroach on the control area of river.



Figure 4-13 Functions distribution in Changhua District (Source: self-illustrated by the author)

#### 4. Improvement of the boundary line of street

The streets around and within Changhua Street have basically been optimised in terms of boundary line, widening the main road pedestrian path and reducing the space for motor vehicles; the reduced width of the streets within the district is conducive to control the mobility or parking of motor vehicles, optimising the slow walking experience of the streets and further guiding and enhancing the walkability of the streets in the district.

According to the relevant plan, Enning Road has the optimization of boundary line from 33m to 18m, including a 7m wide two-way carriageway, 1.5m cycle lanes on each side, 1.2m street furniture space with street lighting or wayfinding signs, and 2.8m of pedestrian space on each side to promote commercial activity in the shops on the ground floor of the street, while improving the comfort and convenience of pedestrians.

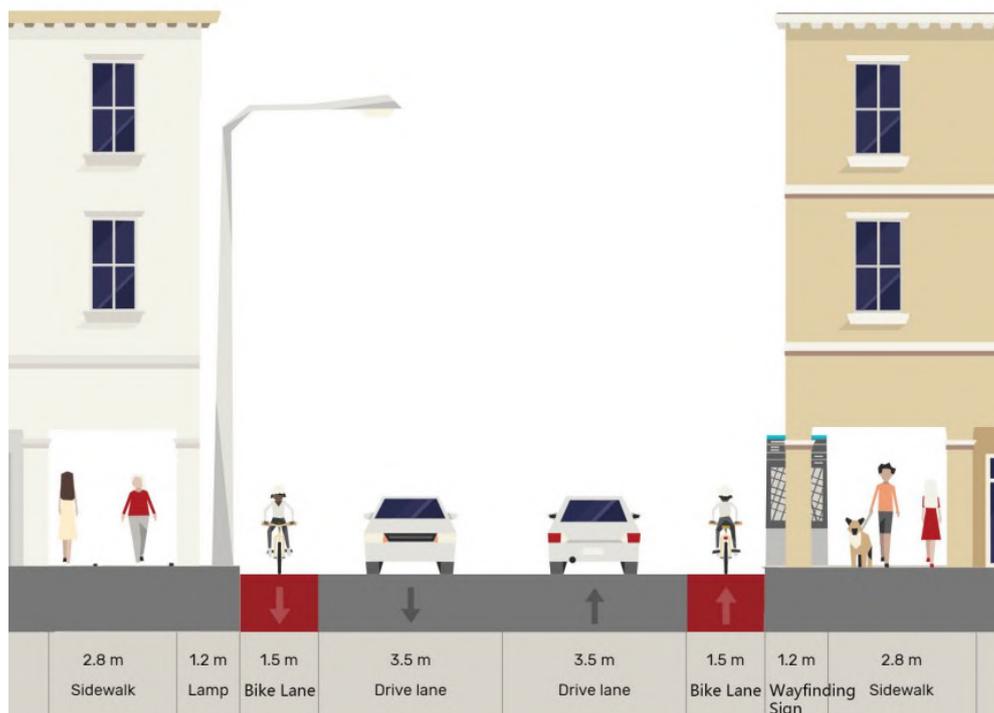


Figure 4-14 Section of Enning Rd (Source: self-illustrated by the author)

In the current state of Changhua District, there is a 7m wide pedestrian path, but the parking of motor vehicles encroaches on 4.2m of pedestrian space, leaving only 2.8m

of actual pedestrian width, and the street interface is not transparent enough due to the majority of physical walls, which has an impact on the vitality of the street. In the future, the optimization of boundary line of roads is from 7m to 4m, in conjunction with the off-block parking, parking lane will be eliminated and the street will be used exclusively for walking and daily interaction.

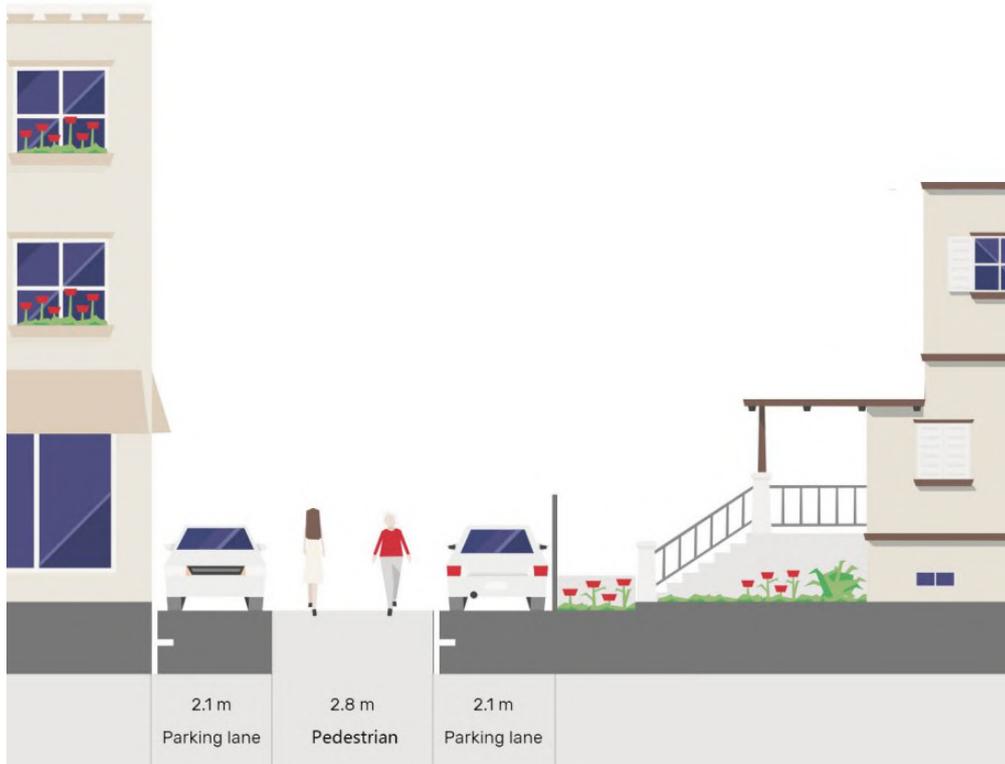


Figure 4-15 Section of Changhua St (Source: self-illustrated by the author)

#### 4.1.4 Swot analysis

Based on the previous analysis a comprehensive Swot analysis of the district was carried out, summarising six dimensions: society, economics, policy, environment, technology and mobility, identifying the characteristics within the district and the factors that could be optimised. The main problem is that the district is not sufficiently attractive to the pedestrian around the district, the historical and cultural resources within it have not been fully exploited, and the walkability of the street mainly serves the local residents. For the opportunities of future development, on one hand the district can combine historical and cultural also landscape resources to enhance the

walkability of the street, attract the surrounding activity groups to walk into the district, so as to better demonstrate its historical and cultural value and stimulate the vitality of the site. On the other hand, it also focuses on maintaining the living conditions of the residents, so that the traditional customs can be continued and the neighbourhood relationship can be enhanced to improve the sense of identity and belonging of the residents, thus realizing the promotion of sustainable development of the district.

	 Strengths	 Weakness	 Opportunities	 Threats
 <b>Society</b>	historical resources in site Presence of traditional life	Architectures with poor quality	Energising the site Inherit historical and cultural values	Balance between tourists and residents
 <b>Economics</b>	Adequate resident-oriented business	Single business in the district	Increase the local revenue	Profits of private land owners
 <b>Policy</b>	Part of cityslow traffic system As an important tourism resource for the city	A gap between policy and actual implementation	Strengthen the walkability systematically	Less sensible to the environment timely
 <b>Environment</b>	Presence of green open space Presence of Changhuachong	Presence of decaying and vacant buildings Lack of sufficient service facilities	Integration in the system of community park Use of the river for increasing activity platform	Risk of flooding
 <b>Technology</b>	Convenient community service centre	Lack of sensors for recording	Instant recording of crowd walking Timely improvement of pedestrian space	High cost Space occupied
 <b>Mobility</b>	As a temporary parking for surrounding neighborhood Easily accessible for drivers	Encroachment on pedestrian space Traffic noise	Public parking near the district Improvement of walkability	Distance between parking and district

Figure 4-16 SWOT Analysis of site (Source: self-illustrated by the author)

## 4.2 Quantitative evaluation of walkability indicators

A quantitative study of the streets was carried out in conjunction with the indicators mentioned above. The scope of the streets evaluated was to extend from the centre of Changhua District to the surrounding streets (about a circle with 400m in diameter) to mitigate boundary effects. The indicators were calculated by integrating the data in three main ways: (1) automatic evaluation of open data, which is suitable for analysing the overall situation of the district; (2) evaluation of crowdsourcing mechanisms (with the help of online mapping platforms such as Mapbox and OSM) for crowd walkability analysis and refinement; (3) evaluation of human-computer interaction based on

streetscape data and on-site research as a complement to the detailed analysis of specific streets.

#### 4.2.1 Optimization of indicator selection

Combined with consideration of the existing site characteristics of Changhua District, the quantitative evaluation method in the previous paper was optimized to achieve the maximum degree of targeted evaluation, and the following principles should be observed in the process.

(1) The evaluation indexes should be as concise as possible in terms of quantity while covering the integrity of the evaluation system.

(2) The evaluation data source method should be as mature as possible, and the data source should be reliable with strong operability.

(3) Since the target of this evaluation is the historic district, the existing evaluation methods need to be improved to make them suitable for the needs of the historic district.

According to the questionnaire research and on-site interviews, 90 questionnaires were sent out and 70 questionnaires were effectively returned. More than 50% of the people think that food, architectural features are the most attractive elements, followed by leisure and entertainment and public space nodes; at the same time, nearly half of the investigators prefer the public transport, and more than half of them feel that walking in and around Changhua District is generally comfortable and would focus more on the green landscape. However, it is considered that motor vehicles encroach on the pedestrian space and affect the accessibility. In terms of comprehensive preferences, more residents focus on the diversity of the street, followed by comfort and history, thus mainly concentrate on the evaluation indicators of vitality in the district, while the evaluation of the environmental indicators of the district only accounts for a relatively small part.

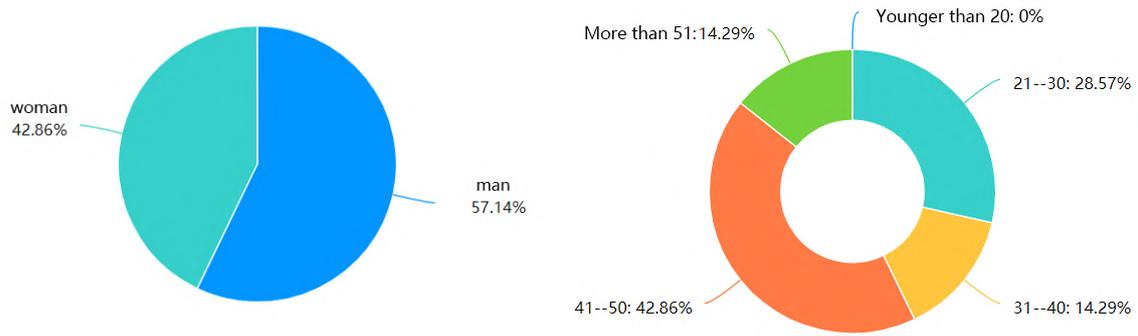


Figure 4-17 The characteristics of investigator (Source: self-illustrated by the author)

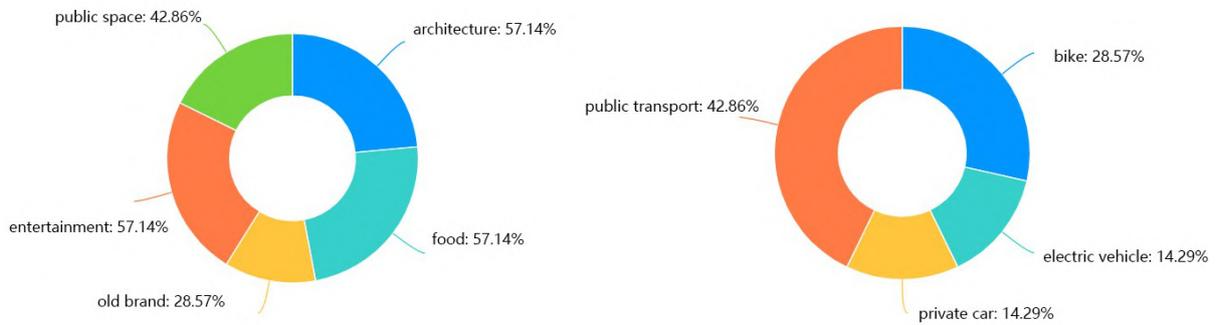


Figure 4-18 The interest and way to travel of investigators (Source: self-illustrated by the author)

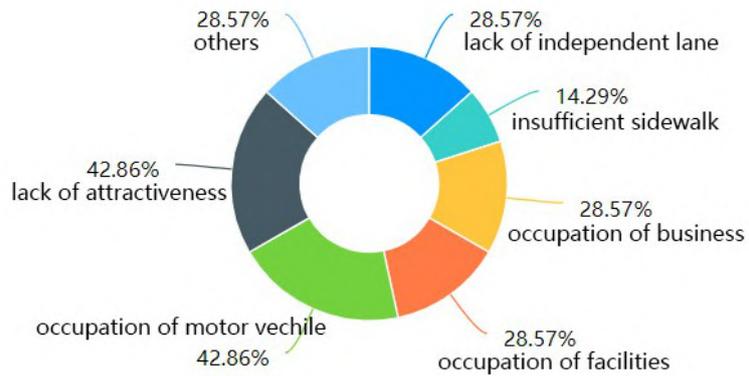


Figure 4-19 The problems evaluated by investigators (Source: self-illustrated by the author)

Based on the residents' evaluation of the importance of each indicator in the questionnaire survey, the frequency of selection of each indicator was counted by providing various types of street space intention pictures (Figure 4-19), so as to obtain the selectional preference and then confirm the weight of each indicator.

During the interview, three main feedbacks were obtained, the details are as follows: the passers-by need more leisure space to enhance the attraction. The staff in the district suggests repairing and renting historical buildings to activate popularity to avoid abandonment. And the personnel specializing in parking management identifies that there are people living in the underground of the cultural relics building, but the house is relatively damaged. The surrounding parking lot has been upgraded and improved, so Changhua district has become the main parking lot in the surrounding area, but the parking on the block will be improved after the social car park is built.



Figure 4-20 Preferences of residents (Source: self-illustrated by the author)

Therefore, a comprehensive value evaluation of history is formed according to the experts' judgement in the latest plan: Changhua District Historical And Cultural Block Protection and Utilization Planning. The evaluation of the comfort in the district focuses on the obvious parking situations, the greening rate and shading rate as the important factors to display the features of district and attract people to stay, are also included in the specific score. For the safety, the result shows that investigators focus more on the guiding system and lighting facilities which have a greater influence on human activities and behaviors, thus an optimized indicator system is constructed.

Table 4-1 Basis for scoring (Source: self-illustrated by the author)

Specific Evaluation of walkability in Changhua District				
Primary Indicators	Secondary Indicators	Evaluation Method	Weight	Sequence
History	Comprehensive value of historic buildings	The evaluation from experts	0.20	3
Diversity	POI diversity	Open data	0.25	1
	POI Mixing Degree	GIS		
Comfort	Interface Transparency	Image evaluation	0.22	2
	Parking situation	Image evaluation		
	Green view rate	Image evaluation		
Connectivity	Shading rate	Image evaluation	0.10	5
	Density of the pedestrian network	CAD Calculation		
	Relative walking width	CAD Calculation		
Convenience	Coverage of furniture	Image evaluation	0.10	6
Safety	Wayfinding system	Image evaluation	0.13	4
	Lighting facilities	Image evaluation		

#### 4.2.2 Open Data and crowdsourcing mechanism evaluation

The analysis of open data provides an in-depth understanding of the characteristics of people in and around the district and helps to clarify the features of the people's activities; it locates the current distribution and conduct data statistics of the points of interest in the district to show the interaction between the site and people's activities;

through collecting and analysing the topics about Changhua District and the surrounding area on Weibo, a word cloud map can be formed as a reference for the public's basic impression and as a primary data for future optimisation of the district.

