Towards Sustainable Streets Design:

Indicator System of Sustainable Evaluation

for Shanghai Streets

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A thesis submitted to the

Welsh School of Architecture, Cardiff University

For the Degree of

Doctor of Philosophy

May 2020

Acknowledgements

Many people have given me help and support throughout the time of this research. Without them, this thesis might not have been possible.

First and foremost, I would like to express my sincere gratitude to my supervisor, Dr. Philip Johns. His encouragement, valuable advice, and constant help were essential for me to complete the study. Thanks to Dr. Julie Gwilliam for her patient reading of my draft and provided precious advice for improvements. Thanks to Katrina Lewis for her constant help with administrative matters. Also, I would like to thank all the staff members at the Welsh School of Architecture at Cardiff University.

My sincere thank also goes to Dr. CAO Shu, Mr. ZHAO Bo, Mrs. GE Yan, and Dr. JIN Shan who accepted the Expert Interview and provided insightful thoughts and inspired new ideas in me. Besides, I would also thank the 50 experts who participated in the questionnaire survey for this research and also 161 strangers who accepted the street questionnaire and supported my study.

A huge thank goes to my husband, SHEN Shuopu, for his patience, love, and encouragement, and my 7-year-old son, SHEN Huaifang, for his understanding that Mom had to write thesis rather than play with him. Also, thanks to my parents-in-law for their support of my PhD study.

Finally, my deepest gratitude is dedicated to my parents. Their unconditional support and endless love have been and will be always the powerful supports to me.

Abstract

The streets are one of the most significant system in urban areas under the background of Climate Change and the transformation of China's high-density built environment. With the problem of a lack of practical evaluation tool to guide the street design in a comprehensive and effective way, this research aims to build an indicator evaluation system for sustainable streets in Shanghai to provide suggestions for street design.

Firstly, the research established the theoretical basis of sustainable street design and an evaluation framework of sustainable streets by literature review. The investigations of 236 streets in Shanghai and the questionnaire survey of 50 experts were conducted to apply the evaluation framework, to assess the overall performance of Shanghai streets, and to construct a set of indicator evaluation system for sustainable streets in Shanghai. Three streets were evaluated by the established system. The evaluation results were compared with the questionnaires' data of 50 street users to examine the accuracy and objectivity of the system. Finally, 4 experts who were famous in the fields of street design, research and management in Shanghai were interviewed. The interview outcomes were integrated with the whole research findings so as to optimise the evaluation system.

The key findings included: 1) the theoretical basis of sustainable street design, including the definition, 3 principles, 15 design objectives and a set of toolkits with 75 design methods; 2) an indicator evaluation system for sustainable streets in Shanghai, including 15 evaluation criteria and 32 evaluation indicators, a set of standardisation methods and weighting system, and a package of calculation formulas; and 3) an overall assessment of Shanghai streets and some useful suggestions for future renovations of Shanghai streets.

With the research outcomes, it promoted the theoretical development of sustainable street design and filled the academic gaps. Also, it provided a set of design toolkits to promote the practice of sustainable street design, which were not only a framework for comprehensive thinking but also a useful manual for street design. Finally, the research delivered a set of sustainable evaluation tool for Shanghai streets, and its framework and the construction method could be expanded to other cities and regions. This is a tool to measure the sustainability, not only helping the designer to identify issues and find solutions, but also helping decision-makers to compare different schemes and quantify their selections.

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Chapter 1. Introduction

1.1 Research Background

This research is established based on the two main areas, namely Climate Change and China's transformation. Climate Change, is the most significant challenge to humanity, and has caused considerable adverse effects environmentally, socially, and economically. So theoretical studies and technical practices to reinforce the city's adaptability are of profound importance worldwide. Moreover, China's massive population, rapid urbanisation, and unique land system not only promotes impressive economic growth but also brings a series of development issues. Nowadays, the transformation of development is the primary tasks of China. Therefore, the external driving force of Climate Change coincides with the internal driving force of China's transformation, which drives the shift of sustainability. It is under the research context that this research focuses on urban streets. Based on this, the research studies the formation and application of sustainable streets in a Chinese city.

1.1.1 Climate Change

Climate Change, as the greatest challenge to humanity, is predicted to potentially damage every natural and human system on the planet (IPCC, 2007; Garnaut, 2008). The energy-intensive way of life has created numerous problems that continuously threaten the endurance of ecosystems on the global and local level, while additionally, the Climate Change begins to modify our perception of the living environment regarding accepting its limitations and actions to mitigate the effects.

The phenomenon of Climate Change is not only related to long-term global change but also closely connected with short-term local variation. Globally speaking, Climate Change includes global warming, sea-level rise, more natural disaster, while the urban areas are confronted with the most threats to sustainable development. The measurable effects within cities are warmer average temperatures and greater extremes in temperature and precipitation (IPCC, 2007). The invalid control of urban growth led to the deterioration of urban climate and the aggravation of global Climate Change.

However, the traditional methodology of urban design is unable to deal with those issues, and sometimes even aggravates the negative influences caused by extreme weather. It is found that people's activities are the core element in Climate Change, while high-density urban form, unreasonable functional organisation, and solid urban fabric all further intensified "Urban Heat

Islands Effect" and somehow exacerbate the extreme climate (Gleeson, 2008; Matthews, 2011; United Nations, 2007a).

Therefore, many urban planners and designers have been trying to find some new solutions to Climate Change, especially at the local scale. As Climate Change is an irreversible process, among existing response options, basically there are two paradigms: mitigation of Climate Change and adaptation to Climate Change (IPCC, 2007; CCSC, 2015). Between this two, more researchers are for the adaptation solution, because the adaptation solution can be practised and implemented on a small scale and its effectiveness can be measured and evaluated in a short time more efficiently (Bulkeley, 2006; Smith, et al., 2010; Wilson & Piper, 2010). So theoretical studies and technical practices of Climate-Change-Adaptation design are of profound importance nowadays.

1.1.2 China's pattern and sustainable shift

Hugh population and rapid urbanisation:

China is a developing country with a territory of 9.6 million Km^2 and 1.36 billion people which make up to 20% of the world's total population. The average population density of China is 143 people per Km^2, and it is about 3.3 times that of the world's population density. Moreover, its population distribution is very uneven: the most density part is the eastern coastal area, and the population density of some cities, like Shanghai, Guangzhou, Hong Kong, Tianjin, even exceed 900 people/Km^2.

Meanwhile, the scale and pace of China's urbanisation have developed at an unprecedented rate since 1980. Much land is constructed to be the metropolis within only several years. Undeniably, such a rapid urban expansion with the large population brings impressive economic growth, but also causes numerous risks socially and environmentally, especially under the background of Climate Change.

Unique land system and urban morphology

Different from other countries, China's land system is a dual structure mode: the state-owned and the collective-owned of land, which means no land belongs to a private person. This particular land system not only shapes a strong ability of government macro-control but also enables "urban planning and design" to powerfully drive the cities' construction. In other words, planning and design have strong enforcement. Therefore, scientific and reasonable design leads a long-term benefit, while hasty and profit-oriented plan causes tremendous problems afterwards.

The year 1978 witnessed China's reform and the start of the real estate market. Since then, a large number of developers have joined the so-called "Enclosure Movement": bidding large pieces of land to develop substantial residences and even a new town. This kind of land system and fast development of the real estate market gradually shape China's unique urban morphology: High-Density and Super Block (Wei, 2014). The High-Density is not only reflected by its high building density from a horizontal perspective but also embodied by a mass of high-rise from a vertical angle. Super Block is caused by the economic benefit maximisation in the real estate development process. The mechanism of pursuing benefit maximisation often leads to the relatively low quality of public space, especially urban streets.

A shift from growth-oriented to sustainable development

In the process of economic and social development, China has experienced the rapid economic growth and been the world manufacturing centre. However, the development pattern of low per capita resources shares and the economic growth mode of the extensive form have made the resource shortage, environment worsening, as well as the severe constraints of the economic and social development. Specifically speaking, the conflicts are that the supplies of land, water, energy, mineral resources, and ecological environment do not match the demand for economic and social development. Hence, "China's Agenda 21", the world first national level's "Agenda 21", was released in 1994, which indicates China's transformation of sustainable development.

Urban streets, as one of the most important components of the urban system, also show this transformation. Particular land systems and urban morphologies, in the context of huge population and rapid urbanisation, have created many "large, boring and car-oriented streets". In 2016, Shanghai released the country's first "Street Design Guidelines", which proposed four development goals of safe, green, vitality and smart streets, which marks the sustainable transformation of Chinese streets.

1.2 Research Focus and Scope

Concerning the formation of sustainable streets, the research mainly focuses on the part that design can play a vital role in moving towards sustainability. Because proper planning and spatial design are crucial to create an attractive and liveable environment and deliver sustainable development (DoTLGR, 2001). Therefore, the research studies the general principles, a design toolkit and an evaluation framework for sustainable streets, which reflects a pattern of a design-oriented procedure of "vision-design-evaluation-feedback-revision-design." Also, the evaluation system of sustainable streets is also built based on a design-oriented methodology. Undoubtedly, there are other paths and instruments such as operation and management, public engagement, and new technologies, which could also contribute to the delivery of sustainable street. These parts are not studied in detail in this research, but they are considered in the design stage and referred to where appropriate.

This research focuses on the study of holistic sustainability of urban streets rather than some technical solutions. Hence, the three dimensions of sustainability, namely environmental, social and economic sustainability, will be studied with equal importance, and the evaluation framework will be built based on this structure. However, some specific solutions, such as rain garden, thermal comfort, and historical preservation of urban streets, are not the focus of this study. But these solutions are incorporated into Design Toolkit and reflected by the Evaluation System of Sustainable Streets, thereby providing information for future research.

Finally, ***the application study of sustainable streets focuses on Shanghai.*** The application of sustainable streets is related to geographic location and climate situation. The economic development and social context also largely influence the delivery and evaluation of sustainable streets. Besides, the formation of the street network is closely linked to urban context and cultural influence. It can be said that different development patterns and culture background shape different characteristics of streets. Given this, the applied research of sustainable streets must have the specific location. Hence, Shanghai is chosen to be the object of the application study. Firstly, Shanghai, with the district area of 6340 KM^2 and 24 million, is a typical high-density metropolitan city. Shanghai, initially a water town, has developed to be the commercial and financial centre of mainland China over the past several decades, and now is renowned as a global metropolitan with diverse culture interaction, various urban form, as well as different kinds of street types. So, the study of sustainable streets in Shanghai can provide wide references domestically and internationally. Secondly, Shanghai has a humid subtropical climate and experiences four distinct seasons. Winters are chilly and damp, and summers are hot and humid. The effect of Climate Change makes this uncomfortable climate type worse and extreme weather events more frequently. Hence the study of sustainable streets is the internal demand of Shanghai development. "Shanghai Street Design Guide", released in October 2016, is China's first street design guideline. It explicitly sets out four development goals. They are safety, efficiency, green and smart respectively. It emphasises the principles of humanized street design. Those are in the line of sustainable development of urban streets. Clearly, the Guide's releasement indicates the action and determination of sustainability delivery from the Shanghai government. Also, the design, renovation, and management of Shanghai streets are recognised as one of the best practices in China. Hence this research can provide a pilot study for China.

1.3 Research Aim and Objectives

With the problem of a lack of practical evaluation tool to guide the design in a comprehensive and effective way, **the primary aim of this research is to build an indicator evaluation system of sustainable streets in Shanghai, thereby providing suggestions for street design.**

Based on the overall aim, 4 research objectives are:

Objective 1: *to form a theoretical basis for the design of sustainable streets and a preliminary evaluation framework of sustainable streets.*

Objective 2: *to build an indicator system of sustainable evaluation for Shanghai streets.*

Objective 3: *to apply and examine the indicator system of sustainability evaluation in sample streets.*

Objective 4: *to optimise the established indicator system of sustainability evaluation.*

1.4 Significance of the study

The significance of this research lies in the four areas indicated below:

1) **Significant to enrich the theoretical development of sustainability in the built environment:** Although there has been a great deal of literature and researches on sustainability, most of them are about sustainable cities, communities, and buildings. The study on the sustainability of urban streets is few. Therefore, this research is to develop a set of the theoretical framework of sustainable streets and to enrich the "Sustainable Family" theoretically.
2) **Significant to the development of urban streets:** Concerning the studies and practices urban streets, most of them focus on only one or several aspects, such as social safety, humanistic care, low-impact to the environment, or economic promotion. There is a lack of a practical framework to guide the streets develop in a comprehensive and effective way. The sustainable evaluation system of this research could fill the gap and provide a holistic thinking framework for urban streets.
3) **Significant to practices of sustainable streets**. Regarding sustainable streets, many works stop at the theoretical studies of sustainable streets. The practices of sustainable streets are blank research areas. Hence, this research fills in the gap and actively promote the practices of sustainable streets, including its design, evaluation, and renovation.

4) **Significant to promote the sustainability transformation of Shanghai streets**. First of all, this study systematically reviews the historical evolution and current development to demonstrate the necessity and significance of sustainability transformation to Shanghai streets theoretically. Secondly, the key outcomes of this study, including the established Indicator System of Sustainability Evaluation, the application of the Indicator System to Shanghai streets, and a series of evaluation results of Shanghai streets, have pushed the development and transformation of Shanghai streets towards sustainability practically. Thirdly, the Indicator System of Sustainability Evaluation established in this study provides a valuable tool and useful guidance for future research, evaluation, and management of Shanghai streets towards sustainability.

1.5 Structure of the Thesis

The thesis consists of ten chapters. The content of each chapter is briefly introduced as below:

Chapter One provides an overall introduction of this research, including the research background, focus and scope, research aim and objectives, as well as the significance of this study.

Chapter Two studies the two concepts of Climate Change and Sustainability in the built environment. Climate Change is the research background, and the Sustainability in the built environment is the fundamental concept of this research. Hence, it is to build the theoretical foundation for the study and to find the internal relationship between these two concepts.

Chapter Three constructs the theoretical framework of "Sustainable Streets". The concept of “Urban Streets” are studied firstly. Then, a conceptual model is built to demonstrate the vicious circle of these adverse effects that Climate Change brings to urban streets, thereby highlighting the importance and necessity of sustainable streets. Finally, integrated with the critical findings of Sustainability in Chapter Two, the theoretical framework of sustainable streets is presented, including the concept definition, design toolkit and a preliminary evaluation structure.

Chapter Four elaborates on the research methodology. Firstly, the methodological framework for this research is defined, including the research philosophy, research approach, and research strategy, thereby providing a reliable basis for the research design. Secondly, the research design is introduced in detail. The concept development, research methods, and specific techniques are designed according to the overall research aim and four specific research objectives. Thirdly, the whole research can be divided into four stages, so the methods of data collection and data analysis of each research stage are elaborated. Finally, the ethical issues are discussed and the reliability of this research are analysed, thereby proving the rationality and scientificity of the adopted methods of this study.

Chapter Five puts the study of sustainable streets into Shanghai practical framework through the analysis of Shanghai background and street development. The historical evolution and current development are expounded in this chapter to demonstrate the necessity and significance of sustainability transformation to Shanghai streets theoretically.

Chapter Six states the preliminary assessment results of sustainability of Shanghai streets and meanwhile selects sample streets for further study. So the evaluation results of 236 Shanghai streets are presented at firstly. Based on the statistical analysis and qualitative summary of the assessment results, three streets are selected as the sample cases for a detailed evaluation of the next stage.

Chapter Seven introduces the establishment process and results of the Indicator System of sustainability evaluation for Shanghai streets. Based on the preliminary evaluation structure presented in Chapter Three, this chapter builds the Indicator System of sustainability evaluation for Shanghai streets through the four steps, namely Indicator Selection, Data Normalisation, Weight Allocation, and Final Aggregation respectively.

Chapter Eight compares the two sets of assessment results of three Shanghai streets that are obtained from the Indicator System of sustainability evaluation and the Questionnaire Survey respectively. Based on the cross-comparison, the application experiences of the Indicator System are further analysed, thereby summarising a series of improvement points of Indicator System.

Chapter Nine proposes an optimised scheme of the Indicator System by systematic analysis of results of Expert Interviews and application experiences. Also, it further discusses some issues that that influence the delivery of sustainable streets in Shanghai.

Chapter Ten draws conclusions for the whole study, including the achievements of research aims and objectives, contributions and limitations of this research, and suggestions on future work.

Chapter 2. Climate Change and Sustainability in Built Environment

2.1 Introduction

The chapter is to review and study the two concepts of Climate Change and Sustainability in the built environment with an aim at building the theoretical foundation of this research.

Climate Change is the research background. The study starts with its definition and the leading causes of it. Though the analysis of the existing and potential effects of Climate Change, it further points out that urban areas are one of the leading causes of Climate Change and they also suffer from the adverse effects of Climate Change the most significantly.

The sustainability of the built environment is the fundamental concept of this research. By studying the three concepts, namely Sustainability, Sustainable Development, and Sustainable Design, concerning their definitions, the conceptual models, and characteristics, the sustainability assessment is illustrated.

Through literature review, conceptual comparison and combing, it can be seen that Sustainability and Climate Change are closely linked and mutually interact. In addition, a preliminary theoretical framework of sustainability assessment is sorted out, including the evaluation purpose, principal methodologies, establishment process, and preliminary structure.

2.2 Climate Change and Adaptation Design

2.2.1 Cause and Effect of Climate Change

Climate Change is the subject of how global climate patterns change over decades or longer (Garnaut, 2008; IPCC, 2007; Matthews, 2011). Since the 1950s, many of the observed changes are unprecedented during the previous decades to thousands of years. The Global atmosphere and oceans have warmed, the amount of snow and ice have diminished, and sea level has risen (IPCC, 2014).

Based on many lines of evidence, human's influence on Climate Change is crucial and obvious. Since the pre-industrial revolution (about 1750), the human-made emissions of greenhouse gas have an increase of 70% between 1970 and 2004 and reaches the highest level at present, which is mainly due to the population growth and economic development (IPCC, 2007; IPCC, 2014).

Urban areas are the most critical factors causing Climate Change because they are large and high-density human settlements where people gather and transform the natural environment into the artificial system which is more conducive to their development (Gleeson, 2008; Matthews, 2011). An UN report shows cities contribute 70% of global greenhouse gas emission (United Nations, 2007a). Hence, it can be said that urban systems are the primary cause of Climate Change.

A variety of potential adverse impacts of Climate Change on the global scale have been pointed out, including more frequent floods and longer droughts (less rainfall and dry soil), a continuous rising of sea levels and increasing risks to the coasts, changes in ecosystems and the higher risk of “mass extinction”, and a threat to human health from extreme weather events and alterations of environment and ecosystems (CCSC, 2015; IPCC, 2014; Warren & Lemmen, 2014; CNA, 2015).

These adverse effects of Climate Change on the urban system are more severe. Table 2. 1 summarises the negative impacts on the urban scale associated with Climate Change. It is important to note that massive population, increasing energy consumption and greenhouse emission, and high-density built environment characterise the urban system. All these features make the urban system and their residents more vulnerability in front of the impacts of Climate Change (Condon, et al., 2009). As a result, even a small effect of Climate Change may influence a large number of people and even destroy the whole urban system. It can be said that urban features exacerbate the adverse effect of Climate Change and deepen the vulnerability of urban area (Matthews, 2011).

Based on the analysis above, it can be found that ***urban areas are one of the leading causes of Climate Change and they also suffer from the adverse effects of Climate Change the most significantly***.

Therefore, Shanghai, a coastal metropolitan city with ultra-high living density, is confronted with massive risks in such a vicious circle. The increasing frequency of extreme weather events not only leads to serious environmental issues but also results in considerable threats to citizens' lives and property. Hence the immediate response to curb the negative effect of Climate Change is urgently necessary. This is one of the main motivations of this study.

Table 2. 1: Negative Impacts on Urban Areas Associated with Climate Change

ENVIRONMENTAL IMPACT	
The rise of sea level	• *Increasing risks to the coasts.* • *Increasing risk of storm surge, floods, coastal erosion, invasion of saltwater and sea.* • *A series of corresponding problems, like water pollution.*
Floods and Droughts	• *More frequent floods* • *More frequent and longer meteorological droughts (less rainfall).*
Water	• *Decline of renewable water supply* • *A decrease of clean water supply*
Changes in ecosystems	• *Risk of a major biodiversity crisis.*
Extreme weather events	• *More and even worse extreme events, such as windstorms, rainstorms, heat/cold extremes and meteorological droughts.* • *Urban infrastructure system shows vulnerable and collapse.*
Urban Heat Island	• *The rise of urban temperatures, especially in the city centre*
SOCIAL IMPACT	
Physical injuries	• *Increased injuries and deaths due to extreme weather events, like flooding, high winds, and storms.*
General Health	• *Food and waterborne disease* • *Increase in disease due to air pollution* • *Increase in sickness because of temperature and precipitation shifts.*
Mental Health	• *Anxiety, stress and other mental health problems resulting from extreme weather events, and potential evacuation or migration.*
Safety and Crime	• *Increased risks of food shortage and water supply.* • *Increased risks of social chaos, crime, and violence.*
ECONOMIC IMPACT	
Land	• *Loss of land along the coastline and riverside areas.* • *Increased costs to prevent flooding along coastline and riverside areas.*
Water	• *Loss of original water resource* • *Increased costs of water treatment and transport*
Food	• *Reduced availability and increased cost of agricultural.* • *Increased costs of food transport.*
Housing	• *Loss of buildings during extreme weather events* • *Increased costs of housing in the coasts.* • *Employment and business opportunities in sustainable construction and design.*
Energy	• *Increasing energy consumption due to the change of weather pattern.* • *Disruption of electricity supplies during weather events.*
Transport	• *Disruption of transport and communication networks due to extreme weather events.* • *Increased costs of rebuilt.*
Employment	• *Loss of some business, skills, and jobs due to business failure or extreme weather events.* • *Opportunities for business, skills, and jobs relating to sustainability.*
Business	• *Increased costs for establishing and maintaining business facilities and operations in sensitive areas.* • *Increased costs of insurance.* • *Opportunities for sustainable technology and business.*

The table was designed and made by the author, and the information was adapted from (Walmsley, 2010; IPCC, 2014; Ackerman, et al., 2008; Matthews, 2011; EPA, 2008; Lemmen, et al., 2008).