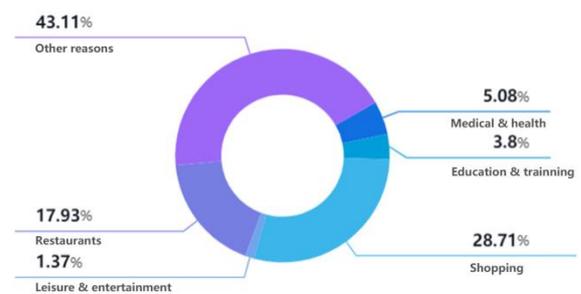
Quantitative indicators are used to evaluate the diversity of POIs, number of POIs within 50m of the street, the mix of POIs, the proportion of certain POI points within 50m of the street to the total number of POI points, and the recognition of characteristics, Weibo word cloud map.

#### (1) Characteristics of the population

In Changhua District and its surrounding area, the total number of residents is 17,032: the colour shade of the heat map and the size of the coverage area reflect the distribution of the total population in the area, with a trend of gathering in the middle and decreasing in the surroundings; the people who visit the area mainly visit for other reasons, accounting for nearly half of the total; nearly half of them visit for daily commercial activities including shopping, dining and leisure. Combined with the on-site research in the later section, the analysis shows that most of these people visit the district for work reasons, such as hygiene and cleaning services, traffic guidance, mail delivery, etc. Therefore, the main users of the district mainly include residents and staff. In the process of further improving the walkability of the space, the non-motor vehicle travel needs of staff can be more fully met, and appropriate parking spaces can be set up to improve the comfort of the block.



a)



b)

Figure 4-21 Characteristics of the population. a) heat map of residential groups; b) visit preferences of the crowd (Source: <https://www.swguancha.com/home/customer-group-detail/0>, 2022.05)

(2) Perception of the district from public --- Weibo word cloud map

Compared with the surrounding streets, we can see that the most frequent words about Changhua District are primary school and community, reflecting its function of mainly residential life, of which 280 times were mentioned for primary school, 242 times for community, 193 times for enrolment and 36 times for Lizhiwan, while Sai Kwan Mansion, which is an important historical and cultural resource, was only mentioned 13 times. In contrast, the historical and cultural resources of Enning Road and Lizhiwan attracted more attention, while Duobao Road and Longjin West Road were dominated by commercial food. The conclusion that can be drawn is that the main concern and evaluation of Changhua District by the network group is focused on the information of primary school, community, enrollment and other life-level information, while the attention to the historical and cultural resources only accounts for a small part, indicating that the traditional life style is the main feature at present, and the display of historical and cultural resources needs to be further improved, so as to be more fully excavated and exerted as another characteristic value of the district.

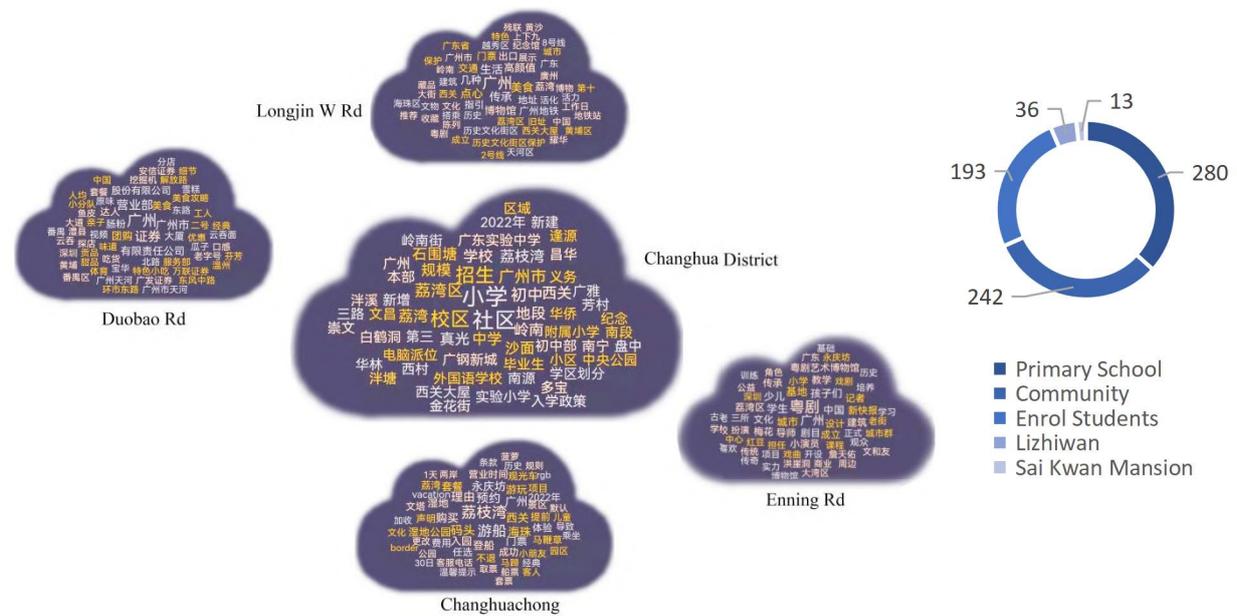


Figure 4-22 Word Cloud Map for Main Street (Source: self-illustrated by the author, 2022.05)

### (3) Different types of POIs in the base and the evaluation from Dianping

The site has a variety of POIs, reflecting the diversity of the streets, with retail and restaurants accounting for the highest proportion of 59.29%, mainly located along Duobao Road and Enning Road, attracting a large number of people. The interior of Changhua District is dominated by living services and education and training, accounting for 23.46%, mainly for the residents in the district; it can be analysed that there is room for further improvement in the vitality of daily life. The diversity of streets in the district can be enhanced by moderately updating the buildings in the main street, combined with some public-facing functional layouts as new POIs to demonstrate the greater appeal of the district.



Figure 4-23 Distribution of POI (Source: <https://www.swguancha.com/home/area> currentActiveTab=1, 2022.05 and self-illustrated by the author)

The statistics for each street in the district reveal that Riverside Rd has life service and historical and cultural buildings as its main attraction, Changhua St has restaurant and retail as its main feature, and Duobaonanheng mainly focus on education and training, so all these data serve as the basis for the latter quantitative evaluation.

so all these data serve as the basis for the latter quantitative evaluation.

Table 4-2 Distribution of POI in each street (Source: self-illustrated by the author)

Numbers of POI / Street	Longjin W Rd	Enning Rd	Riverside Rd	Changhua St	Duobao St	Changhua Ave	Duobao nanheng	Duobao Rd	Changhua New Ave	Total Number
Restaurants	21	71	0	5	1	0	1	38	0	137
Retail	35	94	0	3	2	2	2	58	0	196
Leisure & Entertainment	3	23	0	0	0	0	0	15	1	42
Education & Training	2	9	0	1	0	1	4	2	1	20
Sports & Fitness	1	3	0	0	0	0	0	3	0	7
Life Services	11	49	2	3	0	0	1	38	1	105
Finance & Insurance	0	0	0	0	0	0	0	3	0	3
Beauty and Wellness	2	9	0	0	0	0	1	5	0	17
Vehicle Services	0	0	0	0	0	0	0	5	0	5
Public Stations	2	0	0	0	0	0	0	5	0	7
Historical and Cultural Buildings	3	1	1	9	3	1	3	5	6	32

The street frontage along Duobao Road and Enning Road has obtained the highest rated food and drink according to Dianping to attract various people and it becomes the main destination for the pedestrian. (Dianping is a software offering local business search, user generated reviews, detailed business information, featured discounts, group buying and other merchant services in China)



Figure 4-24 Popular review ratings for the pois (Source: self-illustrated by the author, 2022.05)

### 4.2.3 Street view data

For the street in the selected areas, streetscape images were captured from five directions at every 50m of the street, with a total of 160 images (Figure 4-24). Combined with the characteristics of the streetscape images, the main quantitative indicators can include: the preservation of historical buildings and cultural identity in history; street greenery ( $X=S$  greenery/ $S$  total), parking situation and shade rate in comfort; interface transparency ( $X=S$  building/ $S$  wall) in diversity; furniture coverage in convenience; lighting facilities and wayfinding system in safety. Finally, the indicators of each street are compared and analysed to form a composite score, thus giving a primary comprehensive walkability score for each street.

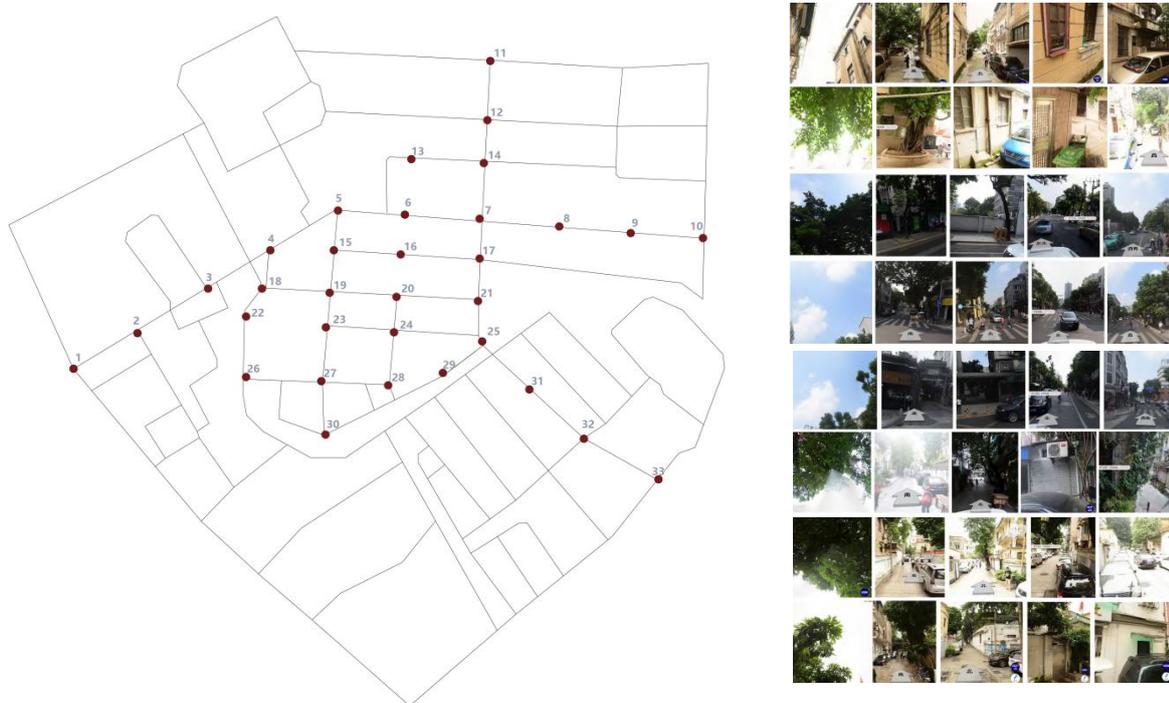


Figure 4-25 Street view pick-up points and selected images (Source: self-illustrated by the author)

#### (1) The basis of history evaluation

Table 4-3 Reviews and scores from experts in the latest planning (Source: Protection and Utilization Plan for the Historic and Cultural District of Changhua District, Guangzhou, Guangdong Province (2021-2035) transfer-illustrated by the author)

Comprehensive assessment of the historic building	Representative historic buildings in the street	Score
Popular and lively; pleasant environment, normal use; friendly neighbourhood	Veranda No.30 Enning Rd, House No.10 Changhua St, Houses No. 26, 28, 30-34, Duobaonanheng	0.8-1.0
Popular and lively	Houses No.82,114, 116, 118, 120, 122, 124 Duobao Rd	0.6-0.8
Comfortable environment, normal occupancy	Houses No. 2-2, 24 and 8 Changhua Ave	0.4-0.6
friendly neighbourhood	Houses No.14, 3-1 Changhua New Ave	0.2-0.6
Poor environment, lack of crowds	House No. 51, Duobao Street	0.0-0.2



Veranda No.30 Enning Rd



Houses No.82 Duobao Rd



Houses No.8 Changhua Ave



Houses No.3-1 Changhua New Ave



House No. 51, Duobao Street

## (2) The result of evaluation

Table 4-4 Evaluation based on street view data (Source: self-illustrated by the author)

Quantitative evaluation based on street view pictures								
Key road nodes/corresponding indicators	history		comfort		diversity	convenience	safety	
	Comprehensive value of historic buildings	parking situation	Green view rate	Shading rate	Interface Transparency	Coverage of street furniture	Lighting facilities	Wayfinding system
Enning Rd (7, 17, 21, 25, 31, 32, 33)	0.95	0.63	0.63	0.65	0.92	0.41	0.92	0.95
Longjin W Rd (11, 12, 13, 14)	0.83	0.65	0.71	0.42	0.93	0.25	0.96	0.91

Changhua St (5, 15, 19, 23, 27, 30)	0.93	0.65	0.53	0.38	0.35	0.43	0.61	0.92
Duobaonanheng (18, 19, 20, 21)	0.72	0.63	0.52	0.45	0.42	0.22	0.42	0.83
Duobao Rd (1-10)	0.73	0.25	0.63	0.72	0.82	0.25	0.95	0.82
Changhua Ave(23, 24, 25)	0.72	0.83	0.82	0.42	0.33	0.24	0.43	0.51
Riverside Rd (18, 22, 25, 26, 29, 30)	0.84	0.98	0.98	0.53	0.52	0.43	0.82	0.83
Changhua New Ave (26, 27, 28)	0.63	0.68	0.83	0.52	0.24	0.22	0.42	0.62
Duobao St (15, 16, 17)	0.45	0.95	0.72	0.63	0.41	0.45	0.43	0.82

#### 4.2.4 The comprehensive evaluation

Based on the public choice preference, the corresponding weights were assigned to the streets, and combined with the previous comparative scoring and quantitative evaluation of specific indicators (where the scoring of the comprehensive value of historic buildings is based on the expert comments in the latest plan, the scoring of pictures is based on the proportion of each element of the streetscape and the comparison, and the other indicators are based on the calculation results of specific formulas, etc.), the overall scoring of the streets was obtained, and it can be seen that commercial Enning Road and Longjin West Road are the most walkable, and within Changhua District, Changhua St, Changhua Ave and Riverside Rd are more walkable, followed by Duobaonanheng, Duobao St and Changhua New Ave.

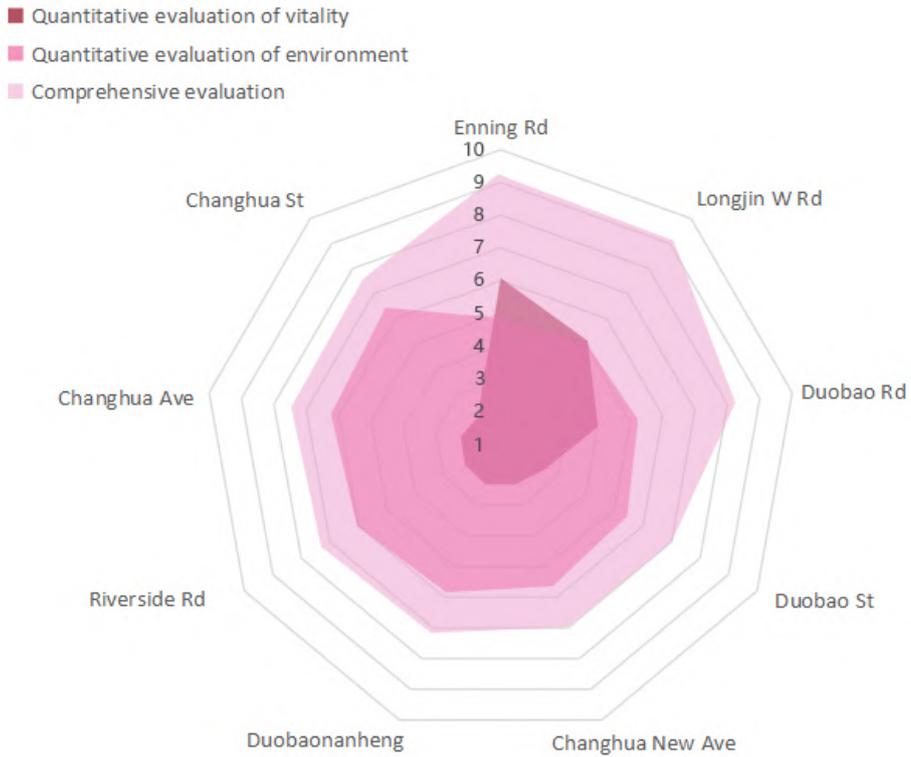


Figure 4-26 Comprehensive score of each street (Source: self-illustrated by the author)



Figure 4-27 Score corresponding to the space (Source: self-illustrated by the author)

#### 4.2.5 Classification of streets

Based on the analysis of the previous comprehensive data, it is clear that there are sufficient attractions around Changhua District to bring in the walking population. The western section of Duobao Road is mainly residential, while the eastern section embodies the former shops and the latter residences; Enning Road and Longjin West Road create sufficient commercial veranda street space while the streets within the district are mainly for residential activities. Thus, Enning Road, Duobao Road, Changhua Street, Changhua Avenue and Riverside Road within the district with the highest comprehensive walkability are classified as the most promising class A streets, which are divided into A1 commercial streets - streets where the first floors of buildings are dominated by commercial activities, A2 historic streets - streets with a cluster of historical and cultural buildings, showing the traditional streetscape and landscape resources. The rest of the streets are divided into dynamically adaptable Class B streets, including B1 living service streets - streets dominated by community service organisations or institutions, B2 residential streets - streets dominated by residents daily life activities. Therefore, according to the characteristics of Class A and B streets, corresponding optimisation strategies and designs will be generated.

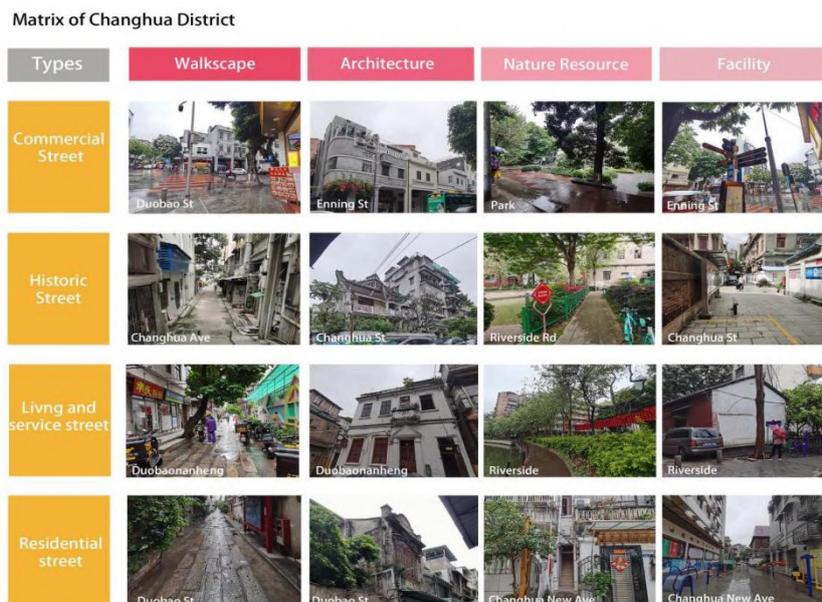


Figure 4-28 Matrix of Changhua District (Source: self-illustrated by the author)

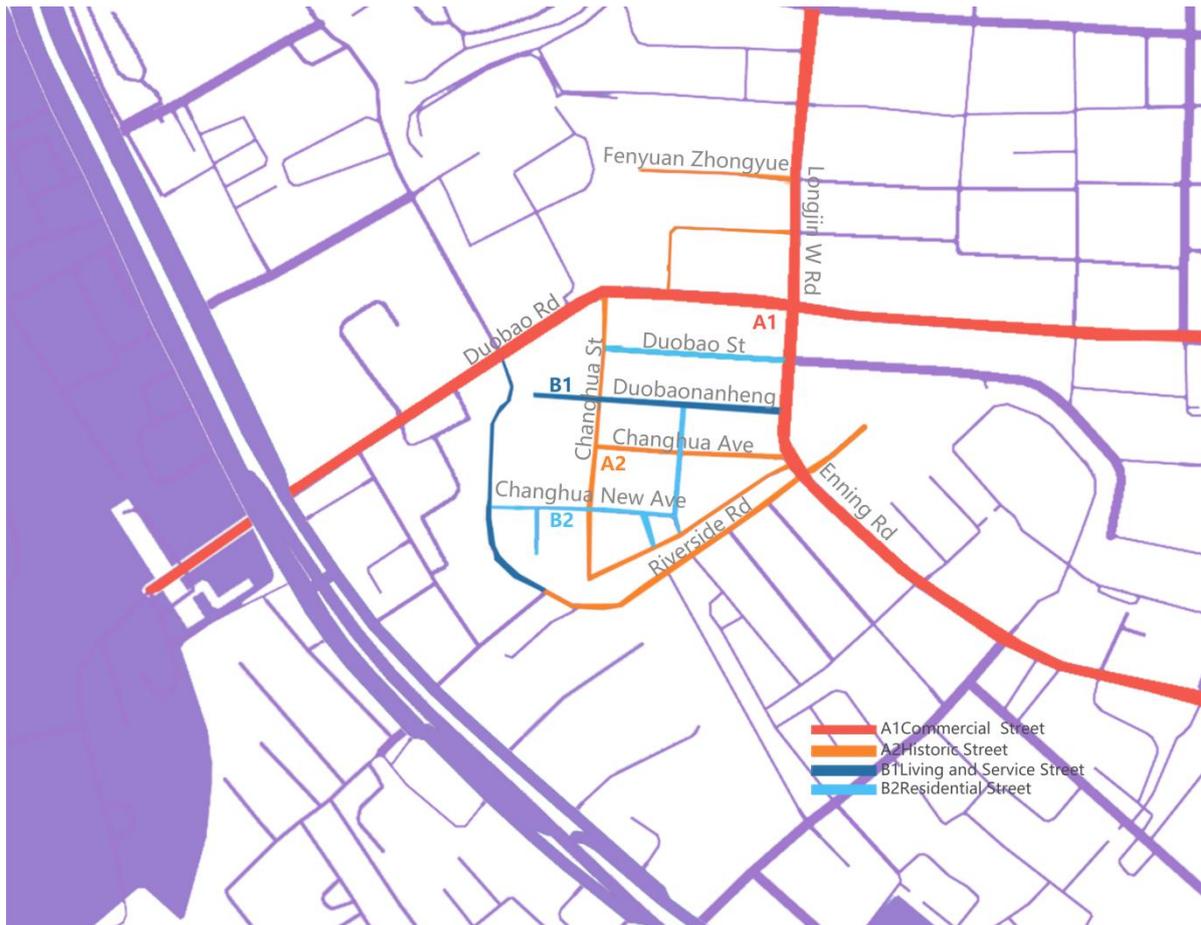


Figure 4-29 General plan of divided street (Source: self-illustrated by the author)

#### 4.2.6 Conclusion

On the basis of the comprehensive street score, the results of the quantitative evaluation of different types of streets are used at the same time to have a classification which is useful to identify the different importance of street. And the problems existing in the specific indicators of each type of street can be identified and then solved in a targeted manner by summarizing, so as to achieve a promotion of targeted street walkability evaluation.

Table 4-5 Analysis of the evaluation (Source: self-illustrated by the author)

Classification	Marking	Concrete street	Comprehensive evaluation	Strong indicators	weak indicators
The most promising class A streets	A1 commercial street	Enning Rd Longjin W Rd Duobao Rd	8.78	POI diversity and wayfinding system	Coverage of street furniture
	Optimized tension	Make good use of the commercial attraction and increase integrated facility			
	A2 history street	Changhua St Changhua Ave Riverside Rd	7.37	Comprehensive value of historic buildings	Interface Transparency and Parking Situation
	Optimized tension	Increase the interface transparency combing with historic buildings and identify the parking situation			
The dynamically adaptable Class B streets	B1 living and service street	Duobaonan heng	7.25	Wayfinding system	Coverage of street furniture
	Optimized tension	Make good use of the optimal sidewalk to increase flexible street furniture			
	B2 residential street	Changhua New Ave Duobao St	7.00	Sanitation and cleanliness of streets	Interface transparency
	Optimized tension	Increase the interface transparency by incorporating greenery			

# Chapter 5 Optimal Design of Walkability in Changhua District

## 5.1 Design intentions

### (1) Interaction of data

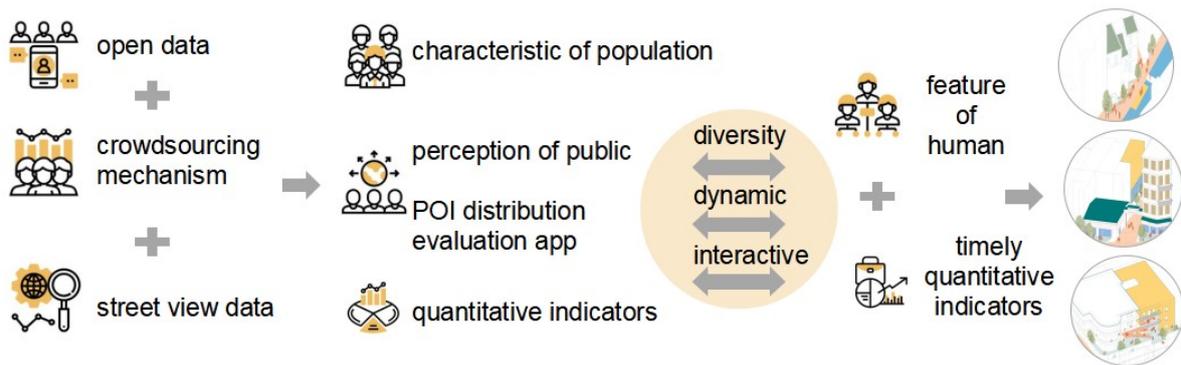


Figure 5-1 Implementation plan (Source: self-illustrated by the author)

### (2) Analysis of people



Figure 5-2 Characteristics of people in the district (Source: self-illustrated by the author)

### 5.1.1 Consideration of software and hardware

As a result of the previous analysis, a better enhancement of the walkability of Changhua District and its surrounding environment can be carried out on two main levels. Software level: on one hand management policies and planning of various facilities further improve the adjustment of public bicycle systems, parking management systems and parking planning indicators as a basis for improving the friendly walkability of the district. On the other hand, at the level of residents' autonomy, relevant community conventions can be proposed, close to the actual situation and problems of community life. Hardware level: It mainly focus on specific spatial improvements, which can be achieved through the use of vacant buildings, the strengthening of public space nodes and entrances, the enhancement of the pedestrian interface, the improvement of the bicycle traffic environment, the increase in the number of street crossings and the street furniture to improve the walkability of the street.

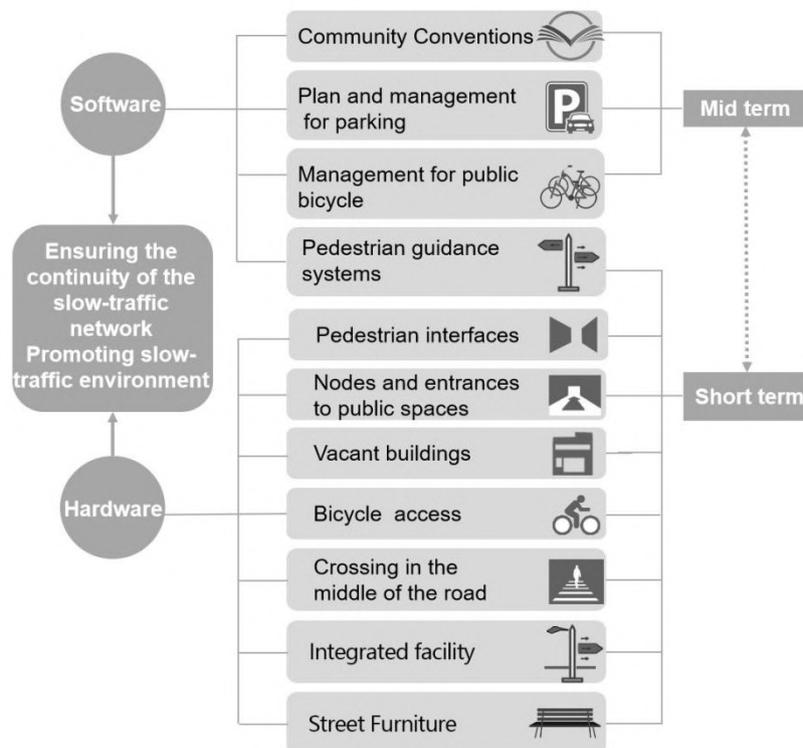


Figure 5-3 Implementation plan (Source: self-illustrated by the author)

## 5.1.2 Overall strategy

### (1) Vitality and green system

The revitalization and renewal of vacant buildings to create public space in the district through a vibrant system, a green landscape system consisting of community parks, neighborhood pocket parks and residential greenery.