2.2.2 Global Response towards Climate Change

By the latter half of the 20th century, increasingly scientists had pointed out that increasingly emission of carbon dioxide results in Climate Change based on various researches and observation studies. The Intergovernmental Panel on Climate Change (IPCC), a scientific and intergovernmental body under the auspices of the United Nations for Climate Change, was established in 1988. IPCC's first assessment report was released in 1990, which is the firstly official calling for a global response to Climate Change (CCSC, 2015). Since then, more and more scientists, researchers, planners, and politicians have joined the group to study and practice the solution.

Among existing response options for Climate Change, there are two fundamental paradigms: mitigation of Climate Change and adaptation to Climate Change (IPCC, 2007; CCSC, 2015). In the Climate Change context, mitigation means limiting and controlling Climate Change by reducing greenhouse gases emission or enhancing the sinks of gases, while adaptation means preparing for the predicted impacts of Climate Change and reinforce the vulnerable system to minimise the harm from Climate Change (Füssel, 2007; EPA, 2008; McCarthy, et al., 2001) . Table 2. 2 summarises the differences and common features of these two responses.

Mitigation options initially receive much attention because they are to reduce impacts on all climate-sensitive systems and the cause of the climate-change problems. It can be cost-effective if using some integrated approaches that combine measures to reduce energy consumption and enhance carbon sinks in land-based sectors (IPCC, 2014).

Gradually, more governments, research groups, think-tanks, professional institutes, and politician institutions advocate of adaptation solutions to Climate Change, because it is a more practical strategy in urban scale, and its effects can be detected and measured in a short time. The UK Institute of Mechanical Engineers (IME) claims that the adaptation of urban systems and infrastructure is vital to tackle Climate Change effects and minimise risks to people (CAP, 2007).

It is significant to note that mitigation and adaptation promote mutually and develop together rather than exclusive alternatives because they work in different time-scale and distinct actions (Füssel, 2007), just as what is explained by IPCC (2014, p. 26): "*adaptation and mitigation responses are underpinned by common enabling factors. These include effective institutions and governance, innovation and investments in environmentally sound technologies and infrastructure, sustainable livelihoods and behavioural and lifestyle choices*".

Many researchers identified that the two fundamental responses to climate change share many similar requirements with sustainable development because enhancement of adaptive capacity to Climate Change and reduction the environmental impact can promote broader sustainable development.

Table 2. 2: Comparison of Mitigation and Adaptation Solutions to Climate Change

<table>
<tr><th>Comparison</th><th>MITIGATION of Climate Change</th><th>ADAPTATION to Climate Change</th></tr>
<tr><td>Targeted system</td><td>All</td><td>Selected</td></tr>
<tr><td>Scale of effect</td><td>Global</td><td>Local to regional</td></tr>
<tr><td>Lifetime</td><td>Centuries</td><td>Years to Centuries</td></tr>
<tr><td>Lead time</td><td>Decades</td><td>Immediate to decades</td></tr>
<tr><td>Ancillary benefits</td><td>Sometimes</td><td>Often</td></tr>
<tr><td>Actor Benefits</td><td>Only little</td><td>Almost fully</td></tr>
<tr><td rowspan="2">Practical cases</td><td>• Sustainable transportation;
• Energy conservation;
• Building code changes to improve energy efficiency;
• Renewable energy;
• Expand deep lake water cooling;
• Improve vehicle fuel efficiency;
• Capture and use landfill & digester gas.</td><td>• Infrastructure upgrades: sewer & culverts;
• Residential programs: sewer backflow & downspout disconnection;
• Health programs: shade policy, cooling centres, smog alerts, air quality health index;
• Emergency & business continuity plan;
• Help for vulnerable people.</td></tr>
<tr><td colspan="2">• Geothermal;
• Solar thermal
• District heating
• Building design for natural ventilation
• Tree planting & care
• Local food production
• Water conservation
• Green roofs</td></tr>
</table>

Note: The table was designed and made by the author, and the information was derived from (Füssel & Klein, 2006; Füssel, 2007; City of Toronto, 2008)

2.3 Sustainability in the built environment

2.3.1 Definition and Interpretation

Sustainability is increasingly important and becomes a vital worldwide issue due to the threats of Climate Change (Miller & Doh, 2015; Apuuli, et al., 2000), which has been pointed out above. Hence, in order to have a comprehensive understanding of sustainability in the built environment, it is significant to first define the three fundamental concepts of Sustainability, Sustainable Development, and Sustainable Design. Some researchers consider these three concepts as one, like Parr (2008), Blewitt (2006), and Nemetz (2007), however more authors, such as Djajadiningrat (1994), Harding (1998), Ola (2009), Turcu (2010), believe that they are different due to their distinctive contexts and theories.

Therefore, Chapter 2.3.1 aims to study the definition, concept model and critical features of Sustainability, Sustainable Development and Sustainable Design respectively.

2.3.1.1 Sustainability

Sustainability is a noun which refers to a condition that can be maintained over an indefinite period (Collins, 2014). So, it can be used in various fields, from ecosystem to urban areas, from producing to designing, from agriculture to buildings. Consequently, many researchers have given various definitions of sustainability based on their understandings and research fields (Table 2. 3). Gow (1992), described sustainability is like happiness while Hardoy, et al. (1992) explained that sustainability is used to contrast with a lack of sustainability; Pearce et al. (1989), Jacobs (1990), and Diesendorf (2000), emphasised the maintenance and preservation of natural resources and natural ecosystem, while Norgaard (1992) underlined a commitment to intergenerational equity. Nevertheless, more researchers supported that sustainability is a concept which is reached by the integration of multiple conditions (Burgess, 2000; Sangsehanat, 2013; Doppelt, 2008; Kelly, 2009; RPC, 2011). No matter how researchers explain from a variety of different angles, but the essential meaning of sustainability is to describe a balanced state over a long-term.

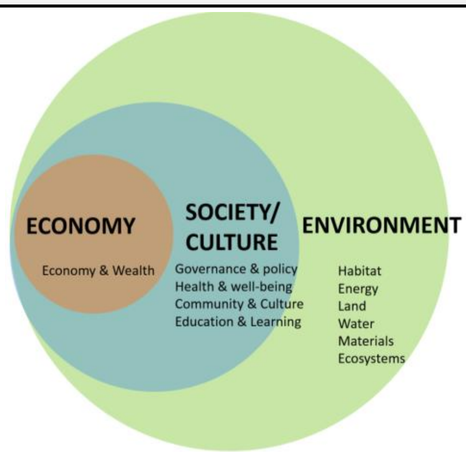
Table 2. 3: Comparison of Existing Definitions of "Sustainability"

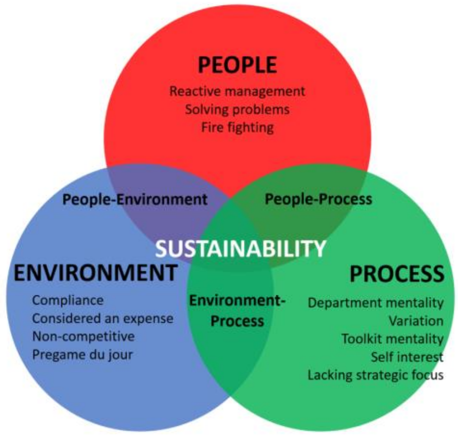
Reference	Sustainability Definition	Key Points
Jacobs (1990)	Sustainability means that the quantity and quality of natural resources and functions should be maintained at a constant level.	*Emphasising the maintenance of natural resources.*
IUCNIUNEP IWWF (1991)	Its environmental usage, as improving the quality of human life while living within the carrying capacity of supporting eco-systems.	*Focusing on the social-environmental aspect of sustainability.*
Gow (1992)	Sustainability is like happiness - everyone believes in it and everyone has a different definition. In fact, sustainability has become so all-encompassing as to be virtually toothless, whether it is financial, institutional, economic, environmental, or technical, to name a few of the more common manifestations.	*Highlighting the complexity and diversity of sustainability.*
Hardoy, et al. (1992)	Sustainability is generally used to contrast with a lack of sustainability which is seen as something which breaks down or does not continue. In some cases, it is used simply to mean that the long-term result of some action or set of actions is consistent with desired outcomes.	*Interpreting by the contrast condition of a lack of sustainability to underline its long-term result.*

Reference	Sustainability Definition	Key Points
Norgaard (1992)	Sustainability can be seen as a commitment to intergenerational equity, or it may be regarded simply as a logical extension of existing commitments to equity within the current generation.	*Making a point of the intergenerational equity.*
Pearce et al (1993)	Sustainability as a theory means ensuring that substitute resources are made available as non-renewable resources become physically scarce. Sustainability is also about making sure that the environmental impacts of using those resources are kept within the Earth's carrying capacity to assimilate those impacts.	*Highlighting the resources and environmental impacts.*
Burgess et al. (1997)	Sustainability is continued rapid urbanisation; the globalisation of economic, social, cultural and political activities; the intensification and globalisation of an "environmental crisis"; and the evolving relationship between state and society.	*Providing a relatively holistic picture of sustainability.*
Diesendorf (2000)	Sustainability is concerned with the preservation of natural ecosystems and reserves and the making of human economic systems last longer so as to have less impact on ecological systems. It is particularly related to concern over major global problems such as Climate Change and the depletion of fossil fuel.	*Underlining economic-environmental sustainability.*
Sangsehan (2013)	Sustainability is a concept to reduce environmental degradation, resource depletion and Climate Change globally; as well as to tackle basic human needs at specific locations where poor sanitation, health and social and economic inequalities are identified.	*Emphasising social-environmental sustainability.*

Note: The table was designed and made by the author, and the information was adapted from (Hardoy, et al., 1992; Gow, 1992; Jacobs, 1990; Norgaard, 1992; Diesendorf, 2000; Pearce, 1993; IUCNIUNEP/WWF, 1991; Sangsehanat, 2013; Burgess, 2000)

Table 2. 4: Comparison of Four Concept Models of "Sustainability"

NO.	CONCEPT MODEL ONE	CONCEPT MODEL TWO
Model Graph		
Key Points	• *It is established in three aspects: Environment, Society and Economics;* • *Each aspect is equally important for sustainability.*	• *It is established both on 3 aspects: Environment, Society and Economics;* • *It defines the sequence of influence as the environmental, social and economic impact.*
Source	(IStructE, 2014)	(Doppelt, 2008)

NO.	CONCEPT MODEL THREE	CONCEPT MODEL FOUR
Model Graph		
Key Points	• *It is built based on the paradigm that several goals are achieved at the same time;* • *It defines four aspects as Climate, Culture, Biodiversity, and Food.*	• *It is built in the same structure of Model One;* • *It defines three aspects as People, Environment, and Process.*
Source	(Kelly, 2009)	(RPC, 2011)

Note: The table was designed and made by the author, and the model sources are listed above.

From four existing conceptual models of sustainability (Table 2. 4), both Concept Model One and Two are established on three same aspects: “Environment”, “Society” and “Economics”, but Model One regards each aspect to be equally essential to sustainability while Model Two defines the importance sequence as “Environment, Society and Economics” respectively. Model Three and Model Four are built based on the same paradigm, but Model Three defines four aspects as “Climate”, “Culture”, “Biodiversity”, and “Food”, while Model Four uses “People”, “Environment” and “Process” to express three influences to sustainability. Among these concepts model, the most widely used one is Model One, and the essence of this Model is that ***Sustainability can be realised only by the condition that these three aspects of environmental sustainability, social sustainability, and economic sustainability are achieved at the same time and well balanced together from a long-term perspective*.**

Environmental Sustainability: Environmental sustainability, also often called ecological sustainability, means that natural resources, such as air, water, land, soil, trees, should be maintained so as not to drive the ecosystem collapse (Daly, 1973; Serageldin, 1993; Khan, 1995). Gooldland (1995) further explained the way to achieve environmental sustainability is on the one side to keep the “source site” harvest rates of renewable sources within the regeneration paces, and on the other side to control the “sink site” waste emission within the assimilative capacity of the environment. Many environmental scientists even argued that ecological sustainability is the most significant for human’s well beings and economic growth because only within ecosystems can life-support process take place (Daly, 1974; Pearce, et al., 1989).

Social Sustainability: Social sustainability indicates that social resources, including equality, accessibility, empowerment, employment, traditions, and customs, should be preserved and maintained (Ruttan, 1991; Khan, 1995). Ruttan (1991) stated that social condition, including poverty and inequality, has an active link with environmental decay and economic development as well. Hence, social scientists tend to advocate that the promotion of social sustainability is critical to realise true sustainability (Wang, 2014; Mckenzia, 2015).

Economic Sustainability: Economic sustainability implies the human-made resources and fortune should be maintained and improved for a long-lasting development (Reisch & Roepke, 2004; Ramos-Martin, 2003; Goerner, et al., 2009). Spangenburg (2005) described that economic sustainability is to maintain a permanent income for humankind, generated from non-declining capital stocks. It was pointed out that economics should grow based on environmental health and a steady society is the foundation of the wellbeing economy (QLPG, 2007).

All in all, the key features of sustainability can be summed up in three points:

1. Sustainability in the built environment is a status which is formed and balanced of environmental, social, and economic aspects, and each aspect is equally important. Hence, only by achieving all three aspects can it be said to reach the status of sustainability.
2. Sustainability is about what "ought to be" sustained rather than what "could be" sustained. So, confronted with increasingly adverse effects of Climate Change, sustainability shift is a must-to-be choice.
3. Sustainability can be applied to each part of the built environment at any scales, like a building, a street, a project, a city, nations, or the whole world. Therefore, the key to sustainability can be specified, but the theoretical framework and application of sustainability should be open for exploration.

2.3.1.2 Sustainable Development

The word of "Sustainable Development" originated in the 1970s (Basiago, 1995), was firstly proposed internationally with the publication of the World Conservation Strategy (WCS) in 1990 (Trzyna, 1995). The most common definition of sustainable development is from the report of

"Our Common Future" of the World Commission on Environment and Development (WCED) in 1987 (Brundtland & Khalid, 1987, p. 27): "*Development that meets the needs of future generations without compromising the ability of future generations to meet their own needs".* After this, in 1991 "Caring for the Earth: a Strategy for Sustainable Living" define "sustainable development" as "*improving the quality of human life while living within the carrying capacity of supporting ecosystems* (IUCN/UNEP/WWF, 1991, p. 10). In 1992, "Agenda 21" further explained the objectives of "sustainable development", including a decline in the use of energy and raw materials, a reduction in the production of waste and pollution, the protection of fragile ecosystems, a sharing of wealth and the promotion of more equal opportunities through planned democratic and co-operative processes, which also reflects the important factors of sustainable design (Sitarz, 1993). Just as the concept of "sustainability", "sustainable development" is also be interpreted in various ways according to different contexts (Table 2. 5).

Table 2. 5: Comparison of Existing Definitions of "Sustainable Development"

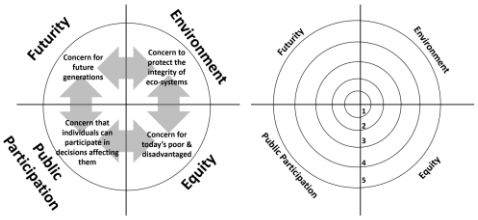
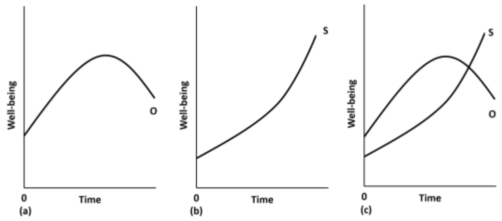
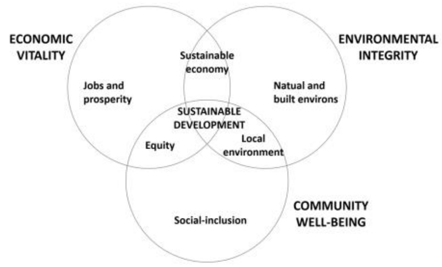
References	Definition	Key Points
Pearce et al. (1989)	Sustainable development means a change in consumption patterns towards environmentally more benign products, and a change in investment patterns towards augmenting environmental capital.	*Emphasising the environmental root.*
FAO (1989)	Sustainable development is the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations.	*Underling the conservation of natural resources and technical change.*
IUCN/WWF/ UNEP (1991)	Improving the quality of human life while living within the carrying capacity of the supporting ecosystem.	*Balancing supply and demand*
LGPB (1993)	`Sustainable Development' means making sure the people who come after us can enjoy opportunities and options as good as we have now.	*Highlighting the need and capacity of future generation.*
DoE U.K. (1996):	Sustainable development means achieving economic development to secure rising standards of living both now and for future generations while protecting and enhancing the environment now and for the future.	*Concerning the future generation and holistic sustainability as well.*
Giddings, et al. (2002)	Sustainable development is the integration of different actions and sectors, taking a holistic view and overcoming barriers between disciplines.	*Highlighting the inter-discipline and wide application.*
Dower (1993)	Sustainable development is that of a kind of development. Whether in poorer countries or in richer countries, which so treats the natural environment that the process of development, or at least the products or benefits of that process, can continue into the future in a sustainable way, both for ourselves and our children, and for future generation".	*Considering not only the current situation but also future generation.*

Note: The table was designed and made by the author, and the information was derived from (Haughton, 1999; Hopwood, et al., 2005; Giddings, et al., 2002; Pearce, et al., 1989; IUCN/UNEP/WWF, 1991; UK Government, 1990; DoE, U. K, 1997; FAO, 1989; Dower, 1992)

Based on a broad review of existing definitions, its general meaning becomes clear, but it is necessary to have a comprehensive interpretation of "development" and "sustainable" from the words themselves to summarise the essence. "Development" is a "specified state of growth or advancement" (Oxford Dictionaries, 2017). This term can refer to various sectors, from social context to economic growth. In a physical sense, it is to "convert land to a new purpose by constructing buildings or making use of its resources" (Oxford Dictionaries, 2017). Under social background, development means an increase in freedom and standards of living from the perspective of health, sanitation, and education (The World Bank, 2000). In the economic context, it is the process of "increasing the wealth of countries or regions for the well-being of their inhabitants" (The World Bank, 2011, p. 6). Meanwhile, it can also be applied to a wide range of activities, from an individual to the whole world, and the enhancement of a national synthetic power. At the same time, "sustainable" should have the same meaning as "sustainability" which has been analysed and elaborated in detail in chapter 2.3.1.1. In summary, ***"sustainable development" can be defined as "a growth path which makes up with various development methods which can be summarised into three aspects, social advancement, environmental conservation and economic growth respectively, thereby meeting the need of contemporary people without compromising the ability of future generations to meet their own needs".***

There are a variety of concept models of sustainable development established by researchers. Table 2. 6 summarises the main four. Concept Model One is built based on four main concerns: future generations, ecosystems, public participation, and equity. However, this model focuses on social-environmental sustainability rather than holistic sustainable development. Concept Model Two illustrates two scenarios of sustainable and not sustainable, and then compares the two paths and shows a situation in which the sustainable path makes future generations better off but current generation worse off, however, it does not show the process and explain how to develop sustainably. Concept Model Three and Four share a common feature that a simple diagram model shows the interrelationship between the three large factors. Concept Model Three highlights sustainable development is a continuous cycle process of advancement in three aspects, while Model four underlines sustainable development is an overlapping area where the economic vitality, environmental integrity, and community well-being are achieved at the same time. Based on the definition of "sustainable development", Model Three is advocated by the author and also commonly used by most researchers.

Table 2. 6: Comparison of Four Concept Models of "Sustainable Development"

NO.	CONCEPT MODEL ONE	CONCEPT MODEL TWO
Model graph		
Key Points	• *It is built based on four main concerns: Future Generations, Ecosystems, Public Participation, and Equity;* • *The model focuses on social-environmental sustainability.*	• *Figure (a) shows a development path that is not sustainable, Figure (b) shows one that is sustainable. Figure (c) compares the two paths and shows a situation in which the sustainable path makes future generations better off but current generation worse off.* • *It illustrates two scenarios of sustainable and not sustainable but does not explain how to develop sustainably.*
Source	(Cooper, et al., 1997)	(Redclift, 1984)
NO.	**CONCEPT MODEL THREE**	**CONCEPT MODEL FOUR**
Model graph		
Key Points	• *It identifies three critical areas of sustainability and the paradigm of sustainable development.* • *It highlights sustainable development is a continuous cycle process of advancement.*	• *The model shows the interrelationship between the three broad factors.* • *It highlights sustainable development is an overlapping area where the Economic Vitality, Environmental Integrity, and Community Well-Being are achieved.*
Source	(Khan, 1995)	(Carley & Kirk, 1998)

Note: The table was designed and made by the author, and the model sources were listed above.

Based on the various conceptual definitions of "Sustainable Development", three features can be derived:

1. ***Sustainable development is not only about the life today but also for future generations, which requires a long-term consideration and a prognosis of the future situation.*** For this reason, design that is "*a scheme or method of acting for future*" (Collins English Dictionary, 2012) are crucial for sustainability delivery.
2. ***Sustainable development integrates development as well as conservation, which is different from traditional development.*** How to balance between conservation and development is a critical issue. Hence, the innovative concepts, methods, and tools,

beyond the traditional framework, might of great importance to the practices of sustainable development.

3. ***Just as the concept of "Sustainability" and "Development", sustainable development possesses the features of a universal application,*** which prompts the application of sustainable design in various sectors and different scales as well.