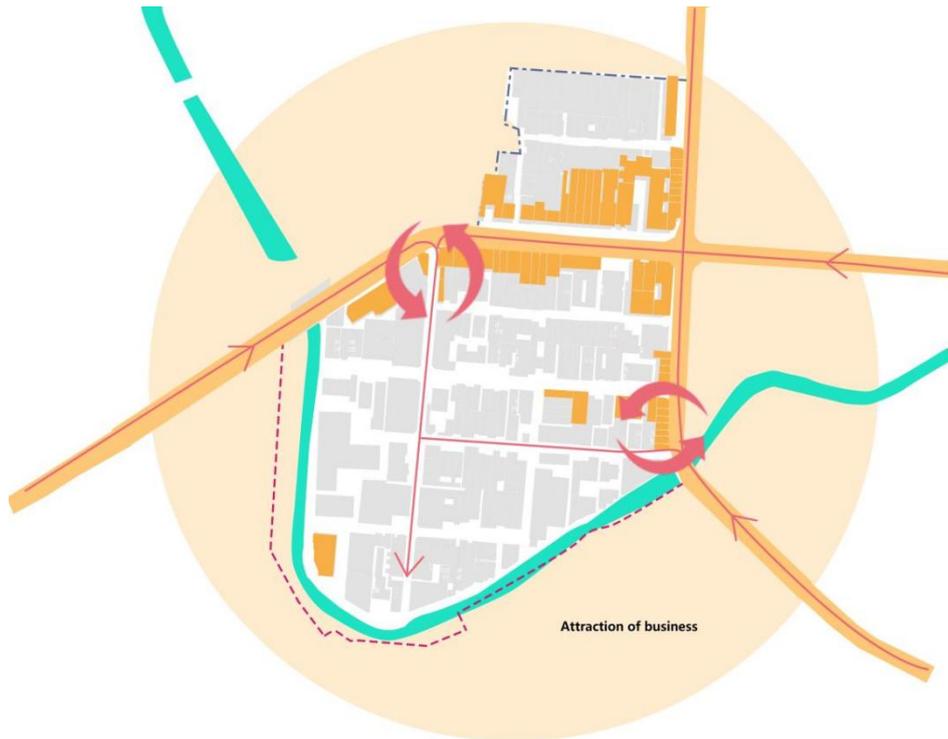


Figure 5-4 Vitality and green system (Source: self-illustrated by the author)

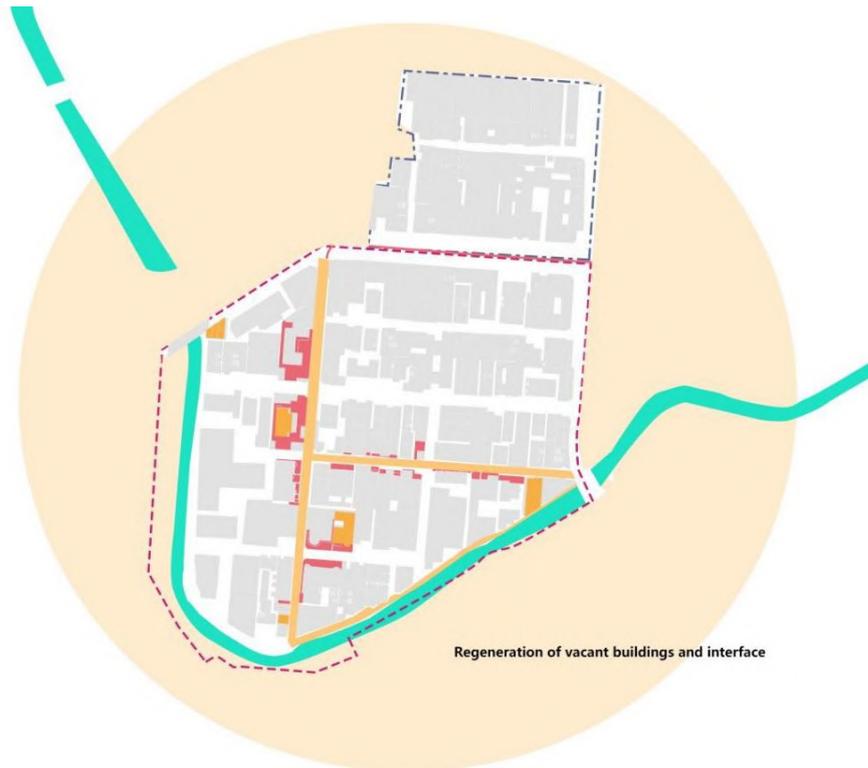
### (2) Strategies of each street

Corresponding street optimization strategies are formed according to the problems and characteristics of different streets. For A1 commercial street, make full use of the original commercial foundation, carry out integrated design of street facilities, strengthen the space for commercial activities, enhance the attractiveness of the main

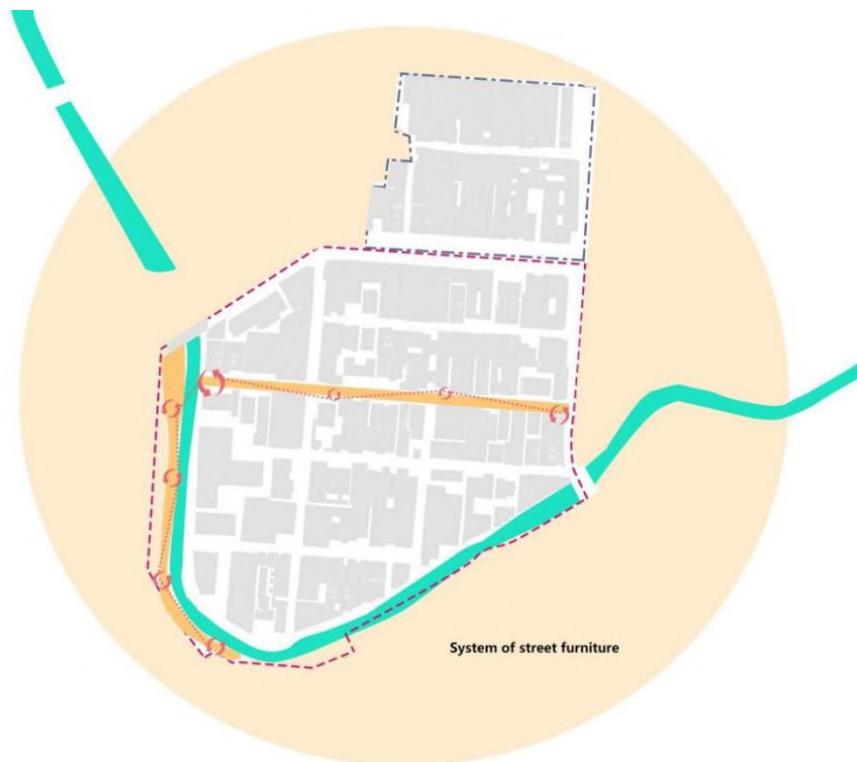
entrances and exits of the block, guide people into the street, and further stimulate the vitality of the block; for A2 historic street, increase the transparency of the street through the revitalization and utilization of vacant buildings; for B1 living and service street, add different types of street furniture to enhance the vitality of the interface; for B2 residential street, create more green space through vacant or retreating space of buildings, and simultaneously enhance the transparency of the street.



A1 Commercial street: improvement of the business attraction with integrated facility



A2 Historic street: regeneration of vacant buildings and street interface



B1 Living and service street: increase of flexible street furniture



## B2 Residential street: enhancement of street transparency with green space

Figure 5-5 Strategies of each street (Source: self-illustrated by the author)

### 5.1.3 General design

Based on the analysis above, the overall design of the district is mainly based on the characteristics of each street, making full use of the original basic conditions of the site to update the design. The block can be divided into 4 types of streets, forming two systems, which can enhance the walkability of the street and show the characteristics of the district by renewing and utilizing the vacant buildings in the street, adding necessary street furniture, improving the transparency of the street interface and so on to enhance the vitality of the district.



Figure 5-6 Axonometric View (Source: self-illustrated by the author)

## **5.2 Optimization of main street**

### 5.2.1 Commercial street

#### (1) General situation

There are mainly four types of facade in the district, including the overhead facade, closed facade, open facade and outdoor space. According to the four different kinds of street space will form different response strategies to promote the characteristics of the street space to be more fully developed. So different transformation are conducted in the district, such as the communicate space to decrease the barrier of street interface and promote the communication of different people, the regeneration of function, conservation of building facade as well as the update of landscape.

So in Changhua Ave, Changhua St and Fengyuan Zhongyue, optimisation of the entrance spaces and enhancement of the businesses are supported so as to increase the transparency of the street facade, enhance the overall harmony and continuity of the streetscape showing the history of pedestrian space.

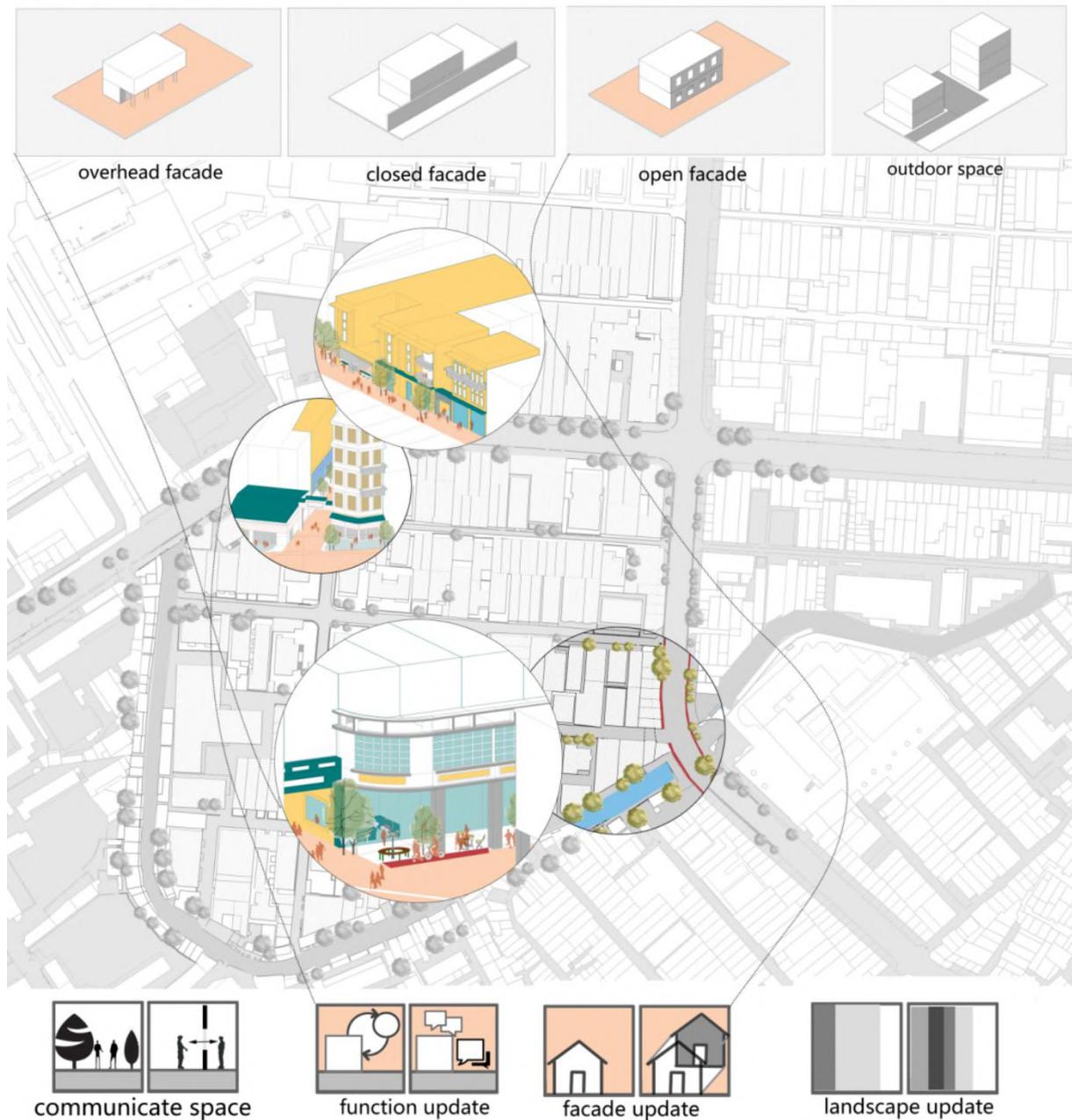


Figure 5-7 commercial street (Source: self-illustrated by the author)

## (2) Regeneration method

Enning Road, one of the typical history streets in Guangzhou, was selected for the study. The veranda street is divided into five main types of pedestrian spaces, including active sidewalks, sharing space, dedicated bike lanes, safe crosswalk and integrated supporting facilities to enhance the safety, comfort and diversity of the

overall street walking, at the same time to increase the attraction of the main entrance of the district.

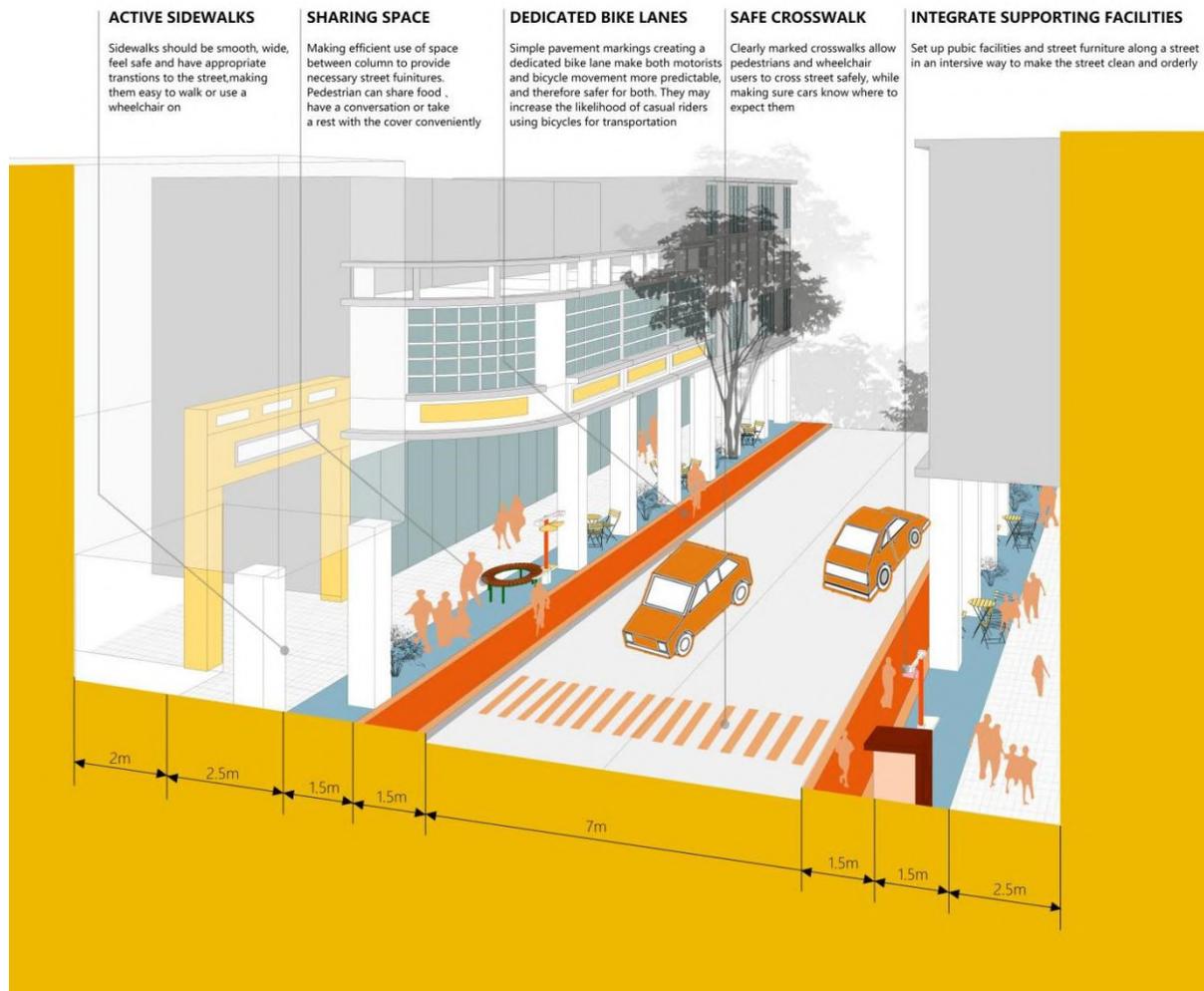


Figure 5-8 Transformation of Enning Road (Source: self-illustrated by the author)

### (3) The application of integrated facility

In commercial streets, due to the existence of various guidance needs, a large number of street facilities such as wayfinding signs, indicators, monitors, etc. are distributed on both sides of the street, making the building interface appear to a certain extent too chaotic, through the arrangement of the collection of facilities to reorganize the facilities around the street, and at the same time, additional seats can be added to further enhance the attractiveness of the street.



Figure 5-9 Layout of facilities around Enning Road, Duobao Road (Source: self-illustrated by the author)

In order to increase the design of integrated supporting facilities, for instance, the street lights can add wayfinding signs, multiple street signs can be unified on a single pole, and at the same time, as a support for street furniture, provide space for pedestrians to stay for a short time, making the overall street more neat and orderly.



Figure 5-10 Light combining with wayfinding sign in Enning Rd (Source: self-illustrated by the author)

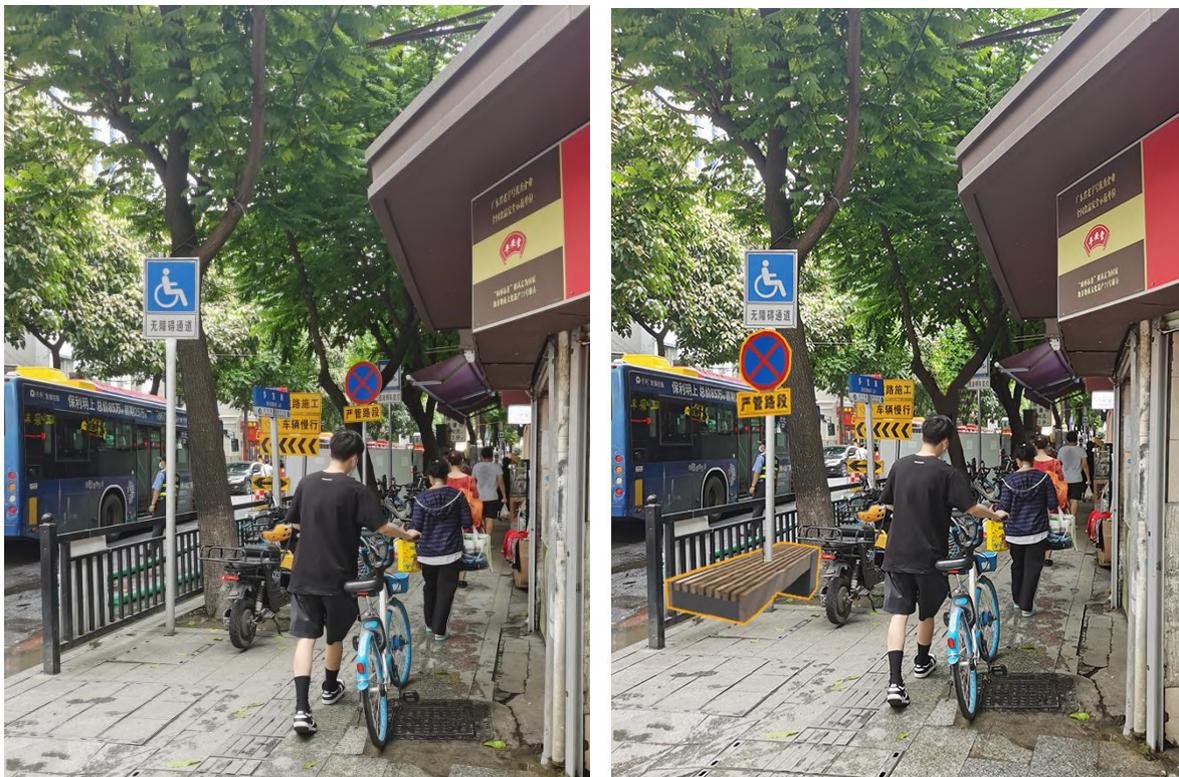


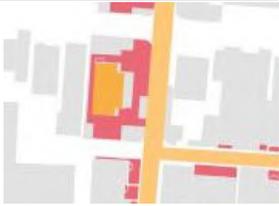
Figure 5-11 Sign combining with street furniture in Duobao Rd (Source: self-illustrated by the author)

## 5.2.2 Historic street

### (1) The general situation of history buildings

Through the analysis of history buildings on the street, specific regeneration method can be put forward to realize a better activation.

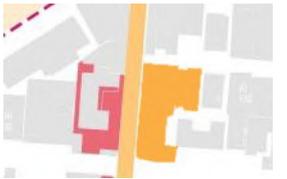
Table 5-1 The essential history buildings in the street (Source: self-illustrated by the author)

Name	Building category	Building Age	Function	Value	Location
House No. 10, Changhua Street	Typical style building or structure	Republic of China	Residence	Featured Crafts and components Western-style pediment	
Renewal mechanism	Follow the principle of not changing the original state of cultural relics by the property right to the administrative department of cultural relics in Liwan District to apply for approval to repair.				
Name	Building category	Building Age	Function	Value	Location
Residential house at No. 16 Changhua New Ave	Celebrities, former residences	Republic of China	From resident to Public service	Green water brushed the stone courtyard door Rounded corner outside the balcony	
Renewal mechanism	Follow the principle of not changing the original state of cultural relics by the property right to the administrative department of cultural relics in Liwan District to apply for approval to repair.				
Name	Building category	Building Age	Function	Value	Location
No.30 Enning Road Riding House	Typical style building or structure	Republic of China (1911-1949)	Combination of commercial and residential	Simple horizontal slit line, arched pediment Manchurian windows, concrete finial decoration	

Renewal mechanism	Protect architectural style, main facade, main structure, materials and characteristic craftsmanship and components, repair the damaged characteristic Craftsmanship and components are repaired according to the original pattern, the chaotic advertising signage is rectified, and the occupation of the street is prohibited.				
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Name	Building category	Building Age	Function	Value	Location
Riding House 1-3, Changhai Ave	Typical style of building or structure	Republic of China (1911-1949)	Residence	Flower-step brick, arched windows, wooden windows  Imitation Ionian column style, etched glass windows	

Renewal mechanism	Preserve the architectural style, main facade, main structure, materials and characteristic craftsmanship and components, repair the damaged characteristic craftsmanship and components as they are, and improve the interior environment as appropriate to meet the needs of modern life.				
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Name	Building category	Building Age	Function	Value	Location
House No. 26, Dobao South Crossing	The former residence of famous people	Republic of China (1911-1949)	Residence	Heshan roof, green glazed tiles with drip-cut edges  Flower-stepped tiles, hexagonal lotus flower roof	

Renewal mechanism	Follow the principle of not changing the cultural relics the principle of the original state, the owner of the property to the administrative department of cultural relics in Liwan District to apply for approval to repair.				
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(2) Increase the interface transparency combining with historic buildings

The vacant buildings can be regenerated with new functions. For instance, House No. 10 renewal requirement is not changing the original state, so through the courtyard space to create cultural and entrepreneurial activities, so as to open the street interface, on the one hand, as a place for people to stay and communicate, on the

other hand, to achieve the activation of the historical building.

Residential house at No. 16, because of the function change from residential building to public service building, is considered to combine with the vacant building on the right side as a social activity center, and through the stairs to provide a fuller communication and interaction platform, at the same time to open up the courtyard space between them to achieve further sharing.

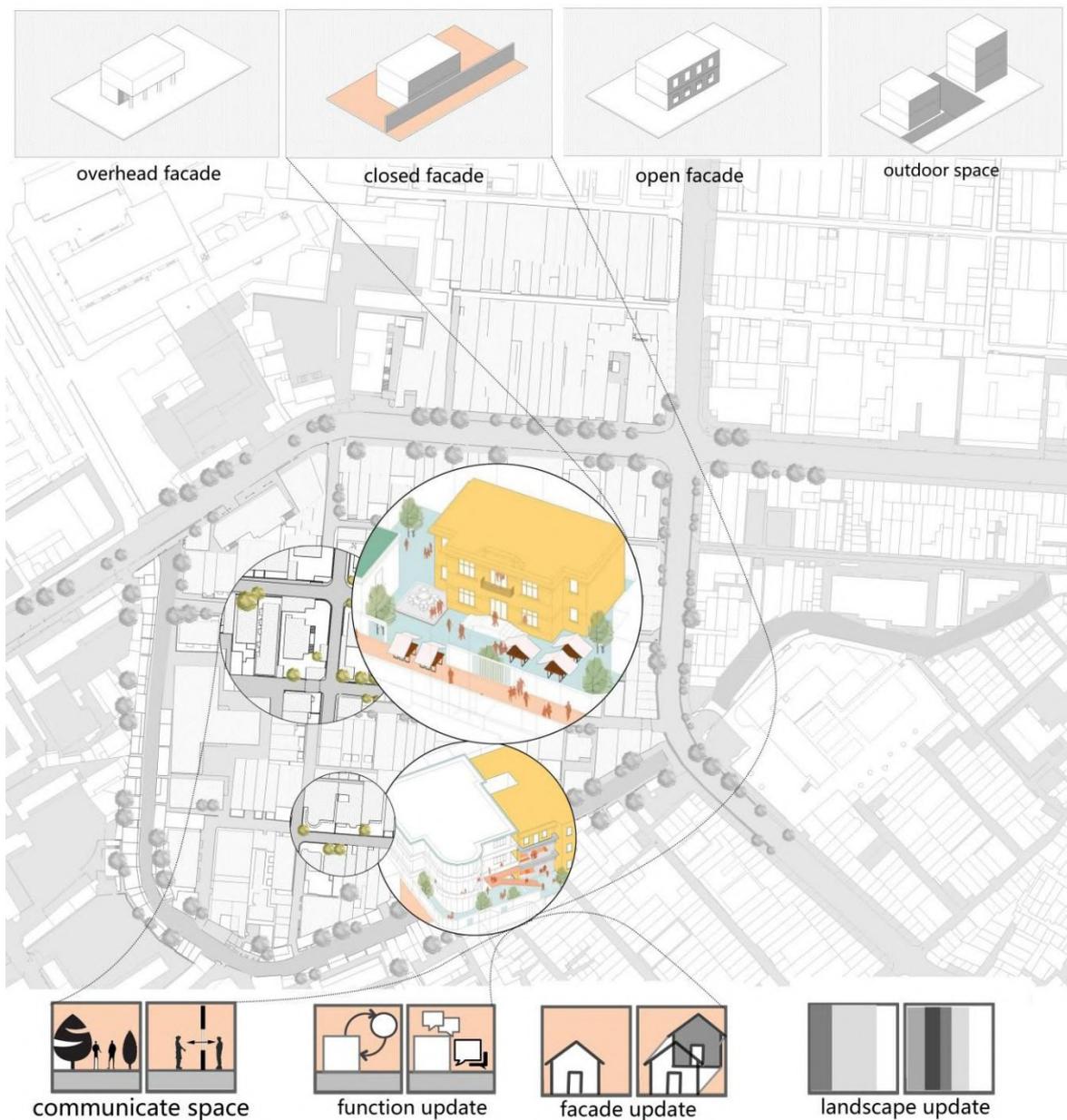


Figure 5-12 History street (Source: self-illustrated by the author)

### (3) Optimization of street interface

There are two different ways to improve the street façade: façade beautification and the use of greenery. The use of historical materials and colors in the facade beautification process allows these elements to blend with the historical environment and perpetuate the historical appearance of the street. The use of greenery is mainly through the improvement of the transparency of the interface, such as the use of grilles to allow greenery to penetrate inside and outside the wall, increasing the interaction with pedestrians and thus enhancing the integration of the building façade with the environment.



Figure 5-13 Different expression of street interface(Source: transfer-illustrated by the author)

### (4) The application of interface regeneration

By extracting the materials and features of the historical buildings themselves, the street interface is transformed to show the integration of buildings and walls, and to better demonstrate the harmonious overall appearance of the district.



Figure 5-14 Regeneration of interface (Source: self-illustrated by the author)

#### (5) The parking situation

As to the motorised parking system of district, a detailed analysis of the current state of motor vehicle parking in the district revealed that Changhua Street is the main parking area in the street with double-sided parking. Duobaonanheng and Changhua New Ave are also double-sided, while Changhua Ave, the other main entrance street of the historical district, is only controlled as single-sided parking. So basically, the parking system in the district is a network of circulation. Due to the limitation of the site itself, we can only rely on the surrounding social parking lot as a new space to mitigate the parking phenomenon within the district.

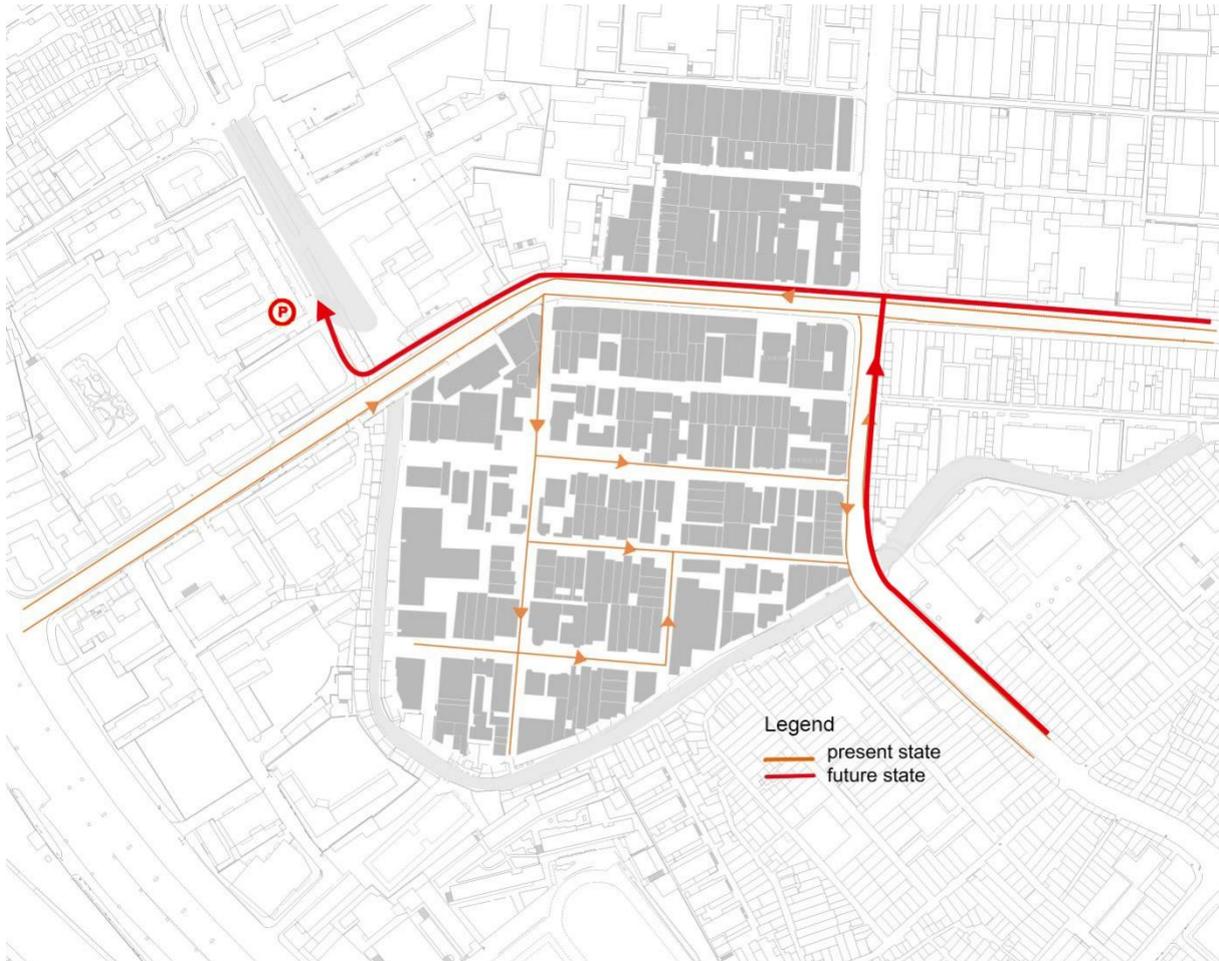


Figure 5-15 Motorised parking system (Source: self-illustrated by the author)

As to the non-motorised parking system of district in consideration of the future control of motor vehicles in the district, full use will be made of the surrounding social car parks to reduce the impact of motor vehicles on the pedestrian environment. To further enhance residents' willingness to travel non-motorised within the district, a parking system for non-motorised vehicles such as electric vehicles and bicycles will be formed within the site by using public service facilities or the setback space of buildings to promote connectivity and convenience of travel within and outside the district.