2.3.1.3 Sustainable Design

According to Ecolife dictionary (Ecolife, 2011), sustainable design is the intention to reduce or eliminate negative environmental impacts through thoughtful designs. This concept can be applied across all fields of design, such as cities, buildings, and products. Manzini (2006) highlighted sustainable design as a strategic path to a sustainable solution. Among this interpretation, Thorpe (2007) described it as a series of theories and practices to improve ecological, economic, and cultural conditions with an aim at supporting human well-being indefinitely. Table 2. 7 reviews seven existing definitions of "Sustainable design". Based on these studies, the author defines ***"Sustainable Design" as a method or philosophy of design in the built environment with an aim at the delivery of social, economic, and ecological sustainability.***

Table 2. 7: Comparison of Existing Definitions of "Sustainable Design"

References	Definition	Key points
(Ecolife, 2011)	Sustainable design is the intention to reduce or completely eliminate negative environmental impacts through thoughtful designs. This concept can be applied across all fields of design such as designing buildings or products	*Highlighting the minimization of environmental impacts.*
(AGD, 2014)	Sustainable design is a process which not on production a fully sustainable product, but rather on gradually improving existing products and processes.	*Stressing improving the existing products and processes.*
(Siegel & Loftness, 2008)	Sustainable design process holistically and creatively connects land use and design at the regional level and addresses community design and mobility, site ecology and water use, place-based energy generation, performance and security; materials and construction; light and air, bioclimatic design; and issues of long life and loose fit	*Interpreting some specific design elements and principles within the urban scale.*
(Manzini, 2006)	Sustainable design is a strategic design activity that conceives and develops sustainable solutions.	*Pointing out a strategic path to the sustainable solution.*
(Otto, 2006)	Sustainable design involves optimising performance and well-being which led some to the notion of a "triple bottom line". The triple bottom line seeks to expand the conventional economic and financial focus of the "bottom line to include social and environmental calculations"	*Indicating to optimise the current performance to a "triple bottom line".*
(Thorpe, 2007)	Theories and practices for the design that cultivate ecological, economic and cultural conditions that will support human well-being indefinitely.	*A relatively comprehensive interpretation.*

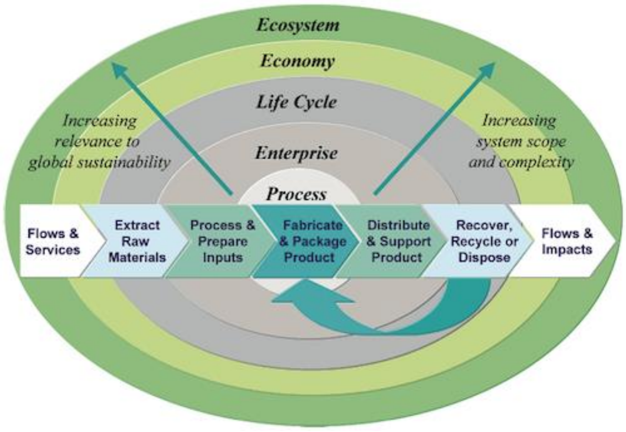
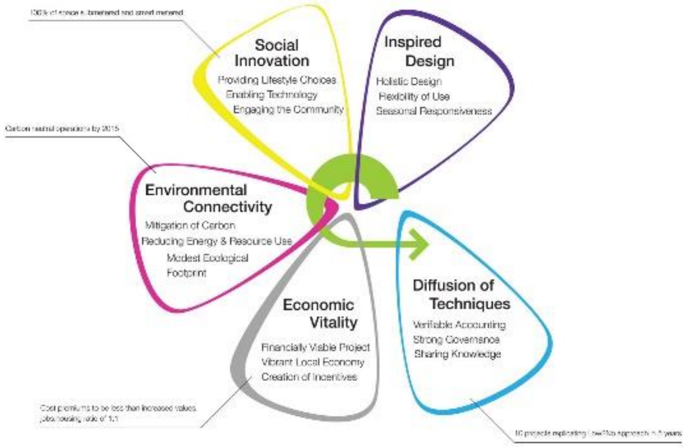
Note: The table was designed and made by the author, and the information sources were listed above.

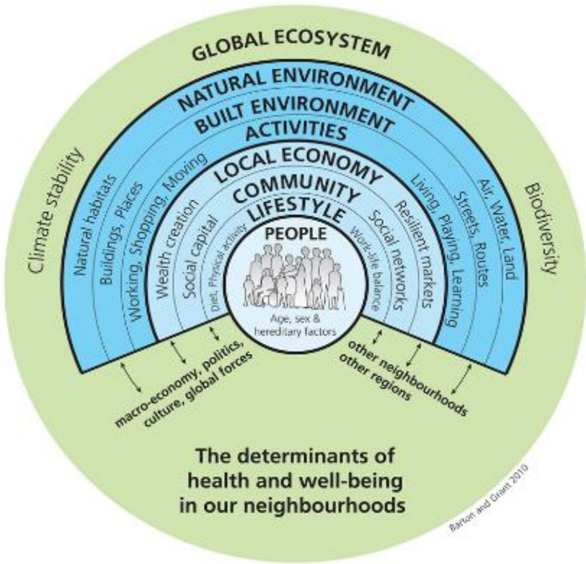
Regarding the concept models of sustainable design, Table 2. 8 summarises four typical models. Concept Model One regards sustainable design as a system which is intimately connected with the Process, Enterprise, Life Cycle, Economy, and Ecosystem, while Model Two shows a connection among Inspired Design, Social Innovation, Environmental Connectivity, Economic Vitality, and Diffusion of Techniques to underlining a comprehensive procedure and consideration. Model Three illustrates a combination of Social-Cultural Needs, Economic Needs, Environmental Needs, and Individual Well-Being Needs. As a product design model, it stresses the significance of the user's requirements. Model Four is mainly for health and well-being aspect, but the framework can be adapted to broader sustainable design. All these models are reasonable in different research context, but the theoretical framework and concept organisation of Model Three are adopted for this study because it is more direct and clearer. Firstly, it conforms to the logic of the concept of sustainability, that is, society, economy, and environment are three key pillars. Secondly, Model Three reflects that the fundamental purpose of design is to meet the user's requirements. The requirements, feedbacks, and engagement of the users of the design object are one of the most important principles to sustainable design.

In conclusion, the features of "Sustainable Design" can be summarised into three points:

1. Sustainable design is supposed to take full considerations of users' needs and requirements as the principle of design task. Because of the diverse application of sustainable design, users can be an individual or a group of people. Hence, understand their requirement is always the most critical step.
2. As one integrated design method which requires to provide a good quality of life for all stakeholders for a long-term, the consideration of stakeholders' benefits, needs, and knowledge about the design objects are also crucial for a holistic sustainability delivery.
3. Sustainable design requires anticipation of the future situation and continuously adjustment. The objective world is always changing, and the changes include the effects of Climate Change, the recognition of the natural world, and the advancement of new technologies. Therefore, sustainable design is an open and dynamic system. A regular assessment is a critical part of the whole system not only for the measurement of the sustainability but also for an appropriate adjustment and optimisation of the system.

Table 2. 8: Comparison of Four Concept models of "Sustainable Design"

NO.	CONCEPT MODEL ONE
Model graph	
Key Points	• *It is to highlight sustainable design is a system;* • *This system is connected with the process, enterprise, life cycle, economy, and ecosystem.*
Source	(Fiksel, 2003)
NO.	**CONCEPT MODEL TWO**
Model graph	
Key Points	*It is to show that sustainable design is a connection between inspired design, social innovation, environmental connectivity, economic vitality, diffusion of techniques.*
Source	(Low2No, 2013)
NO.	**CONCEPT MODEL THREE**
Model graph	
Key Points	• *It is to illustrate that sustainable design is a combination of social-cultural needs, economic needs, environmental needs and individual wellbeing needs.* • *It stresses the individual that is the design user's requirement.*
Source	(Urlbe, 2009)

NO.	CONCEPT MODEL FOUR
Model graph	
Key Points	*• It is to demonstrate a variety of consideration scale of sustainable design;* *The model is mainly for health and well-being aspect, but the framework can be adapted to broader sustainable design.*
Source	(Barton & Grant, 2006)

Note: The table was designed and made by the author, and the information sources were listed above.

2.3.1.4 Summary

Table 2. 9 summarises the definitions, concept models, and critical features of the three fundamental concepts, namely Sustainability, Sustainable Development and Sustainable Design respectively.

It can be seen that **Sustainability and Climate Change are closely linked and mutually interact.**

Firstly, Climate Change is within the theoretical framework of sustainability. Sustainability can be realised only by the condition that environmental sustainability, social sustainability, and economic sustainability are achieved at the same time and well balanced together from a long-term perspecive. Climate Change is initially an environmental issue and also brings massive problems socially and economically. All these problems from Climate Change are included in the framework of sustainability.

Secondly, Climate Change is the key issue to sustainable development. Climate Change has brought considerable negative impacts to urban areas. Also, it is predicted that more destructive impacts will be shown gradually over a long perspective. Therefore, to cope with the challenges of Climate Change, it requires a long-term perspective and a prognosis of the future situation, which is in line with the characteristics of sustainable development. Because a life-cycle assessment and caring for the well-being of the future generation are two key components of sustainable development.

Finally, there are many similarities between Climate Adaptation Design and Sustainable Design regarding requirements and methodologies. Enhancement of adaptive capacity to Climate Change can promote broader sustainable development. Hence the solutions share similar design principles and methods.

Table 2. 9: Comparison of Sustainability, Sustainable Development, and Sustainable Design

	DEFINITION	CONCEPT MODEL	KEY FEATURES
SUSTAINABILITY	Sustainability as a noun is to describe a balanced state over a long-term, and it can be realised only by the condition that environmental sustainability, social sustainability, and economic sustainability are achieved at the same time and well balanced together from a long-term perspective.	 (IStructE, 2014)	• *Sustainability in the built environment is a status which is formed and balanced of environmental, social and economic aspects, and each aspect is equally important.* • *Sustainability is about what "ought to be" sustained rather than what "can be" sustained due to increasing pressure from Climate Change.* • *Sustainability can be applied to each part in the built environment at all scales, and the theoretical framework and application of sustainability should be open for exploration.*
SUSTAINABLE DEVELOPMENT	Sustainable Development is a growth path which is made up with various development methods that can be summarised into three aspects, social advancement, environmental conservation and economic growth respectively, thereby meeting the need of contemporary people without compromising the ability of future generations to meet their own needs.	 (Khan, 1995)	• *Sustainable development is not only concerning the life today but also for future generations, which requires a long-term consideration and a prognosis of the future situation.* • *Sustainable development integrates conservation and development.* • *Sustainable development possesses the feature of the universal application, which prompts the application of sustainable plan and design in various sectors and all sorts of scales as well.*

	DEFINITION	CONCEPT MODEL	KEY FEATURES
SUSTAINABLE DESIGN	"Sustainable design" is a method or philosophy of design in the built environment with an aim at achieving social, economic and ecological sustainability.	 (Urlbe, 2009)	• *Sustainable design is supposed to take full considerations of users' needs and requirements as the principle of design task.* • *Sustainable design is an integrated design method which requires to provide a good quality of life for all stakeholders for a long-term.* • *Sustainable design requires anticipation of the future situation, so a regular assessment is a critical part of the whole system not only for the measurement of the sustainability but also for an appropriate adjustment and optimisation of the system.*

Note: The table was designed and made by the author, and the information sources were listed above

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2.3.2 Sustainability Assessment

Sustainability assessment is always regarded as an essential tool to promote the delivery of sustainability (Pope, et al., 2004), because "Assessment", as a kind of adjustment and optimisation mechanism, not only possesses the function of inspection and introspection, but also has the benefit to see the problems and to find the solutions. Therefore, in the process of promoting sustainable development and improving sustainable design, sustainable assessment is widely used in various fields.

In order to make a theoretical foundation for the follow-up work, the study of "Sustainable Assessment" focuses on the three questions:

- *What are the sustainability assessment and its functions?*
- *What are the methodologies of sustainability assessment and existing cases?*
- *How to construct a sustainability assessment system?*

2.3.2.1 What are the sustainability assessment and its functions?

Directly speaking, sustainability assessment is *"a process by which the implications of an initiative on sustainability are evaluated, where the initiative can be a proposed or existing policy, plan, programme, project, piece of legislation, or a current practice or activity"* (Pope, et al., 2004, p. 595). Devuyst (2001) highlighted the sustainability assessment as a tool that can help decision-makers and policy-makers to promote sustainable development. Also, Verhieem (2002) emphasised that it is to ensure the plans, practices and activates to contribute to sustainable development. At the same time, more researchers underline the feature of "integration" when interpreting sustainability assessment (Sheate, et al., 2003; Eggenberger & Partida´rio, 2000; Lee, 2002), and "triple bottom-line" concept is often considered as the best illustration since it is extended to incorporate social, economic consideration as well as environmental ones compared with traditional Environmental Impact Assessment, (Pope, et al., 2004; Hacking & Guthrie, 2008; Sadler, 1996; Wilkinson, et al., 2004; Dalal-Clayton & Sadler, 2004).

On the whole, it can be concluded that ***sustainability assessment is a special form of integrated assessment which is to evaluate the sustainability of a certain activity or place in built environment based on the "triple bottom line" principle.***

Then, why the Sustainability assessment is necessary and what are the significant functions? Many researchers have elaborated this question (Singh, et al., 2009; Berke & Manta, 1999; Lundin, 2004; Kates, et al., 2001), and the key points can be summarised:

- To anticipate the condition and trends;
- To provide a critical analysis of the current situation;
- To provide a warning in advance and avoid economic, social and environmental hazard;
- To develop better strategies, design or actions for sustainable development;
- To support decision-making.

2.3.2.2 What are the methodologies of sustainability assessment and existing cases?

Regarding the existing methodologies of sustainability assessment, there are two different types: one is monetary aggregation method which is often used by economists; and the other is the physical indicators system which is favoured by more scientists and researchers in sustainability field (Wang, 2015; Singh, et al., 2009). ***The Indicator System of the sustainability assessment is adopted in this research because it is easy to apply, simple to read, and flexible to develop.***

Firstly, the Indicator System is built mainly based on the selection of relevant indicators, which is easy to apply for sustainability evaluation. Meadows had a clear and straightforward explanation of indicator: "*Indicators arise from values (we measure what we care about), and they create values (we care about what we measure)"* (Meadows, 1998, p. 2). Through visualising phenomena and highlighting trends, indicators can summarise, focus, condense, simplify, quantify, and finally transform the intricate and complicated environment into manageable and understandable information (Godfrey & Todd, 2001; Warhurst, 2002). Hence, the Indicator System is adopted to use indicators as tools for measuring and assessing sustainability.

Secondly, the evaluation results of the Indicator System are normally composite indexes. They are simple to read and easy to be compared quantatitively. Sustainability delivery needs to involve more engagements of non-professionals, especially the public. Therefore, reader-friendly results could be more conducive to the promotion and realization of sustainable development.

Thirdly, Indicator system can be built based on various conceptual frameworks, which demonstrated its flexibility of system development. The assessment systems could be variable because of the difference in the assessment purpose, the evaluation subjects, and the scope of focus. Table 2. 10 illustrates six types of existing indicator framework. Momoh (2016) defined the Sustainable Composite Cities Environmental Evaluation and Design Tool (SUCCEED) to evaluate neighbourhood design which is based on four sustainability dimensions, namely Environmental, Social/Cultural, Economic and Planning Sustainability, five core categories for each dimension and a total of 112 sub-categories. However, this assessment method highlights the sustainability of planning procedure which results in the lower level of assessment of the actual situation. Wang (2015) focused on social sustainability assessment and built the framework based on three layers, namely Individual Needs, Social Networks and Community Development. Within this framework, each layer is composed of 10 indicators which are selected by a scoring method under several principles. Radar charts used in the result expression are clear and worth learning. In order to `assess urban sustainability, Li, et al. (2009) provided a full permutation polygon synthetic Indicator System with four aspects and 52 indicators. However, this method emphasises on the performance progress, and the impact of environmental factors on the overall evaluation result is expanded. The assessment frameworks of Akbar (2012) and Kim (2002) have a significant similarity in the whole structure though they are used to evaluate different objects. Both build the assessment structure through some topics, and then further quantify a group of evaluation indicators. However, the main weakness of this kind of framework is that it cannot guarantee the comprehensiveness and typicality of the listed topics, thereby lacking the embodiment of the complete sustainability.

Among all existing frameworks, the structure developed by Laprise, et al. (Li, et al., 2009) (Table 2. 11) was employed for this study. The study of Laprise builts an indicator system to evaluate the sustainability of disused urban areas. The system is robust and flexible regarding theoretical framework:

- The structure is built based on the “three bottom line” principle so that the evaluation results can well reflect holistic sustainability;

- For each sustainable dimension, a set of criteria are defined according to the evaluation object and evaluation purposes, which promotes the applicability and flexibility of this framework;
- Specific indicators are selected for each criterion according to defined principles. Different modes of indicators are accepted simultaneously, and the evaluation result is formed through different quantitative aggregation.

The study adopted three different aspects of sustainability evaluation from Laprise's research:

1) The evaluation framework consists of four layers, namely sustainabilit targer layer, sub-target layer, criteria layer, and indicator layer respectively.
2) The indicator layer can be composed of several indicators that meet the requirements, and the number of selected indicators is not necessarily equal.
3) The sustainability index for the evaluation object can be formed through nomalisation, weighting and aggregation calculation.

Table 2. 10: Comparison of Framework and system of Sustainability Assessment

Reference	Assessment Object	Framework	Evaluation Mechanism
(Momoh, 2016)	Sustainability of neighbourhood design	• *4 sustainability dimensions: environmental, social/cultural, economic and planning sustainability;* • *5 core categories for each dimension* • *112 sub-categories in total*	*Scoring method*
(Wang, 2014)	Social sustainability	• *3 layers: individual needs, social networks and community development;* • *30 indicators (10 for each layer)*	*Scoring method*
(Li, et al., 2009)	Urban sustainability	• *4 aspects: economic growth and efficiency, ecological and infrastructural construction, environmental protection, social and welfare progress.* • *52 indicators*	*Full Permutation Polygon Synthetic Indicator method*
(Kim, 2002)	Community sustainability	• *9 themes: land use and transportation, energy, air, water, soil, flora & fauna, built form, solid waste/waste recycling, people & community;* • *29 indicators*	*Sustainability progress degree*
(Laprise, et al., 2015)	Sustainability of Disused urban areas	• *3 bottom line: environment, sociocultural, economic* • *9 criteria (3 for each dimension)* • *18 indicators (2 for each criterion)*	Integrated aggregation
(Akbar, 2012)	Sustainability of High-rise development	• *8 factors: site & community, economic sustainability, water & environmental quality, facilities management, waste management, CO2emission & indoor environmental quality, pedestrian and transport facilities, innovation and regional contribution.* • *16 sub-factors;* • *70 variables.*	Weight aggregation

Note: The table was designed and made by the author, and the information sources were listed above.

Table 2. 11: Evaluation Framework of Sustainability of Disused Urban Areas

Sub-Targets	Criterion Code	Criterion Title	Indicator Code	Indicator Title	Mode	Initial diagnosis
Environment	C_1	Mobility	C_{1a}	Quality of service in public transport	N	-
			C_{1b}	Number of Parking spaces	N	-
			C_{1c}	Tying status with soft mobility network	E	-
	C_2	Pollution	C_{2a}	Average annual emission of NO_2	N	-
			C_{2b}	Acidification Potential (AP)	N	-
			C_{2c}	Global warming potential (GWP)	N	-
	C_3	Noise	C_{3a}	Average emission of noise –day	N	-
			C_{3b}	Average emission of noise- night	N	-
Socio-cultural	C_4	Proximity of school facilities	C_{4a}	Average distance to a nursery	E	-
			C_{4b}	Average distance to kindergarten	E	-
			C_{4c}	Average distance to an elementary school	E	-
			C_{4d}	Average distance to a junior high/middle school	E	-
			C_{4e}	Average distance to a high school	E	-
	C_5	Proximity of commercial	C_{5a}	Average distance to a commercial zone	E	-
	C_6	Proximity of recreational facilities	C_{6a}	Average distance to a public park	E	-
			C_{6b}	Average distance to a recreational green space/natural area	E	-
			C_{6c}	Average distance to a cultural centre	E	-
			C_{6d}	Average distance to a sport centre	E	-
Economic	C_7	Population	C_{7a}	Net population density	M	-
	C_8	Job	C_{8a}	Net employment density	M	-
	C_9	Local economy	C_{9a}	Proportion of work carried out by local companies	E	-

Source: (Laprise, et al., 2015)

2.3.2.3 How to construct a sustainability assessment system?

Based on a comprehensive review of the existing assessment system and the relevant studies (Gibson, 2006; Singh, et al., 2009; Schröter, 2010; Narodoslawsky & Krotscheck, 2004; Gibson, et al., 2005; Repetti & Desthieux, 2006; OECD & JRC, 2008), the construction process of a reliable framework of sustainability assessment can be divided into 8 steps (See Figure 2. 1):

Designed and drawn by the author

Figure 2. 1: Construction Process of Sustainability Assessment System

1) ***To decide the assessment purpose***. It is important to answer a set of questions at the beginning, including "who asked for the assessment?", "why is the evaluation conducted?", and "what is the role of the evaluation team?" These questions help to explicit the evaluation direction and limitation. A checklist sometimes is helpful in this step (Schröter, 2010).

2) ***To determine the structure of the assessment framework***. The assessment framework is supposed to be built based on relevant theory, empirical analysis, existing research, pragmatism or intuitive appeal, or some combination thereof (Singh, et al., 2009). In this stage, a desk-based literature review is necessary to possess a critical and comprehensive understanding of the fundamental theory of sustainability as well as the assessment subject. Also, the judgments of the researcher have a significant influence on the selection process.

3) ***To define a set of criteria***. The overall assessment system should be comprehensive and robust, so the definition of sustainability needs separate specific categories and criterion within each pillar of sustainability regarding the assessment subject and primary purposes. The principles of criterion selection are (Gibson, et al., 2005):

- ***Representativeness:*** *The selected criteria should represent three pillars of sustainability;*
- ***Comprehensiveness:*** *The integration of criteria reveals the phenomenon comprehensively.*
- ***Measurability:*** *The criteria can be defined and measured by relevant indicators.*

4) ***To select the indicators.*** A bright idea is needed of which indicators are relevant to what to be measured and representative to the criterion. In general, the main principles of indicator selection are (Laprise, et al., 2015; Bossel, 1999; Bell & Morse, 2006; Elle, et al., 2010):

- ***Exhaustive****: The indicators can together represent proportionally and holistically the three aspects of sustainable development;*
- ***Relativity:*** *The indicators can comprehensively reflect the performance of the evaluation object concerning a given criterion*
- ***Sensitivity:*** *The indicators can respond significantly to variations of the parameter that is evaluated for both quantitative and qualitative indicators;*
- ***Objectivity:*** *The selection of indicators should eliminate ambiguity, so a precise definition of each indicator and its valuation method are necessary;*
- ***Accessibility:*** *All selected indicator should be accessible and reflect the reality of the usual practice. Quantitative indicators must be easily calculated, and qualitative indicators should be based on an explicit description;*
- ***Readability:*** All indicators should be interpreted clearly to promote the communication of the evaluation result and further study of the next stage.

5) ***To assess the data quality.*** All indicators are supposed to be high-quality data. Otherwise, some alternative indicators and methods should be applied. If the research is unsure about the source and reliability of the data, then the composite's quality is low. NUSAP which is an acronym for five categories: Numeral, Unit, Spread, Assessment, Pedigree, is a system that can be used to review the quality of quantitative information (Funtowicz & Ravetz, 1990)

6) ***To design the normalisation methods and weighting system.*** This step is to choose appropriate methods for normalising and weighting of the indicators, which is very important in the entire assessment process. Many researchers pointed out that the methods for normalisation and weighing should be transparent enough and able to be traced back (Pollesch & Dale, 2015; Nardo, et al., 2005).

Normalisation is used to transform an indicator into a common dimensionless unit (Paracchini, et al., 2008). The normalisation methods are various which depends on the framework structure, data pattern, and the subjective judgments.

The weighting issues lie in two levels: one is the weights of the indicators within each sustainability dimensions, and the other is the weights among the three dimensions of sustainability. The concept of "trade-off" is introduced here to shape the weighting system (Gibson, 2006; Finkbeiner, et al., 2010). The trade-offs between the three dimensions of sustainability need to be careful so as not to break the balance of sustainability. Qualitative and quantitative data can be combined and weighed to arrive at a single measure for sustainability (Olsen & Fenhann, 2008).

7) ***To choose the aggregation models.*** It is to obtain a final composite value, thus determining the sustainable degree of the evaluation object. The available aggregation methods can be categorised into two: simply summing up all normalised indicators or using aggregation functions. Aggregation functions are one method which is employed from mathematics to clarify and simplify data in the assessment task of social science (Pollesch & Dale, 2015). Hence, a suitable method should be selected according to the research context and practical issues.

8) ***To analyse the robustness of the established system.*** It is crucial to test the robustness of the whole evaluation system. The uncertainties might lie in each step of system construction, such as the accessibility of selected indicators, the objectiveness of the weighing system, and the rationale of normalisation. Therefore, this step is to minimise the subjectivity and potential errors caused from the assumptions in estimating the measurement error in data, transformation and /or trimming of indicators, normalisation scheme, choice of imputation algorithm, choice of weights, etc. (Singh, et al., 2009). More importantly, concerning some inevitable uncertainties, it is to identify them and assess their magnitude.

2.3.2.4 Sustainability Assessment Framework Established

Based on the study above, a preliminary framework of sustainable assessment was established (See Table 2. 12). It can be seen that the established framework referenced the structure of Laprise, et al.'s work (2015) and combined the eight general steps of building a sustainable assessment framework. Based on the established structure, there are still six steps before completing Indicator System of sustainability assessment.

1) ***To define the corresponding criteria at the criteria layer.*** Three pillars of sustainability, namely environmental sustainability, social sustainability, and economic sustainability, are the contents of the sub-target layer. Therefore, a set of criteria should be defined for each pillar of sustainability concerning the criteria layer. The selection of criteria should be accord with the assessment subject and primary purposes, and the fundamental principles are representativeness, comprehensiveness and measurability.

2) ***To select a series of indicators for the indicator layer.*** It is to choose some proper indicators to represent each criterion. Both qualitative and quantitative indicators could be taken into consideration. The key principles of indicator selection are exhaustive, relativity, sensitivity, objectivity, accessibility, and readability.

3) ***To define the properties of selected indicators.*** The properties of each indicator, including the measurement unit, acquisition mode, and calculation formulas, are to be defined accordingly.

4) ***To design the normalisation methods.*** It is to specify the normalisation methods for selected indicators according to the theoretical framework and the data properties. It is important to note that the choice of methods largely depends on the attributes of these selected indicators.

5) ***To assign the Weighting System.*** It has been pointed out in this research that the three pillars of sustainability are equally important and no trade-off. Therefore, the weightings of the sub-targets layer should be equal. Given this, the primary task of the assignment of the weighting system for this framework is to calculate the weightings for the selected indicators based on the principle of an equal weight at the sub-targets layer.

6) ***To calculate the Sustainability Index by proper an aggregation model. F***our composite indexes of sustainability, namely Environmental Sustainability Index (EnSI), Social Sustainability Index (SoSI), Economic Sustainability Index (EcSI), and Sustainability Index (SI) respectively are to be calculated based on the aggregation models in this framework.

Table 2. 12: A Preliminary Framework of Sustainability Assessment

Target Layer	Sub-targets layer	Criteria Layer		Indicators Layer					Weighting System	Sustainability Index	
		Code	*Title*	*Code*	*Title*	*Raw Value*	*Unit*	*Normalised Value*			
Sustainability	***Environmental Sustainability***	C_1	/	C_{1a}	/	/	/	/	/	EnSI	SI
				C_{1b}	/	/	/	/	/		
		C_2	/	C_{2a}	/	/	/	/	/		
				C_{2b}	/	/	/	/	/		
		C_3	/	C_{3a}	/	/	/	/	/		
				C_{3b}	/	/	/	/	/		
		…	/	…	/	/	/	/	/		
		$C_{(3+m)}$	/	$C_{(3+m)a}$	/	/	/	/	/		
				$C_{(3+m)b}$	/	/	/	/	/		
	Social Sustainability	$C_{(4+m)}$	/	$C_{(4+m)a}$	/	/	/	/	/	SoSI	
				$C_{(4+m)b}$	/	/	/	/	/		
		$C_{(5+m)}$	/	$C_{(5+m)a}$	/	/	/	/	/		
				$C_{(5+m)b}$	/	/	/	/	/		
		$C_{(6+m)}$	/	$C_{(6+m)a}$	/	/	/	/	/		
				$C_{(6+m)b}$	/	/	/	/	/		
		…	/	…	/	/	/	/	/		
		$C_{(6+m+k)}$	/	$C_{(6+m+k)a}$	/	/	/	/	/		
				$C_{(6+m+k)b}$	/	/	/	/	/		
	Economical Sustainability	$C_{(7+m+k)}$	/	$C_{(7+m+k)a}$	/	/	/	/	/	EcSI	
				$C_{(7+m+k)b}$	/	/	/	/	/		
		$C_{(8+m+k)}$	/	$C_{(8+m+k)a}$	/	/	/	/	/		
				$C_{(8+m+k)b}$	/	/	/	/	/		
		$C_{(9+m+k)}$	/	$C_{(9+m+k)a}$	/	/	/	/	/		
				$C_{(9+m+k)b}$	/	/	/	/	/		
		…	/	…	/	/	/	/	/		
		$C_{(9+m+k+x)}$	/	$C_{(9+m+k+x)a}$	/	/	/	/	/		
				$C_{(9+m+k+x)b}$	/	/	/	/	/		

Note: 1) m,k,x $\in$ (1, 2, 3, 4,…, n); 2) The table was designed and drawn by the aurthor.

2.4 Summary

This chapter conducted an in-depth analysis of two concepts of Climate Change and Sustainability in the built environment, thereby building the basic conceptual framework and theoretical basis for this research.

Firstly, the study identified that urban areas are the leading cause of Climate Change and suffer from the adverse effects of Climate Change the most significantly. Therefore, a development transformation of urban areas plays a vital role in the respose to Climate change. Among global responses, two fundamental paradigms are mitigation of Climate Change and adaptation to Climate Change. Also, these two paradigms promote and effect mutually. **Therefore, it can be said that the renovation of the built environment is a necessary solution to Climate Change.**

Secondly, in order to have a comprehensive understanding of sustainability in built environment, the definitions, concept models and critical features of the three relevant concepts of "Sustainability", "Sustainable Development", and "Sustainable Design" were analysed respectively. **The study showed that Sustainability and Climate Change are closely linked and mutually interact.**

Finally, based on an in-depth study of the Sustainability Assessment, sustainability assessment is a particular form of integrated assessment which is to evaluate the sustainability of a specific activity or place in built environment based on "the triple bottom line principle". By comparing various assessment system, the Indicator System of the sustainability assessment was adopted in this research because this system is easy to apply, simple for reading, and flexible to develop. Furthermore, the eight-step constructive process of sustainability assessment system (See Figure 2. 1) and a preliminary framework of sustainable assessment (see Table 2. 12) will be adopted to create the evaluation system of sustainable streets in the following study. **The promotion of theoretical and practical development of sustainable assessment is of great significance for addressing Climate Change and a range of other urban issues as well.**

Chapter 3. Streets and Sustainable Streets

3.1 Introduction

This chapter aims at constructing the theoretical framework of "Sustainable Streets". It starts from the study of the concept of “Urban Streets” firstly, including the definition, functions, and design elements and a concept model, thereby forming a comprehensive understanding of the characteristics and components of the urban streets as well as demonstrating the necessity of the sustainable shift of urban streets. Based on these analysis results, a theoretical framework for sustainable streets is finally established, including the definition, principles, design toolkit, and evaluation structure of sustainable streets.

3.2 Urban Streets

3.2.1 Definition and interpretation

According to the word of street in Latin (strata), the word of the street means “paved road”. The Italian “Strada” or the German “Strasse” highlighted the characteristics of the streets as public spaces. In Chinese, the street is a corridor surrounded by buildings on both sides (Xu, 1988). The Oxford Dictionary (2016) defines the “street” as “a public road in a city or town that has houses and buildings on one side or both sides”. The descriptions from dictionaries provide a fundamental definition for the street.

Many scholars have studied and given various interpretations of urban streets. Palladio (1508-1580) raised a geometric perspective to explore and depict the pleasant streetscape in “The Four Books of Architecture” (Palladio, 1965). Jacobs (1961) believed that the streets are the most important organs of one city. Lynch (1981) introduced psychology into urban research and expounds the significance of urban streets for people to understand a city. Gehl (1987) used the human dimension as the starting point to study and measure the success of urban streets. In summary, many researchers highlight the unique values of streets to a city: they are the most significant public space.

Furthermore, it is significant to notice that “Street” and “Road” are different (Mehta, 2006; Mehta, 2015; Peng, 2003; Wang, 2013; Zhang, 2016; Cowan, 2015). The road is an open way, usually surfaced with asphalt or concrete, providing a passage from one place to another (Collins, 2014).

This definition highlights the linear space with the function of transportation and movement. In this sense, the critical features of the road are efficient, fast, and convenient, which is highly functional-oriented. Meanwhile, the street is the linear open space in the city, defined by the buildings on one/both sides. The lined buildings not only shape the physical space of the streets but also stimulate vigorous activities and vibrant social culture in the streets. Urban streets not only provide a link between daily life but also create the crucial place and contexts for social activities (Whyte, 1980; Gehl, 1987). Therefore, both in a material sense and in a spatial sense as well, urban streets not only have the function as a road where the transportation of people, goods, and vehicles occurs, but also possesses the functions as a place where the public activities, daily communication, and social life happens.

In summary, ***urban streets are the linear open space in urban areas. Except for the linear space similar to the road, a holistic concept of urban streets also contains the lined buildings, the people, serving facilities, and the surrounding environment.*** With all these components, the street functions as an essential place for social interaction, cultural inheritance, political communication, economic activities as well as urban ecology.

Table 3. 1: Comparison of "Street" & "Road"

	Definition	Spatial Definition	Features	Requirement
STREET	A public road that is usually lined with buildings	Linear open space with buildings on one/both sides	Various functions: transportation, social, commercial, cultural, political, and ecological functions	Pleasant, dynamic, and vibrant
ROAD	An open way, usually surfaced with asphalt or concrete, providing a passage from one place to another	Linear open space	Functional-oriented	Efficient, fast, and convenient

The table was made by the author, and the definition's source was (Collins, 2014)

3.2.2 Functions of Urban Streets

As the most ubiquitous form of open space, the streets can accommodate multiple functions in the urban system. Many scholars have identified the multiple functions of urban streets. Zeng (2008) stated that urban streets have a wide range of meanings, including politics, economy, culture, society, science, ecology, and philosophy. Zhou (2005) proposed four functions of the streets, namely traffic function, landscape function, commercial function, and the function of historical inheritance. Also, Zhang (2010) emphasised the functions of the streets to promote social harmony, economic vitality, cultural development, and resource conservation, in the research on Slow Streets. In addition, Sholihah (2016) pointed out five roles of a street, namely channel of movement, social space, commercial space, political space, and cultural space.

Based on a comprehensive study of existing literature, ***the researcher summarised the streets' functions into six aspects, namely traffic, social, the commercial, cultural, political, and ecological function respectively*** (see Figure 3. 1).

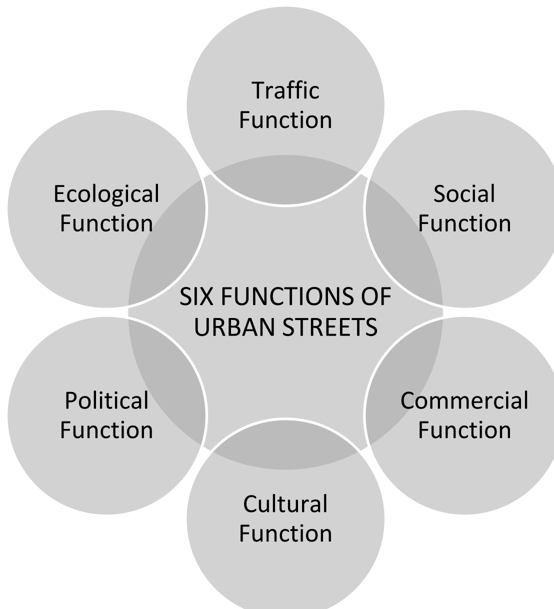


Figure 3. 1: Six Functions of Urban Streets

Traffic Function

First, the primary function of urban streets is to promote the movement of people and goods. As its original definition, a street is a corridor of movement for pedestrians, vehicular and goods to transport from one place to another (Sholihah, 2016; Hidalgo, 2014; Zhang, 2016). Nevertheless, the traffic function of urban streets has extended and been dominate to the overall street design and space division since the modernisation of cities prompted the street function of transportation and focused on speed and the effective use of motor vehicles. In this sense, the pursuit of speed and the efficiency become a threat to street life and other slow modes of transportation, like walking, and cycling, which has been pointed out by many researchers and organisations (Jacobs, 1993; Gehl, 1987; TA Magazine, 2001; Sholihah, 2016).

Social Function

One of the most significant functions of the streets is that they are significant public spaces for the social interactions. Mehta & Bosson (2009) even defined the street as “a third place” where people can regularly visit and commune with friends, neighbours, co-workers and even stranger to support sociability and place attachment. Because the social activities in the streets help to create the local attachment that can act as a “social glue” (JRF, 2006). The absence of social activates in the streets not only results in the social indifference but also increases physical and psychological problems (Hidalgo, 2014; Mehta, 2008; Macdonald, 2011). Therefore, it can be said that urban streets play a vital role in promoting social relationship as well as public health and well-being.

Commercial Function

Urban streets also function as significant places for the exchange of goods or doing business (Rykwet, 1986; Jacobs, 1993; Sholihah, 2016). Because the streets are the vital space for products’ transportation and social interaction, many people often gather in the streets and all goods need to pass through the streets. Therefore, the streets always possess of high commercial value. Moreover, many practices and studies have proved that the quality of the street has a significant influence on local commerce. Sinnett, et al. (2011) proved the quality of walking environment could considerably promote the economic vitality of an area by various types of evidence. Furthermore, the research of Kumar and Ross (2006) shows that the number of pedestrian and turnover of retail in Khao San Rd street, in Bangkok, Thailand, increased considerably after the street renovation and the implementation of traffic calming.

Cultural Function

As a primary component of public space, urban streets play an essential role in inheriting and exhibiting urban culture and history.

Firstly, the streets reflect urban historical morphology and landscape (Lynch, 1960; Gehl, 1987). The streets, as the main open space in cities, not only reflect the built environment that is shaped by the urban citizen in each period, but also demonstrate the public faith and spiritual pursuit (Peng, 2003; Mehta, 2006; Massengale & Dover, 2014; Sholihah, 2016). Jacobs (1961) reminded us that the first thing that comes to your mind is its streets when you think of a city. Also, Lynch (1960) highlighted that it is always to feel the city form and landscape through visiting the streets. Furthermore, the characteristics of the street also reflect people's ideology. A society's civilisation always takes the dominant social culture as the representative, so the city planning and construction are naturally to reveal the will of these superstructures (Peng, 2003).

Political Function

The characteristics of streets usually demonstrate the will of its social ruler, so it can be said that the streets, including the overall street pattern and the streetscape, have a political function.

Above all, the street planning shows local political system (Chipman, et al., 1974; Sholihah, 2016; Mehta, 2013). For example, the planning and layout of urban streets in traditional Chinese feudal society reflect the rigid class hierarchy concept and political order. Moreover, the streets themselves are the political space since they are a crucial place for most of the political events, like open speech and political rally and marches.

Ecological Function

The street network functions as the ecological framework in the urban area from the environmental perspective.

First, urban streets form the ecological framework of the city and play an essential role in the harmonious integration of the built environment and natural system (Bolund & Hunhammar, 1999; Ignatieva, et al., 2011). Because the street network can respect, protect, and enhance the natural characteristic and local ecosystem (CNU, 2012). Moreover, urban streets occupy one-quarter of the total urban area typically, and in some cities, the number can reach 45% (Mehta, 2015). The ecological sustainability of urban streets directly influences the urban ecosystem (Dawe, 2011; Douglas, 2011; Lindal & Hartig, 2015). Furthermore, street design is related to a series of environmental problems, including water consumption and drainage, waste management, air pollution, noise pollution and energy consumption (El-Shimy & Ragheb, 2017). A sustainable street network provides various choice to the public and drive people to have a green and eco-friendly lifestyle (CNU, 2012).

3.2.3 Design Elements

Besides the linear road space, the street' elements include the buildings on both sides, the people, the service facilities and the landscape in the streets. In the street design process, some street' elements can be controlled by design, such as spatial division, street plantings, and facilities, while the others can be influenced by design, such as people and activities within the street. Therefore, a good design of the street's elements can not only create a high-quality urban street but also lead to vibrant public space. Moreover, the well-designed street area is an essential urban asset which has a significant effect on commercial activities, property values, social interaction, emergency response, recreational opportunities.

Hence, which kinds of elements can be controlled from a design perspective? In order to obtain a general understanding, twelve relevant papers, policies and documents are studied and compared together in this section (see Table 3. 2):

Table 3. 2: A List of Studied Documents on Design Elements of Urban Streets

NO.	Document Name	Type	Object	Author	Issue/ Published	Reference
1	Streetscape Guidance 2009: a guide to better London streets	Policy	London, UK	Transport for London	2009	(TfL, 2009)
2	A Policy Statement for Scotland Designing Streets	Policy	Scotish cities, UK	the Scottish Government	2010	(The Scottish Government, 2010)
3	Abu Dhabi Urban Street Design Manuel	Policy	Abu Dhabi, The United Arab Emirates	Abu Dhabi Urban Planning Council	2010	(ADUPC, 2010)
4	Better Streets, Better Cities: a guide to street design in urban India	Policy	India	Institute for Transportation & Development Policy, Environmental Planning Collaborative	2011	(ITDP & EPC, 2011)
5	Complete Streets Chicago: Design Guidelines	Policy	Chicago, USA	Department of Transportation	2013	(DoT, 2013)
6	Complete Streets Guidelines	Policy	Edmonton, Canada	City of Edmonton	2013	(CoE, 2013)
7	Complete Streets Design Guidelines: For Liveable communities	Policy	Southern Nevada, USA	Regional Transportation Commission	2013	(RTC, 2013)
8	Sustainable streetscape as an effective tool in sustainable urban design	Research	Egypt	Rehan	2013	(Rehan, 2013)
9	Complete Streets Design Manual	Policy	Florida, USA	Florida Department of Transportation	2014	(FDOT, 2014)
10	Philadelphia Complete Streets Design Handbook	Policy	Philadelphia, USA	Philadelphia Streets Department	2015	(PSD, 2015)

NO.	Document Name	Type	Object	Author	Issue/ Published	Reference
11	Street Design Manual	Policy	New York City, USA	NYCDoT	2015	(NYCDoT, 2015)
12	Shanghai Street Design Guide	Policy	Shanghai, China	SPLRAB/SMTC/ SUPDRI	2016	(SPLRAB/SMTC/SUPDRI, 2016)

The classification types of street design elements vary according to study context and local background. Table 3. 3 illustrates the 12 samples and the review summary. Specifically speaking, both the research of Rehan (2013) and street design policy of Gujuarat (ITDP & EPC, 2011) list the main elements of street design, such as sidewalks, tree and landscape strips, lighting, bus stop, and on-street parking. However, it is incomplete as all the elements are just listed by random rather than analysed from a systematic structure. A Policy Statement for Scotland Designing Streets (The Scottish Government, 2010) lists seven critical aspects of street design. Meanwhile, more policies and plans classify the design elements of urban streets according to street components, such as "Philadelphia Complete Streets Design Handbook" (PSD, 2015), "Complete Streets Design Manual" of Florida (FDOT, 2014), and Complete Streets Guidelines (CoE, 2013). For example, "Philadelphia Complete Streets Design Handbook" sorts all street design elements into six component types, namely pedestrian component, buildings & furnishing component, bicycle component, kerbside management component, vehicle/cart way component, and intersection & crossing component. It is relatively comprehensive since all components within the street are considered, but not systematic enough from a design perspective. The key to the design is the layout of the space from an overall structure to specific elements. Therefore, such classification lacks the consideration of the design process. Another three samples, "Complete Streets Chicago: Design Guidelines" (DoT, 2013), "Complete Streets Design Guidelines: For Liveable communities" (RTC, 2013), and "Streetscape Guidance 2009: a guide to better London streets" (TfL, 2009), classifies the street elements according to design part and presents the street elements from a design-oriented perspective. Nevertheless, the list of elements in DoT (2013) is not comprehensive enough, and TfL (2009) focuses on the streetscape. The list of RTC (2013) is reasonably detailed. However, it includes some design methods except for design elements.

Among 12 studied samples, the classification and listed elements in "Shanghai Street Design Guide" (SPLRAB/SMTC/SUPDRI, 2016) are the most systematic, sound and practical. It separates elements according to design depth, from functional facilities (the necessary facilities for traffic function) to auxiliary functional facilitates (a list of service facilities). Besides these two categories of elements, the guideline also specifies the details of two design parts, namely walk and activity space and street facade, which are two critical parts for the detailed street design. The only flaw of the guideline is that the design of street intersections is not enough. However, relevant design requirements and design elements of intersections are in auxiliary function facilities.