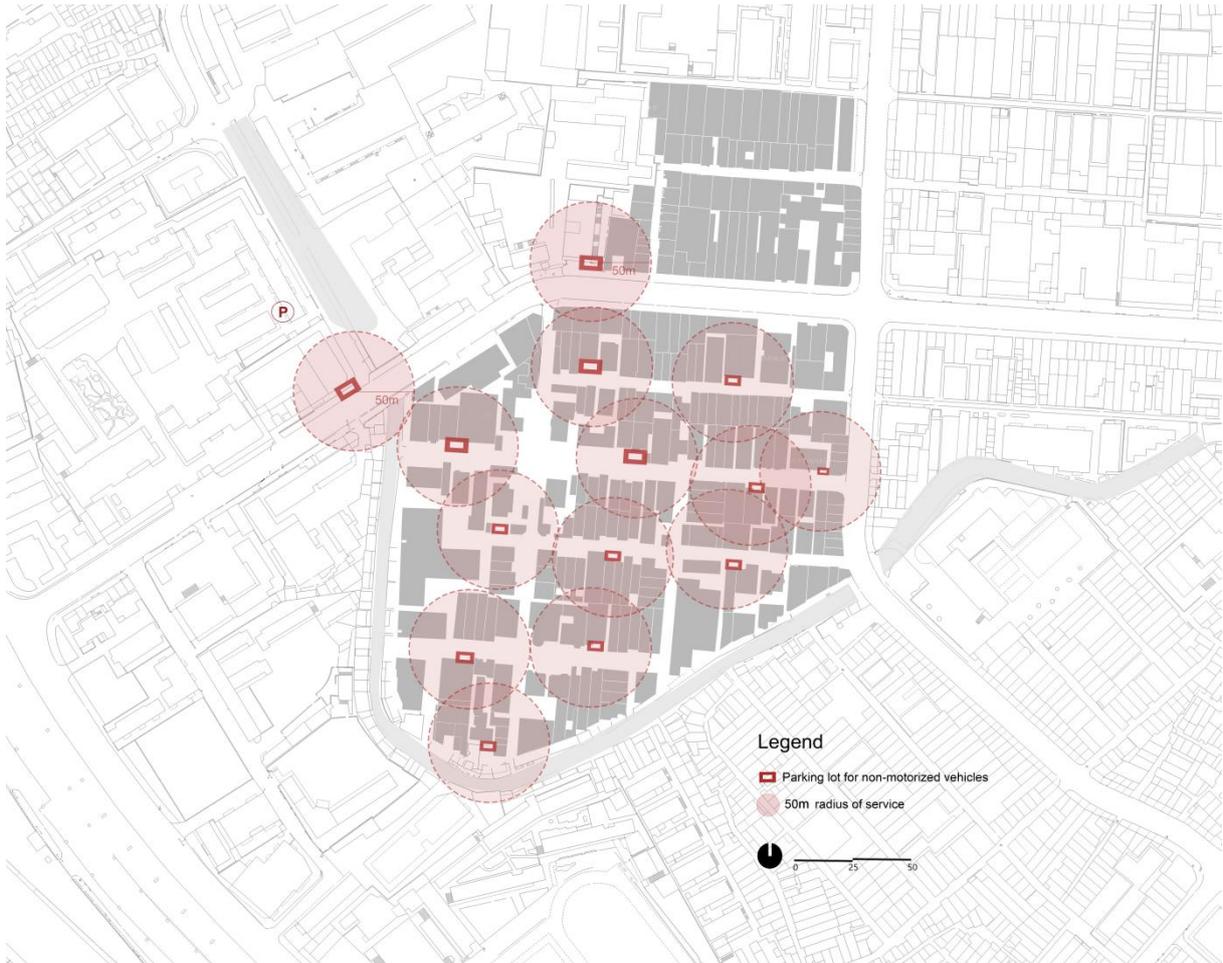


Figure 5-16 Non-motorised parking system (Source: self-illustrated by the author)

### 5.2.3 Living and service street

In response to the problem of lack of street facilities in the Living and service street and the current situation around the river resources, hoping to make better use of the remaining space and natural landscape resources in the street through the addition of street furniture.

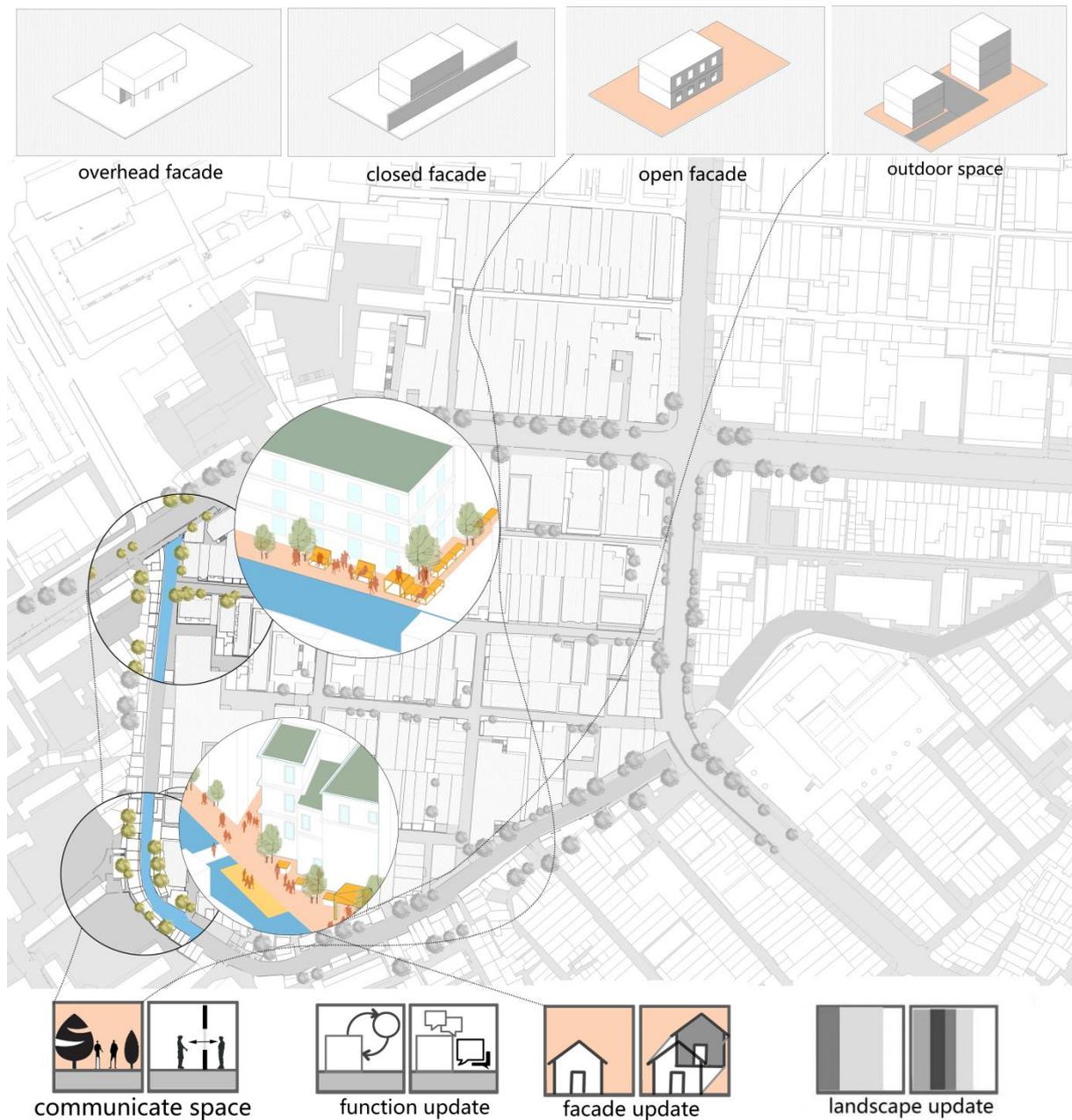


Figure 5-17 Living and service street (Source: self-illustrated by the author)

The use of movable furniture, combined with the open architectural interface, creates new functional stay spaces and facilitates for the interaction of people in the district, thus enhancing the convenience of the street and improving its life service nature. The use of modular street furniture facilitates the harmonization of styles in historic districts, while enabling a more flexible organization to meet the needs of different people.

(1) Modular furniture



Figure 5-18 Distribution of street furniture (Source: self-illustrated by the author)

(2) Intention of transformation



a)



b)

Figure 5-19 Transformation of furniture in riverside. a) before; b) after (Source: self-illustrated by the author)

#### 5.2.4 Residential street

Through the use of the outdoor space in the district, different activity theme spaces are formed, and through the functional conversion of vacant buildings to form small living courtyards, the transparency of the overall street façade is increased and the communication between people is promoted.

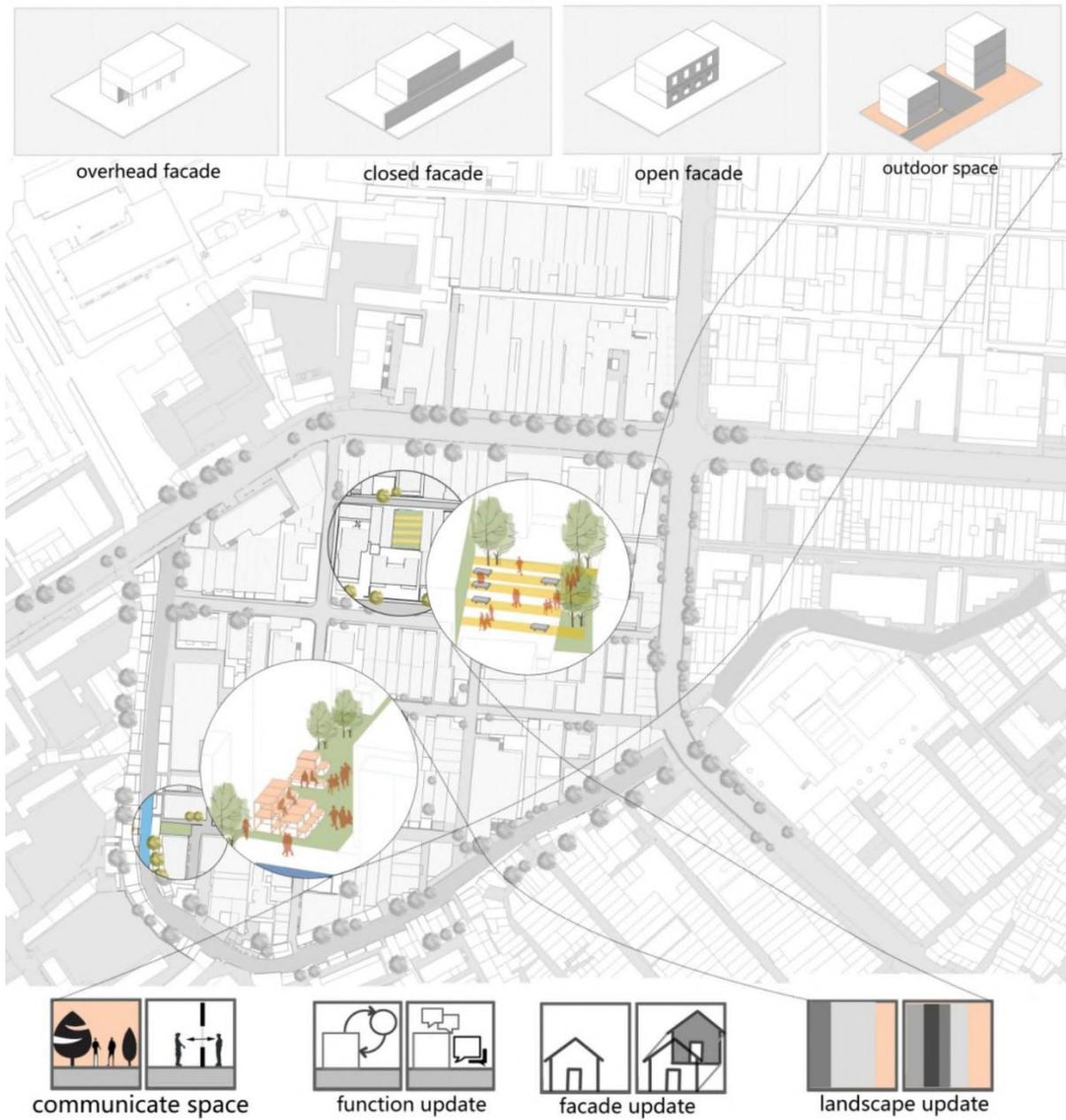


Figure 5-20 Residential street (Source: self-illustrated by the author)

(1) Possible themes of transformation



Figure 5-21 Public space with different themes (Source: self-illustrated by the author)

(2) Intention of transformation

In the internal streets of the district, the use of social parking to reduce internal motor vehicle parking, the provision of additional street furniture to form a space for community residents to have a better interaction, and the use of greenery to increase the transparency of the street interface, showing the harmonious rhythm of the building façade itself, smart lights and sensors can promote and record the activities in the district so as to have a timely transformation and maintain the vitality, thus resulting in an overall more convenient and comfortable pedestrian space.