Hence, a general street design element in this research is built based on “Shanghai Street Design Guide” (SPLRAB/SMTC/SUPDRI, 2016), and also enriched by the other samples listed in Table 3.2. Figure 3. 2 summarised the design elements within street space. It can be seen that all design elements are grouped into four categories: Functional Facilities for Traffic, Auxiliary Function Facilities, Walk and Activity Space, and Street Façade.

Finally, ***Table 3. 4 summarises the Design elements of urban streets and their relevant design requirements.***

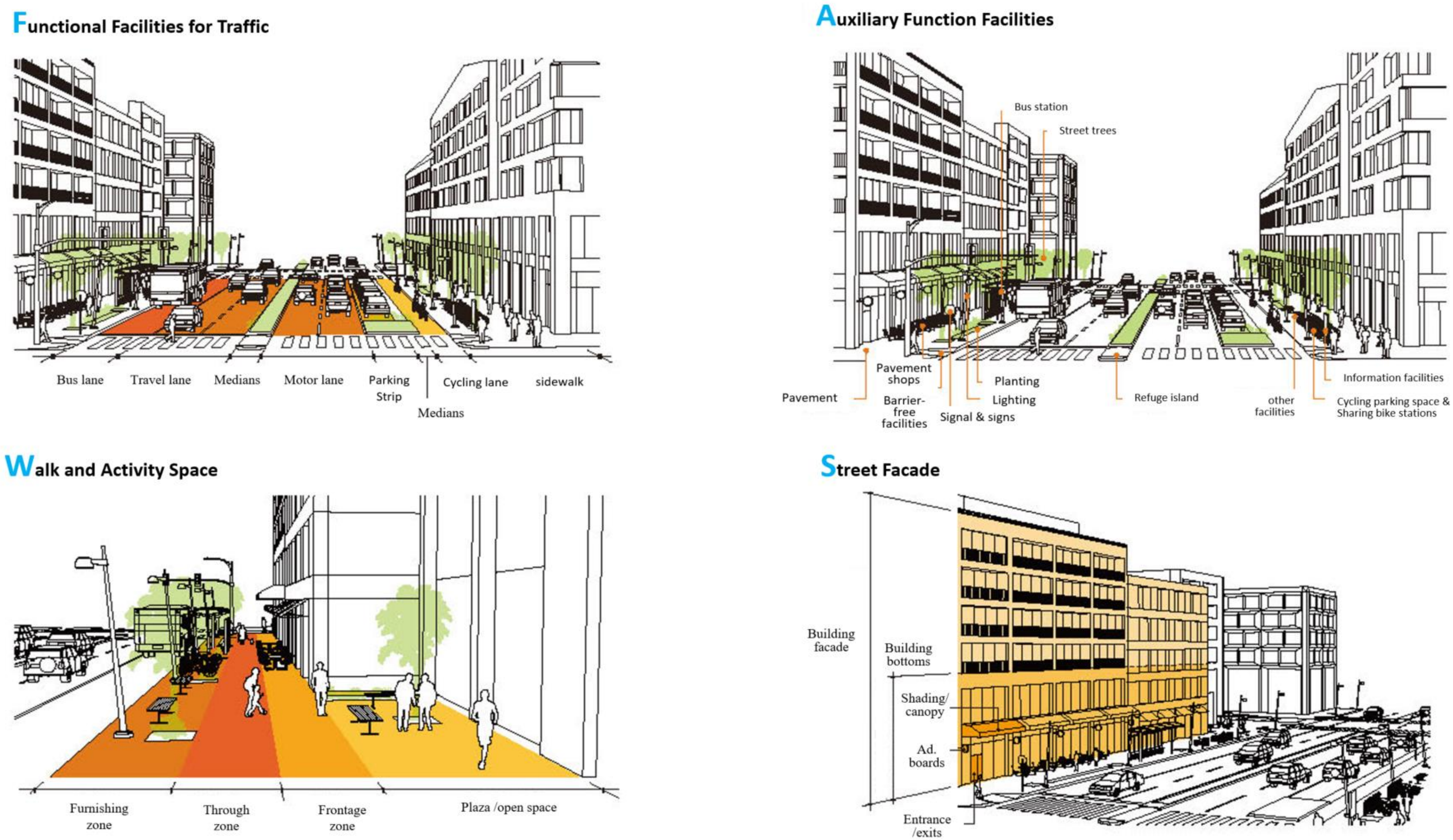
Table 3. 3: Comparison of 12 Documents on Urban Street Design Elements

Reference	**Complete Streets Guidelines** (CoE, 2013)	**Complete Streets Design Guidelines: For Liveable Communities** (RTC, 2013)		**Better Streets, Better Cities** (ITDP & EPC, 2011)	**Abu Dhabi Urban Street Design Manuel** (ADUPC, 2010)
Street Design Elements	• *General Street Design & Operation* - Roadway, travel lands & lane widths - Design speed - On-street vehicle parking - Speed & volume management techniques - Landscape amenities - Utilities • *Pedestrians* - Sidewalks - Curb extension - Streetscape amenities - Pedestrians at intersections • *Bike Network Streets* - Bicycle facilities selection - Marked shared use roadway - Bike boulevards - Bike lanes - Buffer bike lanes - Cycle tracks - Shared use path adjacent to roadways • *Transit* - Bus stop - Transit priority measures - Transit integration with bike facilities - Transit integration with cycle tracks	• *Travelled Way* - On-street parking - Bicycle facilities - Transit facilitates - Travel lanes - Medians - Other geometric elements • *Intersection Design* - Intersection skew - Corner radii - Curb extensions - Crosswalk & ramp placement - On-street parking near intersections - Right turn channelization islands - Signal - Roundabout • *Pedestrian Access* - Sidewalks - Curb ramps - Detectable warnings - Signals • *Pedestrian Crossing* - Marked crosswalks - Raised medians - Signs - Advanced yield - Lighting - Pedestrian hybrid beacon	• *Bikeway Design* - Bikeway marking at intersections - Bike signal heads - Bike boxes - Bicycle countdowns - Leading bicycle intervals - Two-stage turn queue boxes - Coloured pavement treatments - Way finding - Legal status - Bicycle parking • *Transit Accommodations* - Bus stops - Bus bulbs - Bus turnouts - Bicycle connections - Bus lanes • *Street Ecosystem* - Benches & seating - Bollards - Street vendor stands - Information kiosks - News racks - Parking meters - Public art - Sidewalk dining	• Footpaths • Cycle tracks • Carriageway • Bus rapid transit • Medians and pedestrian refuges • Pedestrian crossings • Landscaping • Bus stops • Space for street vending • Street furniture & amenities • On-street parking • Service lanes • Traffic calming elements	• Street composition • Standard cross sections • Flexible dimensions for restricted right-of-way • Additional street types • Designing for pedestrians • Designing for transit users • Designing for bicyclists • Design for motor vehicles • Junction design • Traffic calming
Comments	*It is relatively complete but not systematic from the design perspective.*	*It is a comprehensive classification, but it mixes design methods with design elements.*		*It is an incomplete classification as only the main elements are listed.*	*It is an incomplete classification as only the main elements are listed.*

Reference	**Sustainable Streetscape as an Effective Tool in Sustainable Urban Design** (Rehan, 2013)	**A Policy Statement for Scotland Designing Streets** (The Scottish Government, 2010)	**Complete Streets Chicago: Design Guidelines** (DoT, 2013)	**Philadelphia Complete Streets Design Handbook** (PSD, 2015)	**Complete Streets Design Manual** (FDOT, 2014)
Street Design Elements	• Sidewalks • Street corner • Tree & landscape strips • Rain garden • Planters • Street furnishing • Benches • Lighting • Trash receptacles • Signage • Bus shelter • Medians • Curbs • Bicycle facilities • Crossing • Public art • Cafe space	• Drainage • Utilities • Planting • Materials • Traffic signs • Lighting • Street furniture	• *Pedestrian Realm* - Frontage Zone - Walking zone - Sidewalk furniture zone • *Interstitial Area* - Curbs - Bicycle facilities - On-street parking • *Vehicle Realm* - Bus lanes - Travel lanes • *Median* - Landscaping - Pedestrian refuges - Bus rapid transit (BRT) - Protected bike lane - Left turn lanes	• *Pedestrian Component* - Sidewalk - Walking zone - Curb ramps • *Buildings & Furnishing Component* - Bicycle parking - Lighting - Benches - Sidewalk cafes - Street trees & tree trenches - Planters - Street furniture - Newsstands - Vendors - Architecture features • *Bicycle Component* - Bike lanes - Green coloured pavement - Bike route signs • *Kerbside Management Component* - On-street parking - Loading zones - Transit stops& shelters • *Vehicle/Cart Way Component* - Raised speed reducers - Medians - Bus lanes • *Intersection & Crossing Component* - Marked crosswalks - Curb/corner radii - Curb extensions - Pedestrian refuge islands - Signal timing &operations - Pedestrian hybrid beacons - Rectangular rapid flashing beacons - Bicycle signals	• *Pedestrian Component* - Sidewalks - Street furniture - Lighting - Tree belt enhancements - Surface treatments - Vegetated swales - Storm water planters • *Intersection & Crossing Component* - Marked crosswalks - Curb ramps - Storm water curb extensions - Crossing signals - Vehicles component - Speed humps - Raised table intersections - Refuge islands - Chicanes - Diverters - Medians - Neighbourhood traffic circles - Roundabouts • *Bicycle Component* - Bike routes - Bike parking - Buffered bike lane - Coloured pavement • *Transit Component* - Transit stops - Shelters - Signage - Bus turnouts - Bake rack - Bus lanes
Comments	*It is an incomplete classification as just listing the main elements.*	*It is an incomplete classification as it just lists the main aspects.*	*The classification is not systematic from the design perspective.*	*It is relatively complete but not systematic from the design perspective.*	*It is relatively complete but not systematic from the design perspective.*

Reference	**Streetscape Guidance 2009: A Guide to Better London Streets** (TfL, 2009)	**Street Design Manual** (NYCDoT, 2015)	**Shanghai Street Design Guide** (SPLRAB/SMTC/SUPDRI, 2016)
Street design elements	• *Footway & Carriageway Surface* - Footway surfaces - Shared surfaces - Tactile paving - Inspection covers - Curbs and drainage - Footway crossovers - Side road entry treatments - Road markings - Bus lanes - Cycle lanes & cycle tracks - Subways - Parking & loading bays - At grade pedestrian crossings • *Street Furniture* - Furniture - Lighting - Traffic signals & control boxes - Traffic signs - Variable message signs - Pedestrian direction signs - Roadside cameras and CCTV - Planting - Street trees - Cycle parking facilities - Motorcycle parking facilitates - Bus stops - Trams - Taxi ranks - Seats - Bollards - Pedestrian guardrails - Safety fence and barriers - Salt bins - Environmental monitoring equipment - Public art • *Street Furniture by Third Parties* - Street nameplates - Information signage - Litter bins - Recycling bins - Trade refuse bins - Utility cabinets - Telephone boxes - Parking control equipment - Post & pouch boxes - Smoke vents - Pavement cafes	• *Roadways & Lanes* - Bike lanes & path - Bus lane& bus way - Shared street - Plaza • *Sidewalks & Raised Medians* - Sidewalk - Curb extension - Raised median - Pedestrian safety island - Median barrier • *Materials* - Sidewalks - Curbs - Crosswalks - Roadways • *Lighting* - Poles - Luminaries - Integrated streetlights - Signal poles • *Furniture* - Art display case - Automatic public toilet - Bike parking shelter - Bike share station - Bus stop shelter - City bench - City rack - Multi-track - Newsstand - Walk NYC way-finding system - waste receptacle • *Landscape* - Tree bens - Roadway plantings - Sidewalk plantings - Plaza plants - Limited-access arterial plantings - Storm-water management practices	• *Functional Facilities for Traffic* - Bus lane - Motor lane - Medians - Parking stripe - Non-motorized lane - Sidewalk • *Auxiliary Function Facilities* - Pavement - Pavement shops - Barrier-free facilities - Sign & marks - Street green lighting system - Refuge islands - Leisure facilities - Information facilities - Cycling parking space & public bikes rental spots • *Walk & Activity Space* - Furnishing zone - Through zone - Frontage zone - Plaza/open space • *Street Facade* - Building facade - Building bottoms - Shading/canopy - Ad. Boards - Entrance/exists
Comments	*It is a relatively complete classification but the listed elements only focus on the streetscape.*	*It is relatively complete but not systematic from the design perspective.*	*It is a systematic, comprehensive, and practical classification, therefore it is adopted for this research.*

The table was summarised by the author, and the works quoted were listed above



Note: the graph source was (SPLRAB/SMTC/SUPDRI, 2016), and was translated from Chinese to English by the author.

Figure 3. 2: Illustration of Design Elements of Urban Streets

Table 3. 4: Street Design Elements

Design elements				Design requirement
Types		Items		
Code	Name	Code	Name	
F	Functional facilities for traffic	F1	Bus lane	To provide a priority for public transportation, like bus and tram.
		F2	Travel lane	To form a safe, efficient, and smooth space for vehicles.
		F3	Cycling lane	To provide a safe and comfortable space for bicycles, battery bicycles, and other non-motor vehicles.
		F4	Medians	To serve various functions, including refuge space for pedestrians, a definition of turning lands and tramways, and space for trees and landscaping.
		F5	Parking Strip	To provide on-street parking space for motor vehicles.
		F6	Sidewalk	To create a safe, comfortable, and pleasant walking space in the street.
A	Auxiliary facilities	A1	Pavement	To provide a safe, comfortable, artistic, and environmental-friendly pavement in the street.
		A2	Curb	To reasonably separate between different spaces and ensure safe and convenient traffic flow.
		A3	Barrier-free facilities	To provide convenience and accessibility to the disadvantaged groups
		A4	Signal and signs	To foster an efficient, well-guided and safe street.
		A5	pavement shops	To promote a vibrant and dynamic street life.
		A6	Lighting	To provide a safe, comfortable, and energy-efficient street lighting system.
		A7	Information facilities	To provide boards or wayfinding system with clear, convenient and user-friendly guides
		A8	Cycling parking space	To provide convenient and user-oriented facilities for bicycle parking.
		A9	Sharing bike station	To provide available public bikes rental spot and relevant service.
		A10	Bus station	To provide easily-accessible bus station and pleasant shelter for waiting.

Design elements				Design requirement
Types		Items		
Code	Name	Code	Name	
A	Auxiliary facilities	A11	Taxi Ranks	To provide convenient and well-organised space for taxi waiting
		A12	Street trees	To foster a comfortable and climate-adaptable environment and pleasant ambience of street space.
		A13	Planting	To provide a diverse and pleasant planting landscape of the street and support local environmental sustainability.
		A14	Other facilities	To provide a robust and reliable street service and display local culture features. (Other street furniture, including seats, bollards, pedestrian guardrails, bins, public art, telephone boxes, parking control equipment, post and pouch boxes, smoke vents, newsstands, vendors, speed hump, and chicanes.)
W	Walk and activity space	W1	Furnishing zone	To orderly arrange various street facilities and provide convenient service.
		W2	Through zone	To provide a safe and clear path for all kinds of pedestrian.
		W3	Frontage zone	To form an integrated and multi-functional space to combine and optimise the function between street and buildings thoroughly.
		W4	Plaza /green space	To provide plaza or green space to promote diversity of street.
S	Street facade	S1	Entrance/Exits	To provide safe and convenient entrances/exits of buildings along the streets.
		S2	Advertising Boards	To promote a vibrant but order streetscape and meanwhile maximise the add-value of street space.
		S3	Shading /Canopy	To contribute a climate-adaptable street environment and promote street activities.
		S4	Building Bottoms & Facade	To improve street visual quality and diversity.

The table was designed and made by the author.

3.3 Threats of Climate Change to Urban Streets

Urban systems and human's activities are the primary cause of Climate Change. In this sense, urban streets and their related activities are one of the most significant causes, because urban streets account for 25% of the total urban area, and this number even can reach 45% in some cities (Mehta, 2015). Moreover, most social activities happened in the streets, and the dominant one is traffic. According to the World Bank, traffic is the fastest growing energy consumption and will be responsible for 60% of the world's worldwide growth in greenhouse gas emissions in 2030 (World Bank, 2010). Furthermore, China's energy consumption of transportation increases at a rate of 6-9% annually. If it continues to grow at this rate, China's energy consumption in the transportation sector will be triple of its current level and account for about one-third of global fuel consumption by 2030. Except for fossil fuel consumption and emission of greenhouse gas, urban streets and their related activities are identified to be the main drivers of air pollution, noise pollution, water consumption and drainage, waste management, and worse urban microclimate (El-Shimy & Ragheb, 2017; Stromberg, 2008; Ignatieva, et al., 2011). Therefore, it can be said that poor performance of urban streets accelerates the Climate Change, while sustainable urban streets can effectively mitigate the adverse effects of Climate Change.

Therefore, explicitly speaking, what are the threats to urban streets caused by Climate Change?

The threats start from the environmental aspect, including Urban Heat Island and more extreme weather events in the urban area. These environmental-based issues bring massive risks to urban streets, such as flooding, windstorms, and air pollution, and more and more uncomfortable street conditions. Among these risks, flooding is a leading threat to urban streets caused by Climate Change (Huong & Pathirana, 2013; Li, 2012; Zeng, 2008; Zhang, 2010). Local changes in hydrological and hydrometeorological conditions and caused by global Climate Change have increased the flood hazard within urban streets, and the incomplete design even increases the vulnerability of urban streets. Climate Change makes the weather less predictable, rains more uncertain and rainstorm more likely, and the threat is more pronounced for coastal cities (Huong & Pathirana, 2013). Moreover, the surface of urban streets is often hardened, and most of the guidelines and design manuals of urban streets are based on past weather data that are unable to resist the extreme weather events from Climate Change (Li, 2012). Also, the effects of Climate Change drive outdoor environment more discomfortable. Consequently, people refuse walking or cycling but choose driving cars with air condition, which results in more severe environmental issues.

The threats start from massive environmental issues but do not stop within the environmental dimension. Climate Change and its effects also result in a series of social problems. It was demonstrated that uncomfortable outdoor environment, flooding incidents, and fewer street activities lead to both physical and psychological illnesses (Baxter, et al., 2002; Shackley, et al., 2001), which further expands into less social interaction and worse social relations.

At the same time, disruption of urban streets and transportation networks caused by Climate Change often result in considerable economic losses (Ackerman, et al., 2008; Lemmen, et al., 2008; Walmsley, 2010). The economic losses include the destruction of property in rainstorms or snowstorms, medical care of injured people, and post-disaster reconstruction, increased consumption of energy and additional economic expenditure due to extreme weather condition. Moreover, the cost can be considerable. For example, the torrential rainstorm in Beijing on 21st July 2012 caused a total of 1.9 million people were affected, 79 of whom were killed, and the economy lost nearly a billion RMB (China Meteorology, 2016).

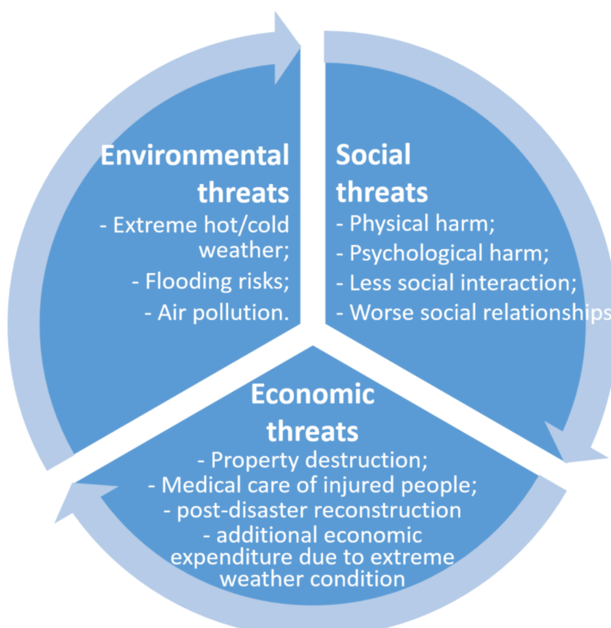


Figure 3. 3: Concept Model of Threats of Climate Change to Urban Streets

On the whole, ***Climate Change brings a series of threats to urban streets from the aspects of environment, society as well as economy***. Figure 3. 3 shows the cycle of the entire hazard. It can be seen that there are three critical features in the hazard model.

1) ***Mutual link and interaction:*** The threats start from the environmental aspect, then expand to more social issues and massive economic costs. As what are shown in the concept model, the negative effects are mutually linked and interact.

2) ***A vicious circle:*** The adverse effects are not only a correlative process, but also a vicious circle. That means the adverse impacts will get worse and worse if there is no external intervention. Without effective intervention, the adverse effects will continue to increase and spread to all aspects of society, economy, and the environment. For example, worse outdoor environment drives people to be more dependent on motor cars and artificial equipment, which not only causes social issues but also increases energy consumption and additional costs. More cars and more energy consumption will drive the natural environment even worse.
3) ***Accelerating Climate Change:*** the whole procedure will accelerate Climate Change and exacerbate its harmful effects on the humanity. In turn, all the hazards in urban systems are magnified again due to high density and huge population.

Hence, ***all the analysis above reflects the significance and necessity of sustainability shift of urban streets.***

3.4 Sustainable Streets

3.4.1 Definition and interpretation

The studies on Sustainable Streets are very few. Table 3. 5 summarises all existing definitions. Greenberg (2009) highlighted the multimodal rights of way designed and operated. Greenberg summarised the sustainability objectives into three: Movement, Ecology and Community. However, sustainability pillars here are interpreted as the three E’s of Environment, Ecology, and Economy, which is not a comprehensive understanding of holistic sustainability. The definition from El-Shimy & Ragheb (2017) is from a design goal perspective, and it underlines the environmental sustainability of urban streets but neglects the economic consideration. Agustin et al. (2014) interpreted from the design perspective and specified that a sustainable street is supposed to achieve several objectives, including supporting transport, minimising environmental impact, enhancing the aesthetic value of street, increasing the economic value of the region. This definition is lengthy but incomplete. Similarly, Bevan, et al. (2007) explained sustainable streets by indicating its five broad goals, but this definition still focuses on environmental sustainability.

Table 3. 5: Comparison of Various Definition of Sustainable Streets

Reference	Definition of Sustainable Streets	Comments
(Greenberg, 2009, p. 2)	Sustainable streets are multimodal rights of way designed and operated to create benefits relating to mobility, ecology, and community that together support a broad sustainability agenda embracing the three E's of environment, ecology, and economy	• *A clear but not comprehensive definition;* • *Built based on an incomprehensive understanding of holistic sustainability.*
(El-Shimy & Ragheb, 2017, p. 690)	The sustainable street is to reduce energy consumption, reduce consumption of material resources, reduce impacts to environmental resources, support healthy urban communities and support sustainability during implementation	• *Defining from the result-oriented perspective;* • *Underlining the environmental sustainability of urban streets, but neglecting the economic aspect.*
(Agustin, et al., 2014, p. 3)	A sustainable street is focused on improving facilities/modes of transport and supporting facilities that are environmentally friendly and humane (pedestrian oriented), energy saving and minimal impact on the environment; its design that maximises the infiltration of rainwater into the ground / minimal inundation (green infrastructure), as well as designs that enhance the aesthetic value of the street in order to increase the economic value of the region and establish the corridor Identity.	• *Defining from the design perspective;* • *Relatively lengthy but incomplete.*
(Bevan, et al., 2007, p. 3)	Sustainable streets should cumulatively align to five broad goals: 1) reduce energy consumption; 2) reduce consumption of material resources; 3) reduce impact to environmental resources; 4) support healthy urban communities, and 5) support sustainability during implementation	• *Defining from the overall goal perspective;* • *Highlighting Environmental Integrity, but neglecting the impact on the local economic development*

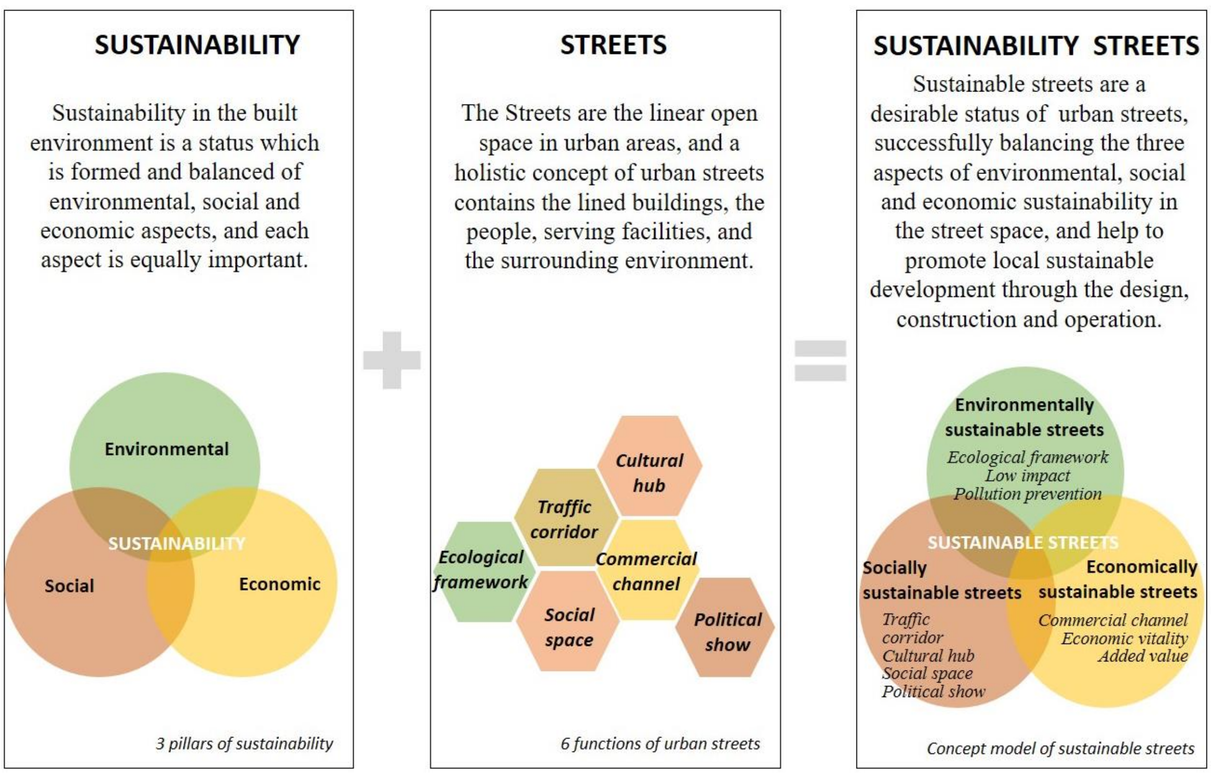
The table was made by the author, and the definition sources were listed in the table.

All the existing definitions are not comprehensive. In order to have a comprehensive understanding of "Sustainable Streets", it is necessary to integrate the meaning of "sustainability" and "street" because as a compound phrase it must contain the core meaning of two words. Figure 3. 4 shows the procedure of how the concepts are developed and combined.

Therefore, sustainable streets can be defined as:

Sustainable streets are a desirable status of urban streets, successfully balancing the three aspects of environmental, social, and economic sustainability in the street space, and help to promote local sustainable development through the design, construction, and operation.

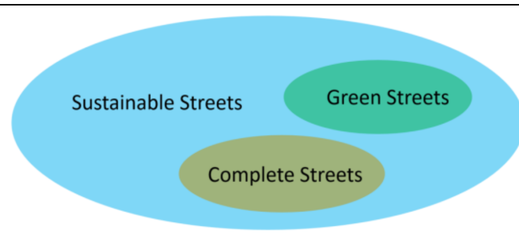
It is worth pointing out that "sustainable streets", "green streets" and "complete streets" are different (Table 3. 6). Green streets emphasise the low environmental impact of the street. Water management within the streets is the key in the design and operation stage, so the main design methods are maximising the use of street trees and rain garden. Complete streets emphasise the equality of street use, so the key is to provide safe access for all users regardless of age, ability, or mode of transportation. Social considerations are the central principle for the design of complete streets. Different from green streets and complete streets, sustainable streets highlight the holistic sustainability of the streets, and the three aspects of environmental integrity, economic vitality, and social welfare are valued equally. Therefore, ***sustainable streets are the most extensive set that contains green streets (environmentally sustainable streets) and complete streets (socially sustainable streets). Design methods of sustainable streets are more diverse and flexible, and evaluation procedure is more integrated and complicated.***



The graph was designed and made by the author.

Figure 3. 4: Procedure of Concept Development of Sustainable Streets

Table 3. 6: Comparison of "Sustainable Streets", "Green Streets", and "Complete Streets"

Concept	Definition	Feature
SUSTAINABLE STREETS	Sustainable streets are a desirable status of urban streets, successfully balancing the three aspects of environmental, social, and economic sustainability in the street space, and help to promote local sustainable development through the design, construction and operation.	• *Emphasising holistic sustainability of streets;* • *Environmental integrity, economic vitality, and social welfare should be considered and valued equally in the streets;* • *Design methods are various and integrated.*
GREEN STREETS	Green Streets are mimic natural conditions by managing runoff on the surface and at its source, and maximises the use of street tree coverage for stormwater interception as well as temperature mitigation and air quality improvement. (Davis, 2006, p. 1)	• *Emphasising low environmental impacts of the street;* • *Water management is the key;* • *Main design methods are to increase street trees and rain gardens;* • *Can be considered as environmentally sustainable streets*
COMPLETE STREETS	Complete Streets are streets for everyone. They are designed & operated to enable safe access for all users. Pedestrians, bicyclists, motorists, & public transportation users of all ages & abilities can safely move along & across a complete street. (SGA, 2014)	• *Emphasising the equality of street use;* • *Design for all users and all kinds of travel ways is the key;* • *Social considerations are the primary design principle;* • *Can be considered as socially sustainable streets*
Concept Hierarchy		

The table and graph were designed and made by the author.

3.4.2 Principles and Design Objectives

Based on the definition and characteristics of sustainable streets, it can be seen that sustainable streets must be in accord with the essential characters and functions of urban streets, and satisfy the three pillars of sustainability. Therefore, the sustainable street should have three fundamental principles, namely social, economic, and environmental sustainability, and its design objectives are the series of requirements formed under these three principles.

Regarding the selection of design objectives, detailed working methods were introduced in Chapter 4.4.1, including the selection of keywords, database, data analysis, and potential limitations. In short, after reading 1182 relevant literatures and studies, 526 eligible articles were systematically annotated and sorted out, thus distilling 15 design objectives under the 3 principles.

Principle One: ENVIRONMENTAL sustainability

Adaptability: Adaptation ability to local climate is a significant design objective of urban streets in sustainable agenda, especially under the background of Climate Change (NYCDoT, 2013a; Badawi, 2017). Firstly, the street design should adapt to the local climate, which can be called Local Climate Adaptation Design. It means the street design is supposed to make full use of local climate resources, to maximise the positive side of climate features, and to avoid the negative impacts of local climate types, thereby creating a healthy and comfortable street environment (Zhang, 2015; Leng, 2017). For instance, the street design of Cairo (Egypt) emphasises the shading and ventilation because of its hot arid climate (Mahgoub, 2015), while the street design of Shanghai (China) highlights the street planting, wind corridor, and waterscape because it is hot and humid in summer and cold and damp in winter (Cao, 2008). Secondly, the street design should adapt to the effect of Climate Change, which can be called Climate Change Adaptation Design. It means the street design that is to use the information about present and future Climate Change to reinforce the vulnerable parts and meet the challenges of the negative impacts of Climate Change (Füssel, 2007; Matthews, 2011). The potential risks from Climate Change in urban areas are flooding, the extreme temperature in summer/winter, and air quality (BCC, 2012). Hence, Climate Change adaptation design of urban streets is supposed to design based on the future potential risks of Climate Change rather than past empirical value, and design with the extreme weather conditions.

Mitigation UHI: Environmentally sustainable design of urban streets should contribute to the mitigation of Urban Heat Island effect (ADUPC, 2010; NYCDoT, 2013a; Badawi, 2017). UHI (Urban heat island) is a main negative effect of Climate Change due to the human modifications of the surface and atmospheric properties which accompany urban development (Oke, 2013). "*The urban streets vary in geometry as defined by height/width ratio, sky view factor (SVF) and the orientation that is defined by its long axis. This directly influences the absorption and emission of incoming solar and outgoing long wave radiation which has a significant impact on the temperature variations within the street as well as the surrounding environment (Urban Heat Island)*" (Bourbia & Boucheriba, 2010, p. 343). Hence, it can be said that urban streets play an important role in mitigating UHI since many UHI technologies and design strategies are related to the streets. The specific solutions include to reduce the carbon emissions of vehicles, to promote urban natural ventilation through the network of street corridors, to increase the street greening, and to use cool pavements and street canyon (Bourbia & Boucheriba, 2010; Gaffin, et al., 2008; Santamouris, 2013; Takebayashi & Moriyama, 2012).

Pollution reduction: An environmentally sustainable street should also contribute to reducing the pollution of air, noise, lighting, and waste (Greenberg, 2009; ADUPC, 2010; Rehan, 2013). The contribution of pollution reduction can be measured from two perspectives: one is from the daily aspect, and the other one is from a lifecycle perspective. Regarding the daily point of view, a sustainable street can improve air quality, water quality, and waste management, reduce greenhouse gas emissions, light pollution, and noise pollution every day (Rehan, 2013; Greenberg, 2009). Relevant studies show that transport sector currently responsible for about 13% of Greenhouse emissions worldwide and 23% of the total energy-related emissions (Black, 2010), so sustainable design of urban streets cannot only encourage green transportation types like walking , cycling and public transportation, but also minimise the pollution of noise, air, water, and waste (SPLRAB/SMTC/SUPDRI, 2016; NYCDoT, 2015). Meanwhile, all the street components, including lighting system, street furniture, pavement, should be designed and considered from a lifecycle perspective concerning pollution reduction (Hartley, et al., 2009; Ramirez, 2007; Aziz, et al., 2012). All of the energy consumption and pollution release should be considered together from the whole lifecycle procedure, namely raw materials, manufacturing, use and disposal/recycling, thereby realising a genuinely green street, which should also be considered during street design.

Ecological balance: Another objective of a sustainable street from the environmental perspective is to minimise environmental impact and support urban ecology. Urban streets also act as the ecological framework in the urban system (demonstrated in Chapter 3.2.2.6). The streets and their network respects protect and enhance the local ecosystem (CNU, 2012). Hence the overall master plan and detailed design of urban streets can effectively support local ecological balance (Liu & Yang, 2014; Bolund & Hunhammar, 1999). The greenways are often considered as critical ecological networks (Zube, 1995; Searns, 1995), and the concept of greenways can also be integrated into street design. The greenways in America employ many landscape ecological features, such as corridors, patches, matrix, and connectivity, landscape architecture principles, inducing design structure, species composition, pedestrian, and bicycle circulation, as well as conservation biology theory (Ignatieva, et al., 2011). Moreover, many green technologies, such as ecological rainwater management, vertical greening, diverse landscape, and green infrastructure, can be integrated into urban street design so as to promoyhrte the diversity of local plants and animals as well as promote the air circulation and rainwater infiltration within street space (Li, 2009; Wang, 2016) .

Green life promotion: As an environmentally sustainable street, it should encourage and lead a green lifestyle. Firstly, the street design should clarify the people rather than cars have the priority of urban streets (SPLRAB/SMTC/SUPDRI, 2016). The street design should provide convenience and efficiency to walkers, cyclists, and public transportation users. Furthermore, the street design should also encourage more outdoor activities, like street jogging, and pavement cafe, by providing a pleasant and comfortable street environment (Guangjun & Zhu, 2015; Qiao, 2009). As important social space, urban streets should take responsibility for the publicity of green life and appeal the public to go green. Various ways, such as digital advertisement boards, print ads, or road shows, can be employed to illustrate the effects and causes of Climate Change as well as the way to supports green life (NBS, 2016). The streets should take the full advantage to demonstrate green technologies and educate the public. For instance, there are recycling bins on every street corner to teach people how to classify garbage in Tokyo, regular street festivals are held in Chicago on how to be green, and some streetlights powered by solar PV in Shanghai are for the potential of renewable energy.

Principle Two: SOCIAL sustainability

Equality: One of the most crucial design objectives of socially sustainable streets is to provide the street accessibility and convenience for all kinds of people, including children, the senior citizens, mothers with the stroller, blind people, and people in wheelchairs, thereby supporting social equality, which has been pointed out by many scholars and policies (El-Shimy & Ragheb, 2017; Rehan, 2013). The street design should ensure the convenient usage of the people of different ages. They should have equal accessibility to each urban street and facilities or shops along the streets. Furthermore, the streetscape is often destroyed by the fence walls, and the public space is blocked, which consequently affect the equality of streetscape (Zhao & Tang, 2007; Hong, 2007). This phenomenon is particularly prominent in China, and increasing scholars propose the demolition and transparency of the fence walls along the streets to reduce the space barrier and improve the continuity and openness of the street landscape, thus further guaranteeing the equality and harmony of public space (Chen, 2017; Xie, et al., 2017).

Safety: Safety is a critical issue to urban streets (Badawi, 2017; Rehan, 2013). Safety in the streets refers to enable all vehicles, cyclists, and pedestrians to go their way efficiently and harmoniously to ensure the personal safety of all traffic participants and orderly manner of all traffic activities. Shanghai Street Design Guide (SPLRAB/SMTC/SUPDRI, 2016) points out the requirement of a safe street includes orderly traffic, non-motorized priority, roads for pedestrians, safe intersections, and reliable facilitates. Abu Dhabi Urban Street Design Manual (ADUPC, 2010) indicates street safety is to provide safety for all users at all times of the day, and with a particular emphasis on children, older adults, and people with impaired mobility. A safe urban street not only leads to orderly traffic but also help to reduce crimes (TfL, 2009). There are many measures to form a safe street, like improving safety–oriented signal and signs, creating a street network that supports communities and places, making bicycling safer and more convenient, and providing an effective street lighting system and CCTV system (El-Shimy & Ragheb, 2017; TfL, 2009).

Accessibility: Accessibility is another necessary and significant criterion for sustainable streets (Matthews & Turnbull, 2007). The meaning of accessibility might vary in different studies (Zeng, et al., 2011). The accessibility of this research refers to the degree to which a place can be reached. In other words, street accessibility is to provide various ways of arrival for all kinds of people. There are various ways to promote street accessibility, including providing comfortable sidewalks with barrier-free facilities, reliable cycling lanes, convenient bus stations and taxi ranks, orderly motor lane and parking areas, and special cars accessibility (ambulance, firefighting truck), thereby ensuring the possibility of various groups of people arriving in different situations. Furthermore, clear signs and the guidance system are necessary for street accessibility, especially in a tourism city (Li & Qi, 2016). For example, New York City provides WalkNYC Way-finding system to help visitors and residents alike navigate the city's streets (NYCDoT, 2015). This kind of guide system not only assist people to find their way but also promote public transportation. Therefore, street accessibility is pointed out not only to be a crucial indicator of sustainable streets, but also an influencing factor of regional vitality and local development (Ye & Zhuang, 2017; Gou & Wang, 2011; Getz, 1993).

Diversity: As an essential part of the urban areas, the streets play various functions. Therefore, the diversity of streets' functions and activities are another criterion for a socially sustainable street (Badawi, 2017; Greenberg, 2009). The diversity of urban streets refers to the diversity degree of the streets' functions, the variety of streets' activities, and the flexibility of streets' space. For example, various street furniture encourages diverse activities of different people. Because youngsters often prefer stairs for seating and chatting, old people prefer seats, and kids prefer statues (Monfared, et al., 2015; Gehl, 2002). One of the main features of cities is the diversity, so urban streets, as critical social space for the public, should promote and highlight the social diversity. The provision of various facilities and flexible space will encourage diverse activities to happen, and in turn, further, activate potential street functions and promote local vitality as well (Quigley, 1998; Zou, 2006).

Culture Inheritance: Urban streets, as a culture window of a city, reflect urban historical morphology, contemporary landscape, and mass culture. Hence an excellent urban street is supposed to inherit the characteristics of historical cultures or specific contemporary features, and then display them to the public. Nowadays, many metropolitans are similar, and this is particularly true in China (Yao, 2006). The critical issue is all the streets are designed for cars and streetscape to look nearly the same (Zou, 2006; Yao, 2006). Therefore, the culture demonstration through urban street cannot only enrich streetscape but also improve local identification to shape a rich and interesting city image. In "Abu Dhabi Urban Street Design Manual", one of the primary design criteria is to "*define the image of Abu Dhabi as a gracious, Arab, and world-class Emirate through attention to details and imageability, from its quiet residential streets to its grand ceremonial boulevards*" (ADUPC, 2010, p. 5). The culture is not necessarily to be historical, and it can also be local contemporary culture. The street design or renovation should be in accord with the historical characteristics and the cultural identity, thereby preserving, inheriting, and even shaping local culture.

Principle Three: ECONOMIC sustainability

Intensive land utilisation: Land is always the most valuable resources in urban area, so intensive land utilisation is considered as a critical criterion of economic sustainability to urban streets (ADUPC, 2010; SPLRAB/SMTC/SUPDRI, 2016). The space of urban streets should be intensively and mixed. Firstly, land waste often occurs in the process of street design and construction, such as too wide lanes, too much on-street parking, or political landscape avenue. Some scholars also point out that the land wastage and too wide road result in insufficient construction land and the increase of development cost, which ultimately cause considerable economic lost and unsustainable economic growth from a long-term perspective (Zhao, 2002). Secondly, the street design should fully consider the function of the sided buildings and street capacity, and then increase the flexible space to encourage mixed use. The streets traffic often show a tidal phenomenon, hence sharing streets and changeable lanes can maximally save the land resource without the influence of traffic volume. Meanwhile, community streets are encouraged to set commercial, cultural, and other temporary facilities along the streets, which not only contributes to the realisation of the intensive land utilisation but also promote a liveable street and a sustainable development of local economies (NYCDoT, 2013b).

Efficiency: Another vital design criterion for urban streets is Efficient Mobility because the fundamental function of the streets is to provide transportation services for people and products (Greenberg, 2009; Badawi, 2017). It is essential to ensure the efficiency of circulation and mobility through the streets, whether it is walking, bicycle or automobile. Efficiency is the core value judgment of economics, and economists categorise efficiency into two categories within the economic system: Productive Efficiency（means society turns its resources into the goods in a manner within minimum costs）and Allocative Efficiency (means that the produced output is distributed in a way to meet the maximum wants of the people) (Mukherjee, 2002). Hence from a micro point of view, the layout of the urban streets and the traffic efficiency have a significant impact on both the production process and the distribution process of the economic system. That is why street network density and road capacity are often regarded as important indicators of economic development for a city or region. On the contrary, a blocked street must have adverse effects on the economic value of the whole place. There are three crucial points for a comprehensive understanding of the efficiency of sustainable streets. Firstly, the efficiency is for all the efficiency of the public, which means the concept of efficiency is to build on the values of the masses to ensure efficient public transportation rather than private traffic. So, the bus-only lanes and fast transportation priority lanes are proposed for efficiency. Secondly, the question of efficiency and fairness is an eternal topic of economics and sociology. In terms of efficiency, driving car is faster than cycling and walking, however urban streets is not only designed for efficient mobility but also to ensure the right for all transportation tools and all the people, which is why many street design guidelines set the order of Right of Way of urban streets as walking, cycling, public transit, shared vehicles, and private vehicles (Proulx, et al., 2015). Thirdly, efficiency is one of the economic design criteria for sustainable streets, but not the only standard. Some scholars proposed that slowing down the street and improving the streetscape will help raise the value of the property along the street and promote local economy (NHF, 2011; Sinnett, et al., 2011; Davis, 2010).

Business creation: A vibrant street can create considerable commercial value, so the types and the number of retailers along the streets are often regarded as important indicators to measure economic vitality and sustainable development of one street (NYCDoT, 2013b). All businesses rely on attracting customers, so the urban streets possess the most valuable business opportunities, the considerable stream of people (TfL, 2003). Consequently, the creation of stores and business along the streets can take the full advantage of its nature not only to provide convenience to the public but also to promote local economic vitality. Many relevant studies show that the density of the stores along the street is closely related to the local economic vitality. The ground floor of commercial streets should be continuous and various small and medium-sized stores, and the desired density of sided stores is e seven stores/shops per hundred meters according to studies (Jin, 2017; Chen & Zhao, 2014). In addition to the businesses in these street stores, some temporary businesses within the street space are also significant to local vitality, such as pavement coffee, mobile newsstands, temporary flower shops and weekend markets. Both the businesses of street stores and temporary business are essential factors for the measurement of street vitality from the economic perspective.