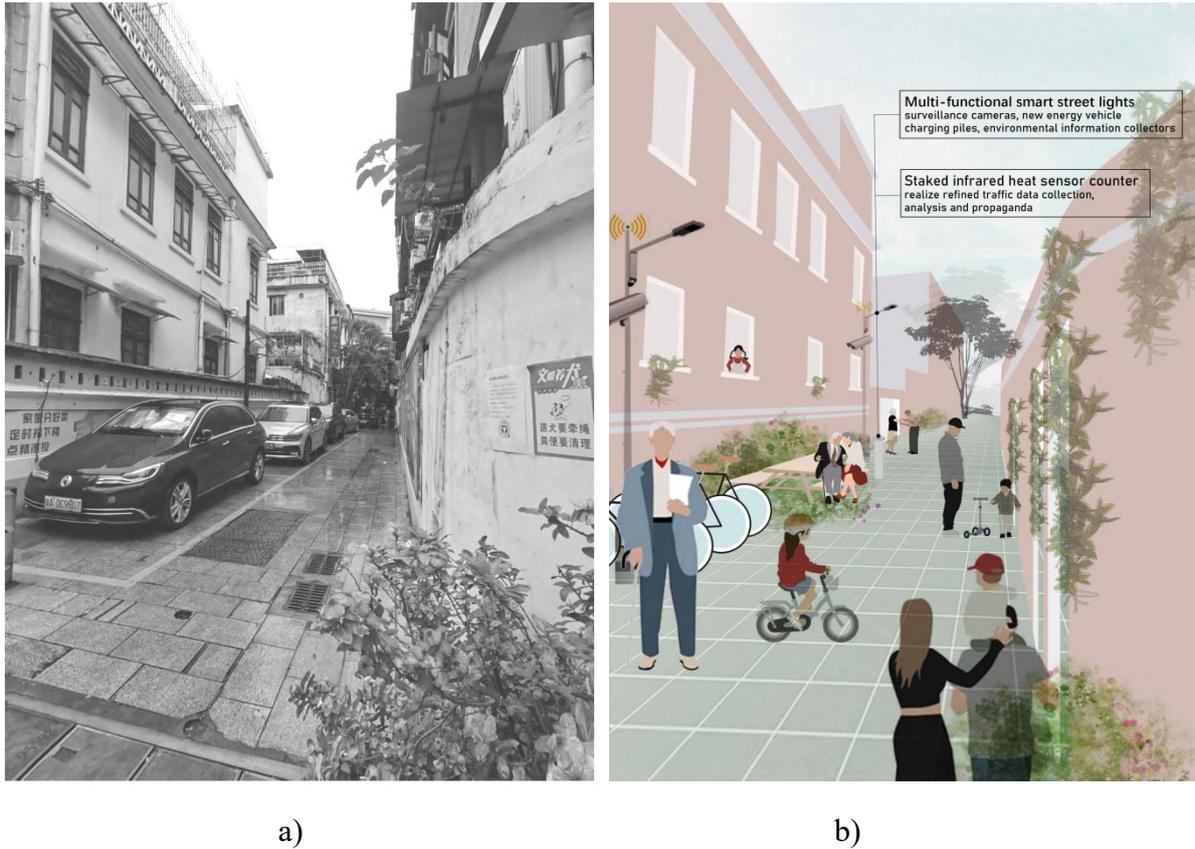


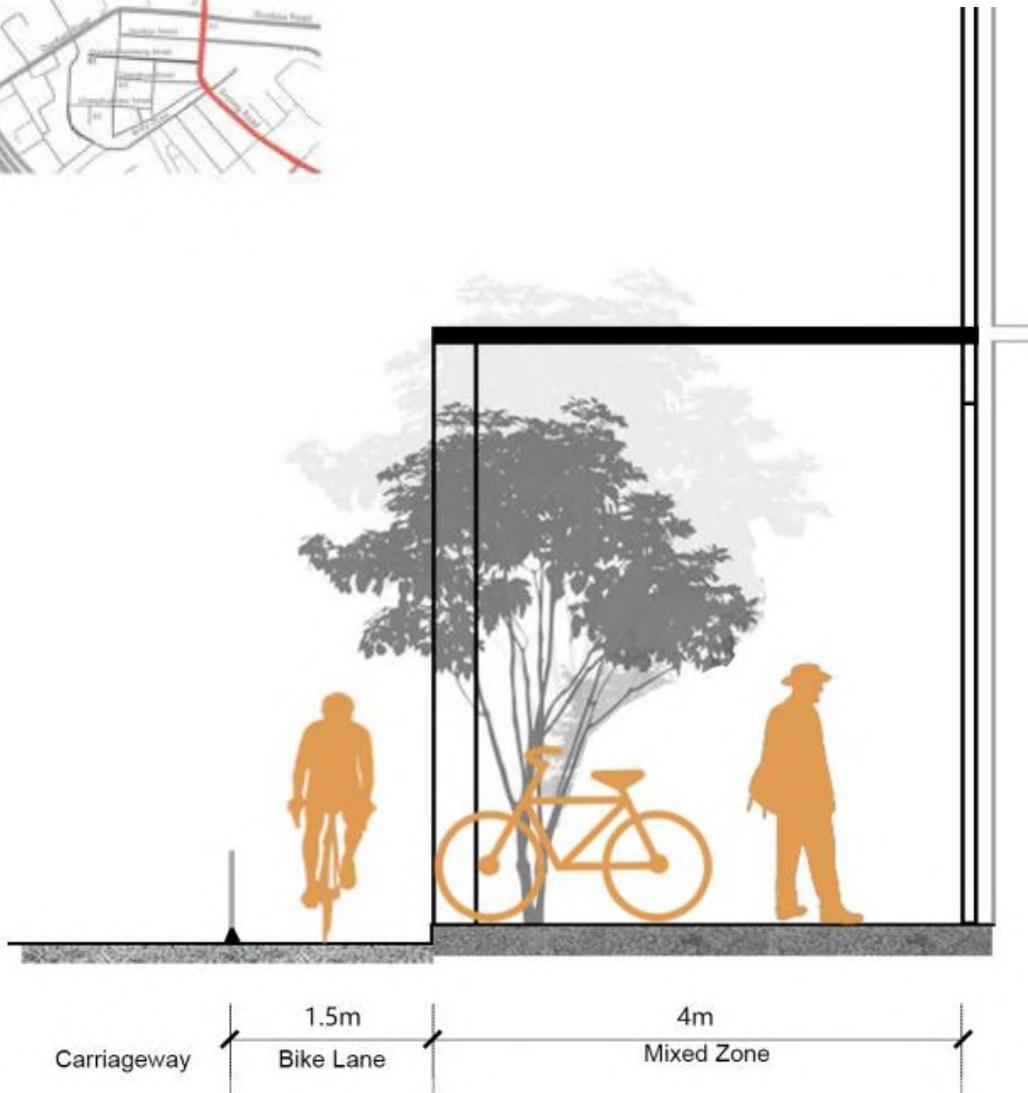
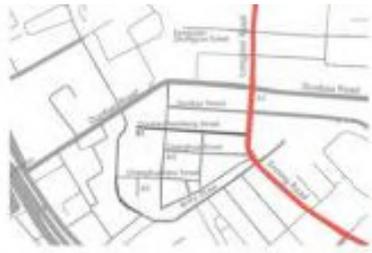
Figure 5-22 Transformation of residential street. a) before; b) after (Source: self-illustrated by the author)

### 5.3 Enhancement of street section

At the same time, strategies for optimising street sections are put forward to each kind of street to have an accurate promotion of walkability.

#### (1) Optimisation strategy of A1 commercial street section

Raise the height of the cycling lane to separate it from the motor vehicle lane, differentiate the ground paving of the veranda street, strengthen the leisure stay area and improve the utilization of different functional areas.



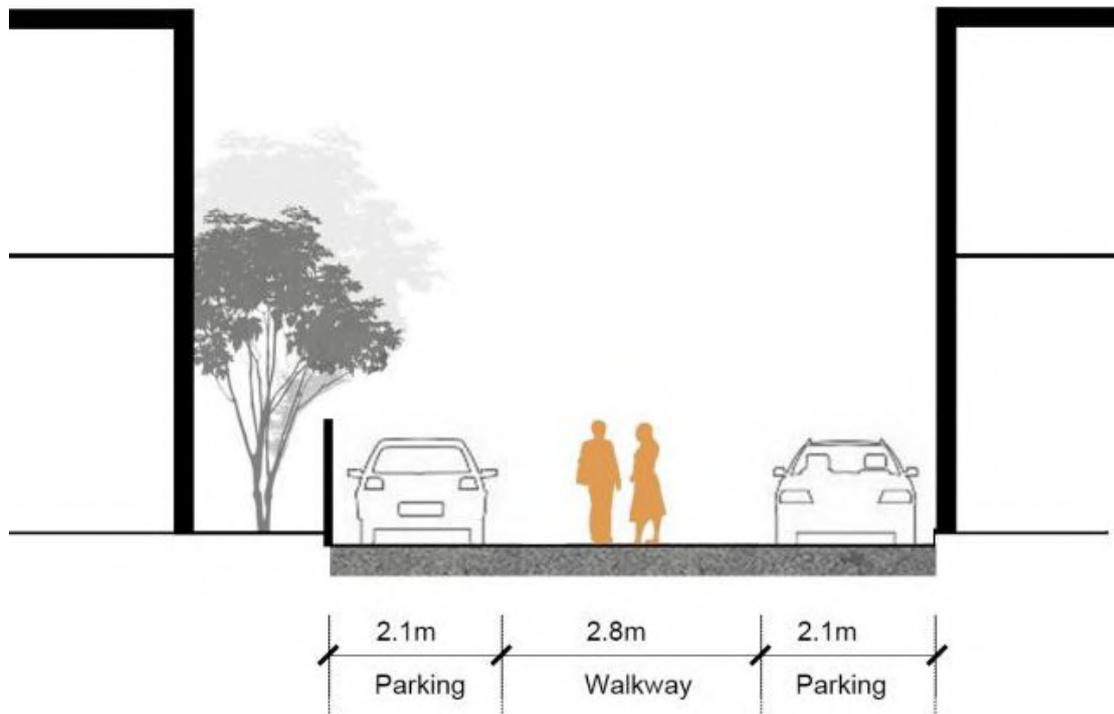
Before transformation



Figure 5-23 Commercial street section (Source: self-illustrated by the author)

(2) Optimisation strategy of A2 historic street section

Control motorised parking on internal streets in the district, reduce physical wall obstructions and increase the transparency of the street interface.



Before transformation

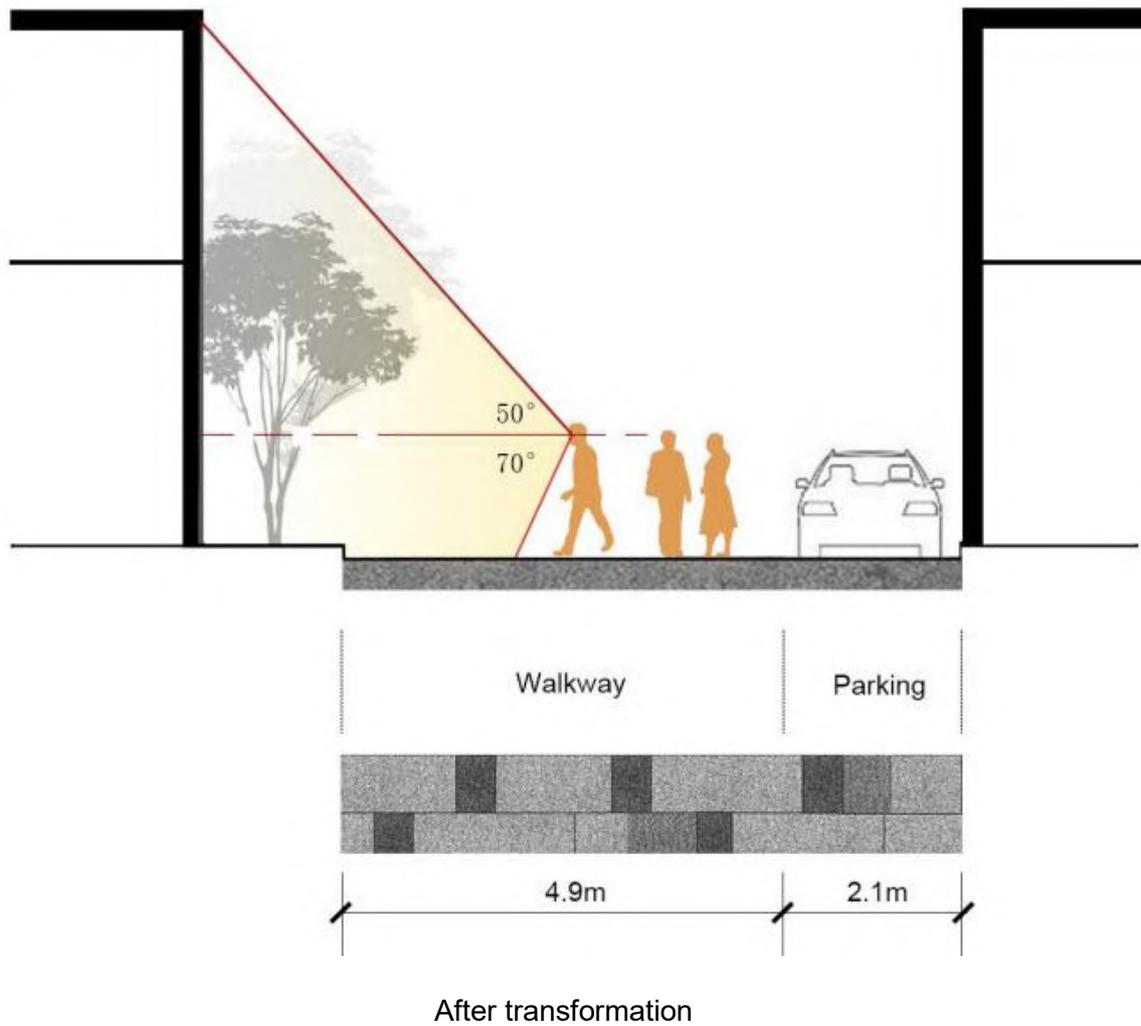
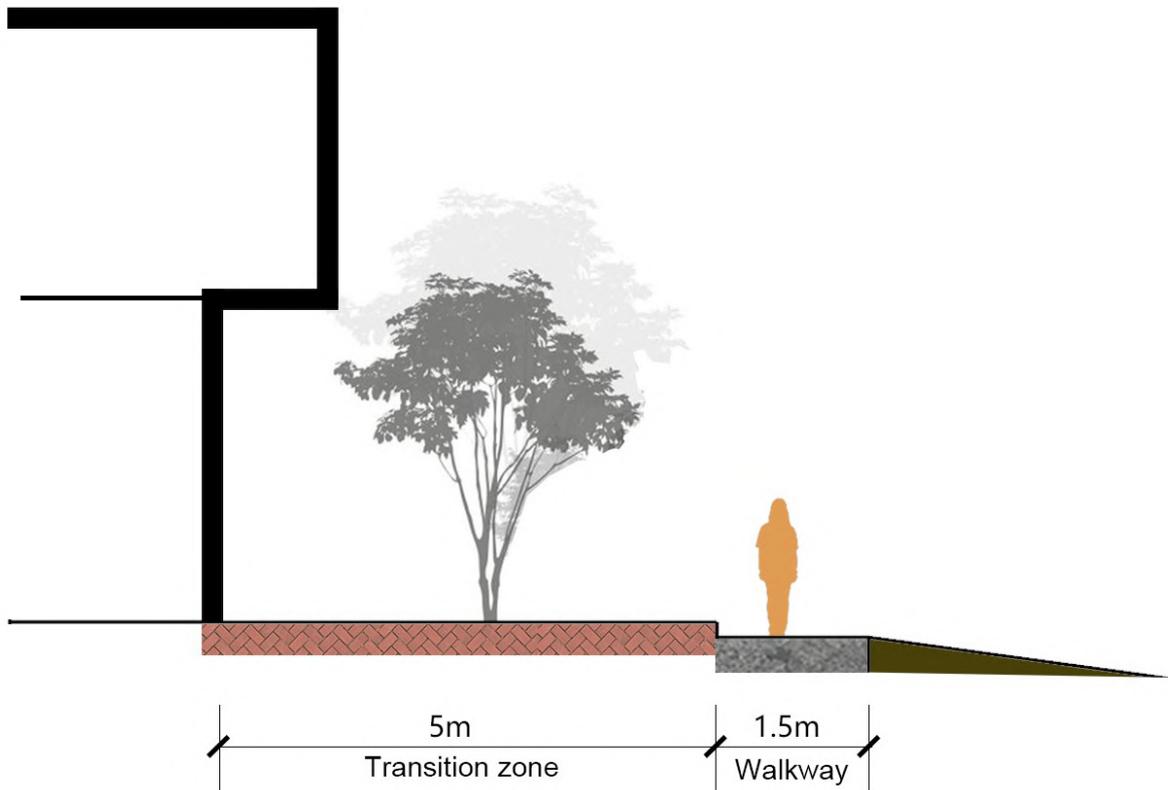