Job creation: Except for business, a vibrant street can expand local employment opportunities (TfL, 2003). If there are stores on both sides of the street and the number and types of stores are diverse, then the street can also bring considerable employment opportunities. Besides, high-quality public space can stimulate various temporary services spots, thus creating more job opportunities, such as street art, flow-selling flowers, and street food. Also, these not only solve the problem of employment from the social perspective but more importantly promote the virtuous circle of the economy (NYCDoT, 2013b). In China, an essential part of the protection and renovation of traditional streets is to preserve those traditional street craftsmen, such as sugar blowing people, hand cane weaving and clay figurines (Gong, 2015; Jiang, 2013). The protection and creation such kind of jobs can help those traditional craftsmen to have jobs and pass down the intangible cultural heritage, and more importantly, it is to develop based on local characteristics and promote long-term economic vitality and sustainable development.

Added-value: In addition to direct economic benefits, a pleasant street brings noticeable added value to the local economy, for example, enhancement of the value of the asset nearby, an increase of Retail sales; and the promotion of visitor spending. NYCDoT Report shows a high-quality street can "*impact businesses' and property owners' bottom lines, most directly by affecting retail sales but also by affecting, among other things, retail rents, office rents, and commercial property values*" (NYCDoT, 2013b, p. 8). Moreover, an interesting street often becomes a travel destination for tourists, even if it is not a commercial street. Attractive and high-quality streets not only attract people to come but also encourage people to stay, which makes the opportunity for business as well as the value for commercial activities, such as the value of advertising and nearby property appreciation. It is important to notice that the added-values of urban streets are difficult to be measured through one or several data because the price of housing and commercial rent are influenced by various factors, like the location, natural resources, and social background. However, based on many scholars' studies and findings, one thing is sure: a right street can indeed bring added-values to the surrounding environment (Shen & Karimi, 2017; Essential Economics Pty Ltd, 2011).

In summary, ***a total of fifteen design objectives were defined according to three primary principles of sustainable streets*** (Table 3. 7). It is worth noting that although every design objective has been categorised into one principle here, the three pillars of sustainability are inseparable, mutual promotion and mutual restriction as what is shown in the sustainability model. Therefore, it is necessary to balance these objectives and reach holistic sustainability through design. For example, the efficiency is one design objective regarding the economic sustainability of urban streets. However, as what was discussed above, efficiency is not only an economic issue but also involves social issues like equality. Moreover, the excessive pursuit of traffic efficiency will also inevitably cause a series of environmental problems. Therefore, ***the fifteen listed design objectives need to be considered equally, comprehensively, and dialectically***, which are to be reflected in the evaluation process of the sustainable street in Chapter 3.4.4.

Table 3. 7: Design Objectives of Sustainable Streets

Principles	Design Objectives		Definition
Environmental Sustainability	1	Adaptability	*Adaptation ability to local climate and Climate Change.*
	2	Mitigation UHI	*Contribution to the mitigation of Urban Heat Island effects.*
	3	Pollution Reduction	*Contribution to reducing pollution of air, noise, lighting, and waste.*
	4	Ecological Balance	*Minimising impact on the environment and support the ecological systems in the built environment.*
	5	Green Life Promotion	*Promotion and publicity of green lifestyle.*
Social Sustainability	6	Equality	*Providing convenient arrival for all kinds of people to support social equality.*
	7	Safety	*Providing safe and reliable streets to all users at all times of the day.*
	8	Accessibility	*Providing high accessibility for various ways of arrival.*
	9	Diversity	*Encouraging the diversity of street functions and the variety of street activities*
	10	Culture Inheritance	*Being in accord with the historical characteristics and cultural identity, thereby preserving, inheriting, and even shaping local culture.*
Environmental Sustainability	11	Intensive Land Utilisation	*Intensive land utilisation and promote mixed and sharing usage within the streets.*
	12	Efficiency	*Promoting the efficient mobility for all street users.*
	13	Business Creation	*Creating various opportunities for street businesses.*
	14	Job Creation	*Creating various and considerable employment opportunities along the streets.*
	15	Added-Value	*Increasing the values and attractions of land, real estate, and businesses along the streets.*

The table was designed and made by the author

3.4.3 General Design Toolkit

The Design Toolkit of Sustainable Streets is a range of best practices and creative design solutions regarding delivery of sustainable streets. A practical design toolkit must well suit local context. Hence the primary purpose of this section was to sort out a general design toolkit based on a broad review of existing design manuals and relevant documents. In order to provide a comprehensive summary, five well-known street design guidelines worldwide were studied (Table 3. 8).

Table 3. 8: A List of Studied Documents of Street Design

No.	Name	Object	Issue Year	Reference
1	Streetscape Guidance 2009: a guide to better London streets	London, UK	2009	(TfL, 2009)
2	Abu Dhabi Urban Street Design Manuel	Abu Dhabi, The United Arab Emirates	2010	(ADUPC, 2010)
3	Complete Streets Guidelines	Edmonton, Canada	2013	(CoE, 2013)
4	Street Design Manual	New York City, USA	2015	(NYCDoT, 2015)
5	Shanghai Street Design Guide	Shanghai, China	2016	(SPLRAB/SMTC/SUPDRI, 2016)

The reasons to choose these five documents could be summarised into three points:

1) ***Contents & Influence****:* These five design guidelines are all for the famous international metropolis, and have a profound influence in the field of transport policy from the perspective of document structure to guideline content, which is worth learning.
2) ***Location & Time:*** The five cases are across Asia, Europe, and the Americas. The Street Guidance of London, as the world's first street design guidelines, was released in 2009, and after that many cities started to compose their street design manuals. "Shanghai Street Design Guide", as the first manual for street design in China, was implemented in 2016. Therefore, the five guidelines can reflect the regional difference in the degree of cultural background and development process from both geographical and time span point of view, thereby helping to summarise the common contents and design methods.
3) ***Sustainable Methods****:* All these five manuals put the urban street design in the context of Climate Change, and then provide a series of design methods for sustainable streets. So, they are reasonably helpful for the summary of a general Design Toolkit for Sustainable Streets.

Table 3. 9 shows the Design Toolkit of Sustainable Streets. The table was established based the structure of design elements of urban streets (presented in Table 3. 4). The eligible design requirements and sustainable methods of the five design guidelines listed in Table 3.8 were summarised accordingly into the table.

Table 3. 9: A General Design Toolkit of Sustainable Streets

Design elements				Design Requirement	Available Sustainable Methods	References
Types		**Items**				
Code	***Name***	**Code**	**Name**			
F	*Functional facilities of traffic*	F1	Bus lane	To provide a priority for public transportation	• *To design a bus-only lane or give bus priority during peak time.*	(TfL, 2009) (NYCDoT, 2015) (SPLRAB/SMTC/SUPDRI, 2016)
		F2	Travel lane	To form a safe, efficient, and smooth space for vehicles	• *One-way street*	(NYCDoT, 2015) (TfL, 2009) (SPLRAB/SMTC/SUPDRI, 2016)
					• *Control the width of motor lanes, decrease the lane width to 3-3.25m while the design car speed is within 30km/h*	(CoE, 2013) (NYCDoT, 2015) (SPLRAB/SMTC/SUPDRI, 2016)
					• *Sharing space of motorway and bikeway in community streets (intensive utilisation and speed control)*	*(TfL, 2009)* (ADUPC, 2010) (CoE, 2013) (NYCDoT, 2015) (SPLRAB/SMTC/SUPDRI, 2016)
					• *Horizontal or vertical deviation to control cars' speed*	(CoE, 2013) (NYCDoT, 2015) (SPLRAB/SMTC/SUPDRI, 2016)
					• *To design different street sections for varied speed requirement based on the surrounding situation.*	(TfL, 2009) (ADUPC, 2010) (CoE, 2013) (NYCDoT, 2015) (SPLRAB/SMTC/SUPDRI, 2016)
					• *To create school speed zones thereby control vehicles' speed.*	(NYCDoT, 2015) (SPLRAB/SMTC/SUPDRI, 2016)
		F3	Cycling lane	To provide a safe and comfortable space for bicycles, battery bicycles, and other non-motor vehicles.	• *Buffered bike lanes*	(CoE, 2013) (NYCDoT, 2015) (SPLRAB/SMTC/SUPDRI, 2016)
					• *To provide a parallel cycling lane for cyclists and other non-motor vehicles for main streets*	(CoE, 2013) (NYCDoT, 2015) (SPLRAB/SMTC/SUPDRI, 2016)
					• *To provide at least 1.5 meter's width for bike lanes (Wider lanes for cycling are desirable to encourage green transportation)*	(CoE, 2013) (NYCDoT, 2015) (SPLRAB/SMTC/SUPDRI, 2016) (ADUPC, 2010)
					• *To consider the environmental quality so as to attract new users.*	(TfL, 2009) (ADUPC, 2010) (CoE, 2013) (NYCDoT, 2015) (SPLRAB/SMTC/SUPDRI, 2016)

Design elements				Design requirement	Available sustainable methods	References
Types		**Items**				
Code	***Name***	**Code**	**Name**			
F	*Functional facilities of traffic*	F4	Medians	To serve various functions, including refuge space for pedestrians, the definition of vehicles turning and tramways, and the space for trees and landscaping.	• *To serve as the safety island*	(NYCDoT, 2015) (CoE, 2013) (SPLRAB/SMTC/SUPDRI, 2016) (ADUPC, 2010)
					• *To raise the medians or to set barriers to reduce the risk of left-turn and vehicle head-on collisions*	(NYCDoT, 2015) (CoE, 2013) (SPLRAB/SMTC/SUPDRI, 2016) (ADUPC, 2010)
					• *To beautify with trees and/or vegetation, or integrated with the river system, and potentially including stormwater source controls*	(ADUPC, 2010) (NYCDoT, 2015) (SPLRAB/SMTC/SUPDRI, 2016)
		F5	Parking Strip	To provide on-street parking space for motor vehicles.	• *Space-sharing and provide an opportunity to serve other uses.*	(CoE, 2013; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)
					• *Provide parking or loading bays if necessary.*	(CoE, 2013; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)
					• *Not to affect the sightlines and safety of people crossing, travelling along and stop at the parking space.*	(CoE, 2013; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)
		F6	Sidewalk	To create a safe, comfortable and pleasant walking space in the street.	• *To form a complete space between the sided buildings and the sidewalks*	(CoE, 2013; ADUPC, 2010; NYCDoT, 2015; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)
					• *To provide pleasant sidewalks with reasonable width.*	(CoE, 2013; ADUPC, 2010; NYCDoT, 2015; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)
					• *Accessible for all kinds of people, including parents with strollers, people in wheelchairs, tourists with suitcases, seniors with limited mobility and the visually impaired people.*	(CoE, 2013; ADUPC, 2010; NYCDoT, 2015; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)

Design elements				Design requirement	Available sustainable methods	References
Types		**Items**				
Code	***Name***	**Code**	**Name**			
F	*Functional facilities of traffic*	F6	Sidewalk	To create a safe, comfortable and pleasant walking space in the street	• *To gather all streetscape amenities orderly and not to interfere the pedestrians*	(CoE, 2013; ADUPC, 2010; NYCDoT, 2015; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)
					• *To provide Skyway or underground passages for pedestrians at intersections.*	(SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010)
					• *To extend the curb and decrease the turning radius of curbs at intersections to reduce crossing distance for pedestrian and car's speed*	(CoE, 2013; ADUPC, 2010; NYCDoT, 2015; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)
					• *To raise crosswalk at intersections for more comfortable crossing experience.*	(SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010; NYCDoT, 2015)
					• *To locate zebra lines for pedestrians to control pedestrian crossings.*	(SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010; TfL, 2009)
A	*Auxiliary facilities*	A1	Pavement	To provide safe, comfortable, artistic and environmental-friendly pavements in the street.	• *Highlighted colourful/marks pavement to remind of safety for intersections, cycling lanes pedestrian passing and school entrances.*	(CoE, 2013; ADUPC, 2010; NYCDoT, 2015; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)
					• *Special pavement to decrease the speed of vehicles and pedestrians.*	(SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010; NYCDoT, 2015; TfL, 2009)
					• *Anti-skidding pavement for safety.*	(SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010; NYCDoT, 2015; TfL, 2009)
					• *Environmental-friendly or recycled materials and construction technologies to decrease the noise, absorb air pollution and ease UHI;*	(SPLRAB/SMTC/SUPDRI, 2016; NYCDoT, 2015)

Design elements				Design requirement	Available sustainable methods	References
Types		**Items**				
Code	***Name***	**Code**	**Name**			
A	*Auxiliary facilities*	A1	Pavement	To provide safe, comfortable, artistic and environmental-friendly pavements in the street.	• *The artistic design of pavements to suit local culture.*	(SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010; NYCDoT, 2015; TfL, 2009)
		A2	Curb	To reasonably separate between different spaces and ensure safe and convenient traffic flow.	• *To be consistent and follow smooth and flowing lines to provide a strong definition between footway and carriageway*	(SPLRAB/SMTC/SUPDRI, 2016; NYCDoT, 2015)
					• *Recycled and low-impact materials*	(CoE, 2013; ADUPC, 2010; NYCDoT, 2015; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)
		A3	Barrier-free facilities	To provide convenience and accessibility to the disadvantaged groups	• *To provide special pavements & wayfinding system for blind people*	(SPLRAB/SMTC/SUPDRI, 2016)
					• *To provide the slope or other mechanic facilities for wheelchairs when steps appear.*	(CoE, 2013; ADUPC, 2010; NYCDoT, 2015; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)
		A4	Signal and signs	To foster an efficient, well-guided and safe street.	• *To optimise the signal system at intersections with suitable signal phase and timing setting.*	(SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010; NYCDoT, 2015)
					• *Featured and highlighted marks on the ground to remind of safety and protect cyclists and pedestrians.*	(CoE, 2013; ADUPC, 2010; NYCDoT, 2015; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)
					• *To provide clear signs of identification, direction, information, and regulation.*	(SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010; NYCDoT, 2015; TfL, 2009)
		A5	Pavement shops	To promote a vibrant and dynamic street life.	• *To use the frontage space or extended curb for pavement cafe and products display.*	(SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010; TfL, 2009)
					• *Not to influence the pedestrian to walk.*	(SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010; TfL, 2009)

Design elements				Design requirement	Available sustainable methods	References
Types		**Items**				
Code	***Name***	**Code**	**Name**			
A	*Auxiliary facilities*	A6	Lighting	To provide a safe, comfortable, and energy-efficient street lighting system.	• *Sufficient lighting in the night for street safety*	(SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010; NYCDoT, 2015; TfL, 2009)
					• *To select durable and recyclable materials.*	(SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010; NYCDoT, 2015; TfL, 2009)
					• *To use renewable energy or energy-efficient lighting system.*	(ADUPC, 2010; NYCDoT, 2015; TfL, 2009)
		A7	Information facilities	To provide boards or Wayfinding system with clear, convenient and user-friendly guides.	• *To provide information spot or Wayfinding system and offer information on on-time traffic and public transportation along the streets.*	(CoE, 2013; ADUPC, 2010; NYCDoT, 2015; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)
		A8	Cycling parking space	To provide convenient and user-oriented facilities for bicycle parking.	• *To design the sharing space;*	(ADUPC, 2010; NYCDoT, 2015; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)
					• *To provide bicycle parking in shaded, well-lit and secure locations*	(ADUPC, 2010; NYCDoT, 2015)
		A9	Sharing Bike Station	To provide available public bikes rental spot and relevant service.	• *To form a network of sharing bikes.*	(SPLRAB/SMTC/SUPDRI, 2016; NYCDoT, 2015)
		A10	Bus station	To provide easily-accessible bus station and pleasant shelter for waiting.	• *To design for safe getting up/down buses and minimise the conflict among vehicles, cycling, and pedestrians.*	(CoE, 2013; ADUPC, 2010; NYCDoT, 2015; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)
					• *To provide shelters, including shading and seats (at least provide lighting, roof, and information facilities if the land use is limited)*	(CoE, 2013; ADUPC, 2010; NYCDoT, 2015; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)

Design elements				Design requirement	Available sustainable methods	References
Types		Items				
Code	***Name***	**Code**	**Name**			
A	*Auxiliary facilities*	A11	Taxi Ranks	To provide convenient and well-organised space for taxi waiting.	• *With a clear sign and not to influence traffic flow and efficiency;*	(SPLRAB/SMTC/SUPDRI, 2016; TfL, 2009)
					• *To be close to main transfer hubs and major tourist attractions;*	(CoE, 2013; ADUPC, 2010; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)
		A12	Street trees	To foster a comfortable and climate-adaptable environment and pleasant ambience street space.	• *To increase the street trees for shading, dust filtration and noise reduction;*	(CoE, 2013; ADUPC, 2010; NYCDoT, 2015; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)
					• *To choose local species which suit the local climate and consider long-term maintenance;*	(CoE, 2013; ADUPC, 2010; NYCDoT, 2015; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)
					• *Flowering trees and coloured foliage plants are preferred to enrich landscape layers, colour diversity and street identity*	(CoE, 2013; SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010; NYCDoT, 2015)
		A13	Planting	To provide a diverse and pleasant planting landscape of the street and support local environmental sustainability.	• *To provide diverse kinds of plants to show local features.*	(CoE, 2013; ADUPC, 2010; NYCDoT, 2015; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)
					• *To use local plants*	(CoE, 2013; SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010; NYCDoT, 2015)
					• *To design rain garden for stormwater management*	(SPLRAB/SMTC/SUPDRI, 2016; NYCDoT, 2015)

Design elements				Design requirement	Available sustainable methods	References
Types		**Items**				
Code	***Name***	**Code**	**Name**			
A	*Auxiliary facilities*	A14	Other facilities	To provide a robust and reliable street service and display local culture features. (Other facilities include including seats, bollards, pedestrian guardrails, bins, public art, telephone boxes, parking control equipment, post and pouch boxes, smoke vents, newsstands, vendors, speed hump, and chicanes.)	• *Time/space-sharing*	(SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010; NYCDoT, 2015; TfL, 2009)
					• *Durable and recyclable;*	(SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010; NYCDoT, 2015; TfL, 2009)
					• *Multi-functional facilities;*	(SPLRAB/SMTC/SUPDRI, 2016; NYCDoT, 2015)
					• *Artistic design*	(SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010; NYCDoT, 2015; TfL, 2009)
W	Walk and activity space	W1	Furnishing zone	To orderly arrange various street facilities and provide convenient service	• *To show local identity, historical features or culture characteristics by artistic design;*	(SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010; NYCDoT, 2015; TfL, 2009)
					• *To combine bus station, garbage bins, bookstores, and information station, smart and integrated facilities to intensive use the street land;*	(CoE, 2013; ADUPC, 2010; NYCDoT, 2015; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)
					• *To provide safety monitoring facilities and fixed emergency alarm facilities;*	(SPLRAB/SMTC/SUPDRI, 2016; NYCDoT, 2015; TfL, 2009)
		W2	Through zone	To provide a safe and clear path for all kinds of pedestrian	• *The width of through zone should be designed according to pedestrian volumes.*	(CoE, 2013; SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010; NYCDoT, 2015)
					• *Public seats and resting nodes should be set up along non-traffic-oriented streets;*	(CoE, 2013; ADUPC, 2010; NYCDoT, 2015; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)

Design elements				Design requirement	Available sustainable methods	References
Types		**Items**				
Code	***Name***	**Code**	**Name**			
W	Walk and activity space	W3	Frontage zone	To form an integrated and multi-functional space to combine and optimise the function between street and buildings thoroughly.	• *To support and enhance the functions of the sided building;*	(CoE, 2013; ADUPC, 2010; NYCDoT, 2015; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)
					• *To open, transparentize or green the fence or wall to provide a vibrant block.*	(CoE, 2013; SPLRAB/SMTC/SUPDRI, 2016)
		W4	Plaza /green space	To provide pleasant and attractive plaza or green space to promote diversity of street.	• *To reserve the flexible space for the plaza or green space.*	(SPLRAB/SMTC/SUPDRI, 2016; NYCDoT, 2015; CoE, 2013)
					• *To balance of plaza and green space based on the demand for social activities and climate adaptability.*	(SPLRAB/SMTC/SUPDRI, 2016; NYCDoT, 2015)
S	Street Facade	S1	Entrance/ Exits	To provide the safe and convenient entrances/exits of buildings along the streets.	• *To ensure right-of-way of pedestrians before motor vehicles.*	(SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010)
					• *To change driveway's grade rather than pedestrian's and limit vehicle's speed;*	(SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010)
		S2	Advertising Boards	To activate the add-value of street space with aesthetic design.	• *Not to affect sight of pedestrian, cyclists, and drivers;*	(SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010)
					• *To coordinate with the building facade and streetscape;*	(SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010)
		S3	Shading /Canopy	To contribute a climate-adaptable street environment and promote street activities.	• *To provide desirable shading and keep off the rain for pedestrians and non-motorized vehicles according to the local climate.*	(SPLRAB/SMTC/SUPDRI, 2016; ADUPC, 2010)
		S4	Building Bottoms & facade	To improve street visual quality and diversity.	• *To form a coherent style with streetscape and local character.*	(CoE, 2013; ADUPC, 2010; NYCDoT, 2015; TfL, 2009; SPLRAB/SMTC/SUPDRI, 2016)

Note: the table was designed and made by the author.

3.4.4 Evaluation Structure

Chapter 2.3.2 has studied the Sustainability Assessment, including its existing framework, methodologies, and construction procedure. Therefore, the evaluation framework for Sustainable Streets built the system based on the developed framework of sustainability assessment according to the eight steps of the construction procedure.

It is important to point out that Chapter 3 studied a general evaluation structure of sustainable streets by the method of literature review, so it was to complete the 1st, 2nd, 3rd, and 4.1th steps of the system construction. Based on the research stage and different research methods, the 4th step was broken down into two small steps, namely 4.1 and 4.2. Explicitly speaking, Step 4.1 was to build the pool of potential indicators and mainly relied on the literature review, while Step 4.2 was to select a set of practical indicators based on the research context via filed study and questionnaire survey. So, from Step 4.2 to Step 8 will be elaborated in Chapter 7.

Table 3. 10 illustrates the comparison between the theoretical procedure of system construction and practices of this research.

Hence, the following parts are to introduce the 1st, 2nd, 3rd, and 4.1th steps of the system construction, thereby presenting a general evaluation structure of sustainable streets.