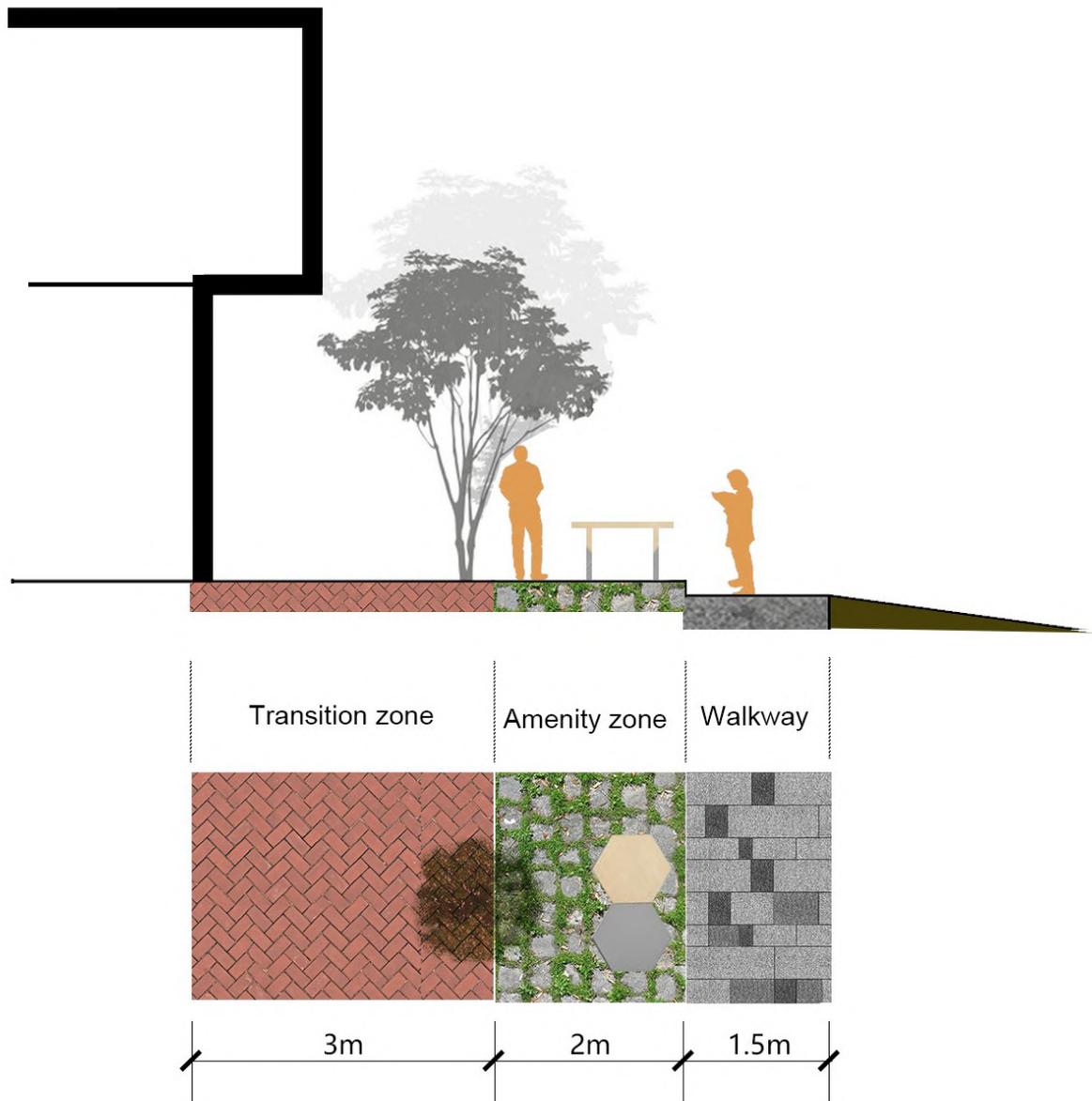
Figure 5-24 Historic street section (Source: self-illustrated by the author)

(3) Optimisation strategy of B1 living service street section

The paving of the riverfront streets has been upgraded to increase the permeability of the streets, while creating distinctive places to stay and increase public interaction.



Before transformation

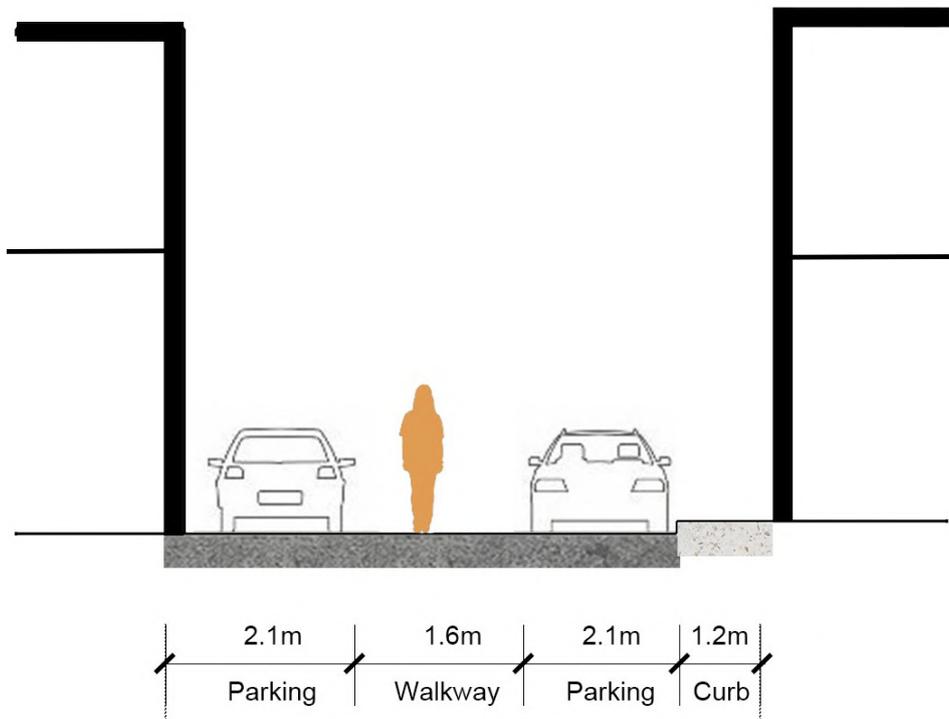
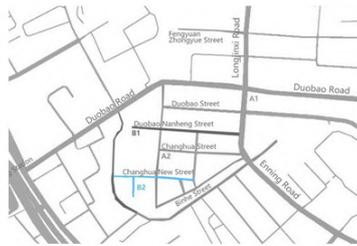


After transformation

Figure 5-25 Living service street section (Source: self-illustrated by the author)

(4) Optimisation strategy of B2 residential street section

Control the parking of motor vehicles and create a green transitional space to facilitate a good community living relationships as well as enhance the comfort of walking in the streets.



Before transformation

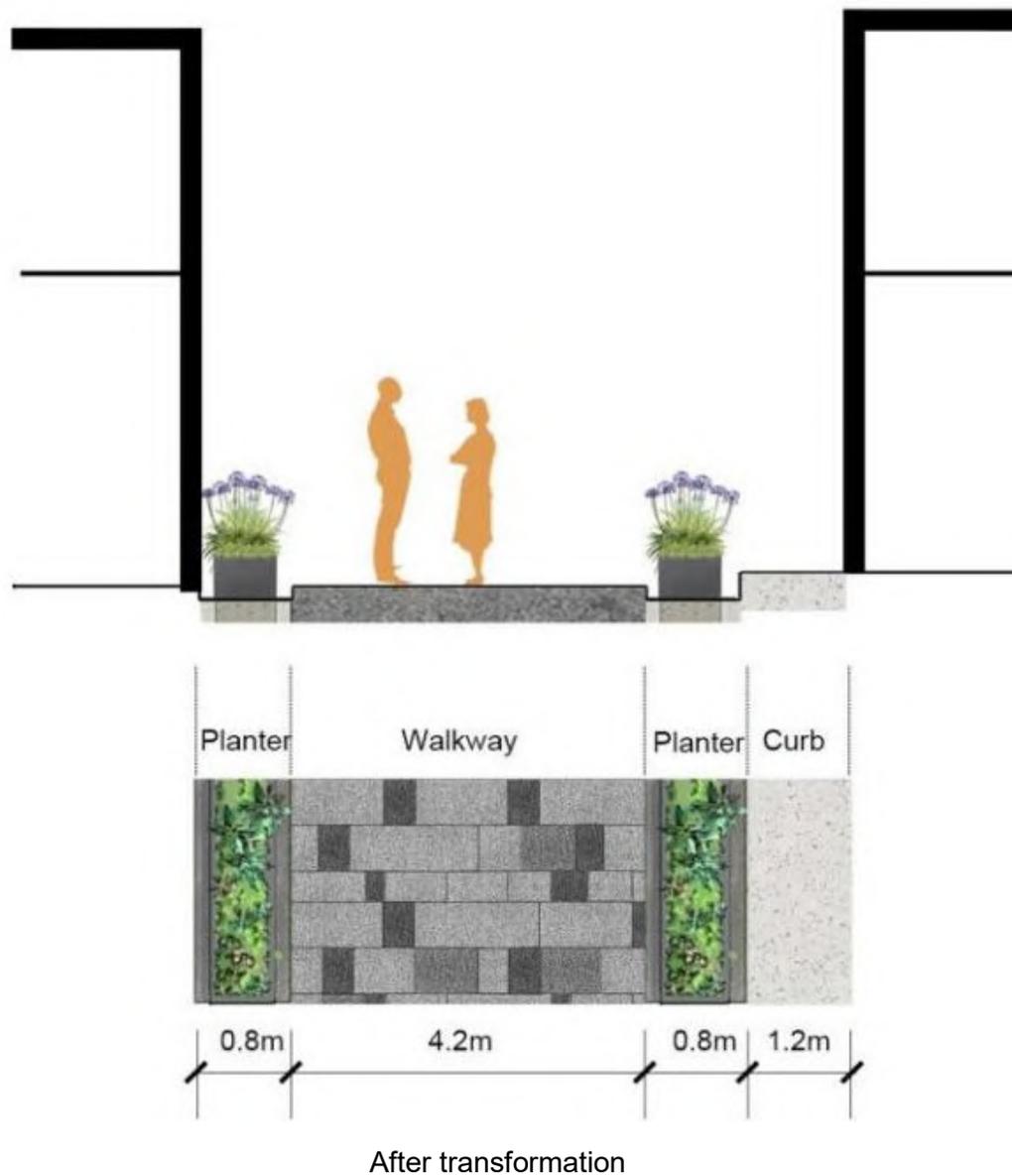


Figure 5-26 Residential street section (Source: self-illustrated by the author)

## 5.4 Interaction scenarios

Through the main public space on the pedestrian route, showing the history, culture and landscape resources inside the district, forming a dynamic zone for people's interaction through the site, and synchronously improve the walkability of the street with multiple indicators.



Figure 5-27 Intention of public space (Source: self-illustrated by the author)

## **Chapter 6 Conclusion and Prospects**

### **6.1 Conclusion**

(1) According to new demands for sustainable urban development in the new century, enhancing street walkability has become one of the vital ways to contribute to it. By combining new scientific information technologies, a quantitative study of street walkability is carried out using data augmented design methods. This paper attempts to sort out the development of street walkability as well as historic and cultural districts, improve the evaluation system of street walkability from the characteristics of historic districts, then based on it to select operational quantitative research methods for the evaluation indicators in the system.

(2) A quantitative study of street environment and vitality in historic districts based on multi-dimensional data was conducted to improve the relevant indicators during the evaluation process, so as to be better adaptive to the actual situation and suitable for promotion in the historic districts.

(3) The empirical study shows that Changhua District has a potential layout and an impressive streetscape. However, there are still problems such as inadequate exploitation of historic resources, relatively low street vitality and the occupation of pedestrian space by motor vehicles, which needed to be addressed gradually with regeneration and optimisation to improve the walkability of the street in future .

### **6.2 Innovation points**

(1) Through a review of existing studies, the quantitative evaluation system of street walkability in historic and cultural district is improved from six dimensions, including street connectivity, convenience, safety, history, diversity and comfort.

(2) Demonstrates the empirical use of data-augmented design method in historic and cultural districts in Guangzhou, making full use of traditional and new data to strengthen the basis for planning and design as well as to exploit the uniqueness of

the site.

(3) Through the analysis of the walkability in historic and cultural district in Guangzhou, specific optimisation strategies and enhancement designs are proposed for the district, as well as to provide reference for future urban regeneration projects in the same category.

### **6.3 Shortcomings and prospects**

(1) Satisfaction evaluation based on questionnaires is in fact a qualitative assessment of the objective walking environment, followed by a quantitative rating by quantifying the satisfaction of the users. As a result, the judgement results are highlighted by differences in the age and gender of individual, and some of the findings may differ from the actual situation.

(2) More data platform could be built to enable real-time feedback from the site, and additional facilities such as street sensors are being considered to record pedestrian activity and walking status in time, so that corresponding street design guidelines or strategies can be formed in a more timely and efficient manner.

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## Appendix

### Survey on the pedestrian friendliness of the streets of Changhua District and the surrounding historic district

Changhua District is located at the intersection of Enning Road, Dobao Road and Lai Chi Wan Chung, and as one of the important historical and cultural districts, we hope to understand people's feelings and evaluation of its walkability to form specific guidelines for future improvement and design.

#### 1. Your gender

- Male
- Female

#### 2. Your age

- 20 years old and below
- 21--30
- 31--40
- 41--50
- 51 years old and above

#### 4. Your occupation

- Student
- Worker
- Civil servant or institution
- Company employee
- Service worker
- Other (non-working, retired)
- Private self-employed person

5. What is your daily transportation mode

- Walking
- Bicycle
- Electric car or motorcycle
- Private car
- Taxi
- Public transportation

6. What is the purpose of walking in general

- Work
- Home
- To and from school / pick up children
- Shopping and spending
- leisure and entertainment (strolling, sports, walking, etc.)
- Other (passing by, transferring, etc.)

7. Your average daily walking time

- 0--30 minutes
- 30--60 minutes
- 1--2 hours
- 2 hours or more

8. Are you familiar with Changhua Street and its surroundings

- Very unfamiliar
- Not familiar
- Familiar
- Familiar
- Very familiar

9. Do you feel comfortable walking on and around Changhua Street

- Very comfortable
- Comfortable
- Generally comfortable
- Not very comfortable
- Very uncomfortable

10. How do you feel about the space in and around Chang Hwa Street

- Empty
- Very empty
- Overly empty
- Generally depressing
- Depressing

11. What aspects of the pedestrian street are you more concerned about

- The historical buildings around the road
- The green landscape of the road
- Cleanliness of the road
- Road connectivity (being able to walk easily to your destination)
- Safety of the road (roadside lighting, wayfinding signs, etc.)
- Facilities around the road (e.g. seats, recreational sports equipment, etc.)
- Public nodes available for recreation

12. Do you think there is a chaotic phenomenon that the walking space in and around Chang Hwa Street is occupied by facilities or other private reasons, and does it affect your passage greatly

- Exists, seriously affects the traffic
- Exist, affects the traffic a little
- Exists, but does not affect traffic
- Does not exist
- Not sure

13. What node attracts your attention most when walking in this neighborhood

- Architectural features
- Food and drink
- Old fashioned food
- Leisure and entertainment
- Public space

14. What do you think are the problems of street pedestrian space?

- Lack of complete and independent special lanes
- Insufficient space and width of pedestrian paths
- Commercial activities along the street encroach on the pedestrian space
- Utility poles, boxes and other municipal facilities occupy the street
- Motor vehicle parking encroaches on the pedestrian space
- Lack of attraction around the pedestrian walkway
- Other

15. How would you rate the overall evaluation of the pedestrian space of the streets in the old city

- 1 2 3 4 5 6 7 8 9 10

16. What are your opinions or suggestions about the pedestrian space in the old city streets [Fill in the blank] \*

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