Table 3. 10: Comparision between Theoretical Procedure of System Construction and Practices of this Research

8 Steps to Build Sustainability Assessment Framework in Theory			**The Practice of This Research: Sustainability evaluation of urban streets**	
Step	**Objectives**		**Research Stage and Main Methods**	**Presented in this thesis**
1	*To decide the assessment purposes*		To build a general evaluation structure by Literature Review	Chapter 3.4.4
2	*To determine the structure of assessment framework*			Chapter 2.3.2.4 Table 2. 12
3	*To define a set of criteria*			Chapter 3.4.2 Table 3. 7
4	*To select the indicators*	***4.1*** *To build the pool of potential indicators*		Chapter 3.4.4 Table 3. 12
		4.2 *To select a set of practical indicators*	To build the indicator system of sustainability evaluation for Shanghai streets by Field survey and questionnaires.	Chapter 7
5	*To assess the data quality*			
6	*To design normalisation methods & weighting system*			
7	*To choose the aggregation models*			
8	*To analyse the robustness of the established system*			

Note: the table was designed and made by the author.

STEP 1: to define the assessment purposes

The primary purposes of sustainability evaluation in this research were:

- To better understand and implement the theoretical framework of Sustainable Streets;
- To explore and construct the Indicator System of Sustainability Evaluation for Shanghai streets;
- To push the development of theory and practices of sustainable streets.

STEP 2: to determine the structure of the assessment framework

Table 2. 12 proposes a preliminary framework of sustainability assessment. Therefore, the assessment framework for Sustainable Streets was built based on this structure.

STEP 3: To define a set of criteria

The three assessment aspects of the evaluation framework for sustainable streets, namely environment, society, and economy, are corresponding to the three design principles of sustainable streets. Also, the sustainable evaluation criteria employed the fifteen design objectives for sustainable streets. Hence, Table 3. 11 shows the evaluation framework of sustainable streets with 15 criteria.

Table 3. 11: Evaluation Framework of Sustainable Streets with Criteria

Target Layer	Sub-Target Layer	Criteria Layer			Indicators Layer			
		Code	Title	Definition	Code	Title	Mode	Initial Diagnosis
SUSTAINABILITY	Environmental Sustainability	*C1*	Adaptability	*Adaptation ability to local climate and Climate Change.*	*C1a*	-	-	-
					C1b	-	-	-
		C2	*Mitigation UHI*	*Contribution to the mitigation of Urban Heat Island effects.*	*C2a*	-	-	-
					C2b	-	-	-
		C3	Pollution Reduction	*Contribution to reducing pollution of air, noise, lighting, and waste*	*C3a*	-	-	-
					C3b	-	-	-
		C4	Ecological Balance	*Minimising impact on the environment and support the ecological systems in the built environment.*	*C4a*	-	-	-
					C4b	-	-	-
		C5	Green Life Promotion	*Promotion and publicity of green lifestyle.*	*C5a*	-	-	-
					C5b	-	-	-

Target Layer	Sub-target Layer	Criteria Layer			Indicators Layer			
		Code	Title	Definition	Code	Title	Mode	Initial Diagnosis
SUSTAINABILITY	Social Sustainability	*C6*	Equality	*Providing convenient arrival for all kinds of people to support social equality.*	*C6a*	-	-	-
					C6b	-	-	-
		C7	Safety	*Providing safe and reliable streets to all users at all times of the day*	*C7a*	-	-	-
					C7b	-	-	-
		C8	Accessibility	*Providing high accessibility for various ways of arrival.*	*C8a*	-	-	-
					C8b	-	-	-
		C9	Diversity	*Encouraging the diversity of street functions and the variety of street activities*	*C9a*	-	-	-
					C9b	-	-	-
		C10	Culture Inheritance	*Being in accord with the historical characteristics and cultural identity, thereby preserving, inheriting, and even shaping local culture.*	*C10a*	-	-	-
					C10b	-	-	-
	Economic Sustainability	*C11*	Intensive Land Utilisation	*Intensive land utilisation and promote mixed and sharing usage within the streets.*	*C11a*	-	-	-
					C11b	-	-	-
		C12	Efficiency	*Promoting the efficient mobility for all street users.*	*C12a*	-	-	-
					C12b	-	-	-
		C13	Business Creation	*Creating various opportunities for street businesses.*	*C13a*	-	-	-
					C13b	-	-	-
		C14	Job Creation	*Creating various and considerable employment opportunities along the streets.*	*C14a*	-	-	-
					C14b	-	-	-
		C15	Added-Value	*Increasing the values and attractions of land, real estate and businesses along the streets.*	*C15a*	-	-	-
					C15b	-	-	-

Note: the table was designed and made by the author.

STEP 4.1: To build a pool of potential indicators.

The specific process and methods of indicator selection were:

1) Based on the established evaluation structure (Table 3. 11), a broad literature review was conducted to search for suitable indicators firstly. The selection criteria are the six principles of indicator selection which were pointed out in Chapter 2.3.2.3, namely Exhaustive,

Relativity, Sensitivity, Objectivity, Accessibility, and Readability respectively. So, all eligible indicators were organised into the evaluation structure.

2) The Design Toolbox of Sustainable Streets (Table 3. 9) was reviewed again, and the design methods and relevant technologies that could promote the delivery of sustainable streets were added into the structure according to the 15 evaluation criteria.
3) Finally, a total of 79 potential indicators were listed in the evaluation structure. Also, the types and sources of these listed indicators were explicit in the structure.

Eventually, ***Table 3. 12 shows the Evaluation Structure of Sustainable Streets with 15 criteria and 79 indicators.*** It can be seen in the table that all potential indicates were categorised into two types according to different patterns of the feasibility test.

Type O: the indicator which needs to be tested by fieldwork, such as on-site observation or measurement, to examine its validation and feasibility of this research;

Type D: the indicator which needs to be reviewed though deskwork, such as online searching the publication of relevant index and its corresponding standards, to examine its validation and feasibility for this research.

Table 3. 12: Evaluation Framework of Sustainable Streets with Criteria and Indicators

Target Layer	Sub-target Layer	Criteria Layer		Indicators Layer			
		Code	**Title**	**Code**	**Title**	**Mode**	**Source**
SUSTAINABILITY	Environmental Sustainability	*C1*	Adaptability	*C1a*	Restoring Mobility Efficiency after the storm/hurricane	D	(NYCDoT, 2013a)
				C1b	Percentage of flood risk area	D	(HBC, 2011)
				C1c	Adaptable capacity to local climate	O/D	SDT
				C1d	Adaptable capacity to extreme weather events	O/D	SDT
		C2	*Mitigation UHI*	*C2a*	Cool pavement	D	(Umer, et al., 2016)
				C2b	Street green rate	O	(NYCDoT, 2013a) SDT
				C2c	% Street tree shading	O	(NYCDoT, 2013a) SDT
				C2d	Air Temp. difference	O	SDT
		C3	Pollution Reduction	*C3a*	Average Annual emission of NO_2	D	(Laprise, et al., 2015)
				C3b	Average emission of noise	O/D	(Laprise, et al., 2015)
				C3c	Air quality	D	(NYCDoT, 2013b)
				C3d	The usage of green asphalt	D	(NYCDoT, 2013a)

Target Layer	Sub-target Layer	Criteria Layer		Indicators Layer			
		Code	Title	Code	Title	Mode	Source
SUSTAINABILITY	Environmental Sustainability	*C3*	Pollution Reduction	*C3e*	Annual energy saving from conversion to LED's	D	(NYCDoT, 2013a)
				C3f	Road transport CO_2 emission	D	(HBC, 2011)
				C3g	% of pavement reuse	D	(Umer, et al., 2016)
				C3h	Recycled materials	D	(Umer, et al., 2016)
				C3i	Regional materials	D	(Umer, et al., 2016)
				C3j	Quiet pavement	D	(Umer, et al., 2016)
				C3k	Waste management	O/D	(KeTTHA, 2011)
				C3l	Lifecycle pollution reduction	D	(KeTTHA, 2011)
				C3m	Road transport CO_2 emission	D	(HBC, 2011)
		C4	Ecological Balance	*C4a*	Permeable pavement and bioswales	D	(NYCDoT, 2013a) (Umer, et al., 2016)
				C4b	Runoff flow control	D	(Umer, et al., 2016)
				C4c	Runoff quality	D	(Umer, et al., 2016)
				C4d	Site vegetation	O	(Umer, et al., 2016)
				C4e	Ecological planting	O/D	(Umer, et al., 2016)
				C4f	Number of Planting types	O	SDT
				C4g	Rainwater management	O	SDT
		C5	Green Life Promotion	*C5a*	Public conversation events for street safety	O/D	(NYCDoT, 2013a)
				C5b	Public Campaigns for traffic safety	O/D	(NYCDoT, 2013a)
				C5c	Green lifestyle promotion	O	SDT
				C5d	Green travel support	O	SDT
	Social Sustainability	*C6*	Equality	*C6a*	Tactile pavement for the blind	O	SDT
				C6b	Barrier-free facilities	O	SDT
				C6c	Transparency of the Party Wall	O	SDT
		C7	Safety	*C7a*	Crashes and injuries for motorists, pedestrians, and cyclists	D	(NYCDoT, 2013b)
				C7b	Traffic fatality	D	(NYCDoT, 2013a)
				C7c	Designed Traffic speeds	O	(NYCDoT, 2013b)
				C7d	Coverage proportion of street cameras	O/D	(NYCDoT, 2013a)
				C7e	Number of street crimes	D	(KeTTHA, 2011)
				C7f	Coverage safety equipment	O/D	SDT

Target Layer	Sub-target Layer	Criteria Layer Code	Criteria Layer Title	Indicators Layer Code	Indicators Layer Title	Mode	Source
SUSTAINABILITY	Social Sustainability	*C8*	Accessibility	*C8a*	Quality of service in public transport	O/D	(Laprise, et al., 2015)
				C8b	Number of parking lots	O	(Laprise, et al., 2015)
				C8c	Volume of vehicles, bus passengers, bicycle riders and users of public space	O/D	(NYCDoT, 2013b)
				C8d	Bus system service Quality	O/D	(NYCDoT, 2013a)
	Social Sustainability	*C8*	Accessibility	*C8e*	Ridership on Bus	O/D	(NYCDoT, 2013a)
				C8f	Bus Lane network	O/D	(NYCDoT, 2013a)
				C8g	Cycling lane network	O	(NYCDoT, 2013a)
				C8h	Coverage of sharing bike	O	(NYCDoT, 2013a)
				C8i	Pedestrian access	O	(Umer, et al., 2016)
				C8j	Bicycle access	O	(Umer, et al., 2016)
				C8k	Transit access	O	(Umer, et al., 2016)
				C8l	The variety of arrival ways	O	SDT
				C8m	Clear sign and guidance system	O	SDT
		C9	Diversity	*C9a*	Diversity of street activities	O	(NYCDoT, 2013b)
				C9b	Number of Street events per year	D	(NYCDoT, 2013a)
				C9c	Number of public seats	O	(NYCDoT, 2013a)
				C9d	Diversity of street functions	O	(NYCDoT, 2013a)
		C10	Culture Inheritance	*C10a*	Number of Urban arts	O	(NYCDoT, 2013a)
				C10b	Aesthetic Quality of urban art	O	(NYCDoT, 2013a)
				C10c	Aesthetic Quality of street furniture	O	SDT
				C10d	Style consistency with surroundings	O	SDT
				C10e	Historical inheritance & culture display	O	SDT
	Economic Sustainability	*C11*	Intensive Land Utilisation	*C11a*	Intensiveness of street space	O	SDT
				C11b	Mixed-use of street land	O	SDT
		C12	Efficiency	*C12a*	Efficiency in parking/loading	O	(NYCDoT, 2013b)

Target Layer	Sub-target Layer	Criteria Layer		Indicators Layer			
		Code	Title	Code	Title	Mode	Source
SUSTAINABILITY	Economic Sustainability	*C12*	Efficiency	*C12b*	Actual traffic speed	O	(NYCDoT, 2013b)
				C12c	Parking Smart program	O	(NYCDoT, 2013a)
				C12d	Intelligent transportation system	O	(Umer, et al., 2016)
				C12e	Traffic Performance Index	D	(KeTTHA, 2011)
		C13	Business Creation	*C13a*	Retail sales	D	(NYCDoT, 2013b)
				C13b	Retailer visitor spending	D	(NYCDoT, 2013b)
				C13c	Retail sales tax filings	D	(NYCDoT, 2013b)
				C13d	Density of shops	O	SDT
				C13e	Types of temporary business	O	SDT
		C14	Job Creation	*C14a*	Employment Creation	O/D	(Laprise, et al., 2015)
				C14b	Number of employments	O/D	(NYCDoT, 2013b)
				C14c	Types of jobs	O/D	SDT
		C15	Added-Value	*C15a*	Added Value of Commercial Rents	O/D	(NYCDoT, 2013b)
				C15b	Added-Value of Housing prices	O/D	(NYCDoT, 2013b)

Note:

1) *SDT listed in the colum of "Source" means the indicator that was summarised from the Design Toolkit of Sustainable Streets in Table 3. 9 .*
2) *The sources of references were listed in the table above.*

3.5 Summary

This chapter systematically reviewed and analyzed the concepts of "Urban Streets", and "Threats of Climate Change to Streets". Integrated with the key findings of Chapter 2, **the theoretical framework of "Sustainable Streets" was finally established, including the definition of sustainable streets, 3 design principles and 15 design objectives for sustainable streets, a set of design toolkit with 75 available sustainable methods regarding28 design elements, as well as an evaluation structure with 15 criteria and 79 potential indicators.**

Firstly, Chapter 3.2 established a theoretical foundation of urban streets. It was concluded that an urban street is the linear open spaces in urban areas. Different from "Road", a holistic concept of the street also contains the lined buildings, the people, serving facilities, and the surrounding environment. Because of these components, the streets have six significant functions in urban systems, namely traffic, social, commercial, cultural, political, and ecological functions respectively. Based on a detailed comparison of twelve Street Design Guidelines, a total of 28 design elements of urban streets were summarised in Table 3. 4.

Secondly, Chapter 3.3 analysed the threats of Climate Change to urban streets, thereby highlighting the importance and necessity of sustainable streets. The study elaborated a serious of problems that Climate Change brought to urban streets and built a conceptual model to demonstrate the vicious circle of these adverse effects in Figure 3. 3. **Given this, street renovation and sustainable shift are of great significance to the development of urban streets and built environment.**

Thirdly, Chapter 3.4 established the theoretical framework for sustainable streets. “Sustainable streets” were defined as “a desirable status of urban streets, successfully balancing the three aspects of environmental, social and economic sustainability in the street space, and help to promote local sustainable development through the design, construction and operation”. Moreover, the study further pointed out that “sustainable streets”, “green streets” and “complete streets” are different. Because sustainable streets are the most extensive set that contains green streets (environmentally sustainable streets) and complete streets (socially sustainable streets). Therefore, the design methods of sustainable streets are more diverse and flexible, and evaluation procedure is more integrated and complicated. Based on an in-depth literature review, a total of 15 design objectives were defined according to 3 primary principles of sustainable streets (Table 3. 7). In addition, the design requirements and sustainable design methods were sorted out accordingly, thereby building a set of Design Toolkit of Sustainable Streets with 75 available sustainable methods regarding 28 design elements (Table 3. 9).

Finally, the evaluation structure of sustainable streets was established. Based on a preliminary assessment framework summarised in chapter two, fifteen design objectives of sustainable streets were employed as the evaluation criteria, and a total of 79 potential indicators were listed accordingly. Therefore, the established Evaluation Structure of Sustainable Streets includes 3 sub-targets, 15 criteria and 79 indicators (see Table 3. 12).

The research findings of this chapter reflect the important relationships between the “design” and the “evaluation”. Firstly, the research highlights that the design plays a vital role in sustainability delivery, because an effective design can not only solve existing problems but also guide future sustainable development. Also, the evaluation is an important part of a design-oriented procedure: “vision-design-evaluation-feedback-revision-design.” Secondly, design and evaluation together constitute a continuous improvement and a closed-loop of the sustainable development. Because the evaluation results could anticipate the condition and trends, provide a critical analysis of the current situation, give a necessary warning in advance, and develop better strategies, design, or actions for sustainable development. Thirdly, this research adopts 15 design principles as the 15 criteria of the evaluation framework and extracts many requirements from the design toolkit as the evaluation indicators (see Table 3.13). Therefore, it can be said that design and evaluation are closely interrelated and mutually supportive.

Table 3. 13: relationships between design and evaluation framework of sustainable streets

Design of Sustainable Streets		**Relationships to the evaluation framework of sustainable streets**
Study Topic	**Outcomes**	
Definition of Sustainable Streets	Conceptual definition & model	Supporting the evaluation structure
Design Principles	3 design principles (environmental, social, and economical Sustainability)	Using them as 3 sub-targets for the evaluation framework
Design Objectives	15 objectives	Using them as 15 evaluation criteria
Design Toolkit	75 available sustainable methods regarding28 design elements	Extracting many requirements of the design toolbox to be the evaluation indicator

Chapter 4. Research Methodology

4.1 Introduction

This chapter presents a detailed account of the methodology that is designed for this research to ensure its aims are adequately addressed.

Firstly, Chapter 4.2 builds the methodological framework for this research, including the research philosophy (Chapter 4.2.1), research approach (Chapter 4.2.2) and research strategy (Chapter 4.2.3), thereby providing a reliable basis for the research design.

Then, Chapter 4.3 introduces the research design in detail. The concept development, research methods, and specific techniques are designed according to the overall research aim and specific research objectives. Chapter 4.3.1 presents four research objectives and a series of research questions based on the primary research aim. Chapter 4.3.2 integrates the research objectives into the whole research process and reasonably design the development of critical concepts, thereby stating the research procedure and logic relationships of concept development. Based on this, Chapter 4.3.3 further links research objectives to research methods to clarify the research methods and techniques, data required and critical outcomes regard to four research stages.

Chapter 4.4 elaborates on the methods of data collection and data analysis in four research stages. Methods adopted in this research includes field survey, questionnaire, and interview in this research, hence this section provides a detailed introduction of the survey objectives, sample selection, survey time, survey techniques, pilot study, questionnaire design, and interview questions.

Finally, the ethical issues and the reliability of this research are analysed in Chapter 4.5. Chapter 4.5.1 presents an ethical consideration, including a clear statement of ethical considerations related to the study and the specific solutions. Chapter 4.5.2 addresses the reliability and validity of this study, thereby providing an objective and comprehensive evaluation of the whole research methodology.

4.2 Methodological Framework

Many factors influence the rationality and professionalism of a study, and the research methodology is the most important one. The methodological framework is guided by a research process that comes with the development of research tools and the entire research procedure (Sapsford, 2006).

The explanation of the methodological framework of the research, including a research theoretical and ideological stance, can provide a clear and straightforward basis for the research design as well as a valid interpretation and analysis of the findings (Sarantakos, 2005).

A systematic research methodology typically includes the research philosophy, research approach, research strategy, and techniques and procedures. Saunders et al. (2007) illustrated the research methodologies and their internal relationships through the model of the Research Onion (Figure 4. 1), and this research is designed and shaped mainly based on this framework. The framework below indicates that research philosophy guides the research approaches, the approaches lead the research strategies, and then these strategies determine the choice and techniques of specific methods of data collection and analysis.

Therefore, Chapter 4.2 describes the establishment of the methodological framework of this research. Specifically speaking, it is to define the research philosophy, research approach and research strategy to shape the overall structure of the research methodology. Also, the other research layers, identified in the model of "research onion" such as Choices, Time Horizons, and Techniques and Procedure, are defined and elaborated in Chapter 4.3 (Research Design).

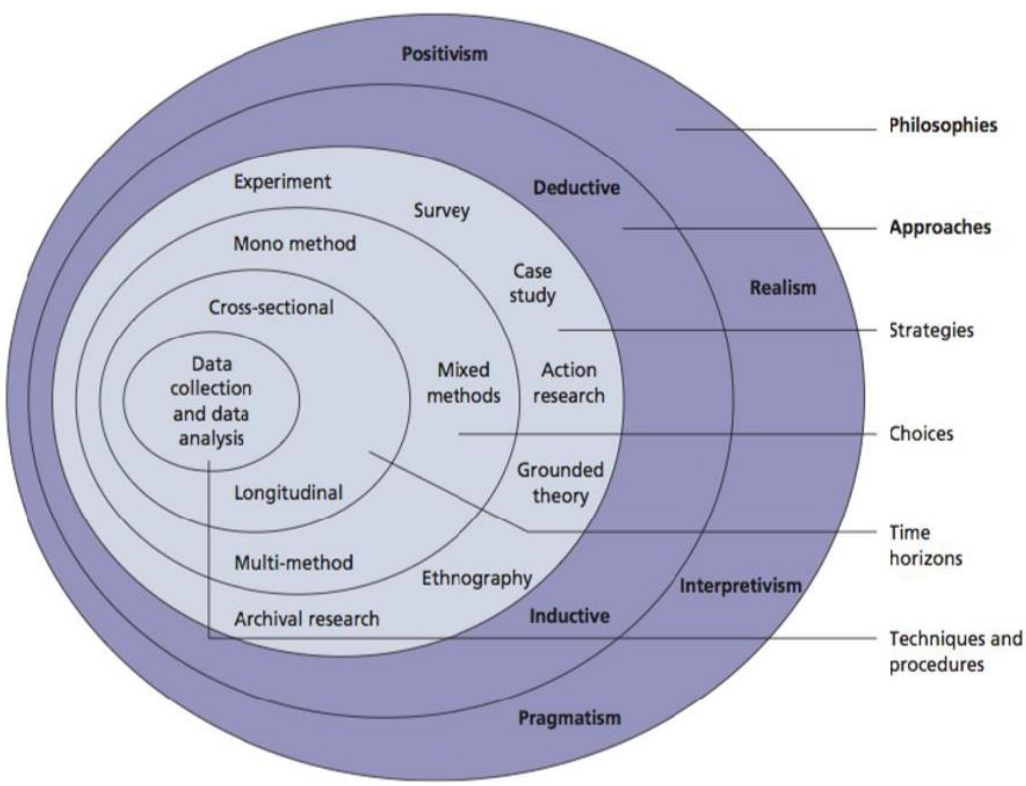


Image Source: *(Saunders, et al., 2007, p. 138)*

Figure 4. 1: Research Onion

4.2.1 Research philosophy

The first step of research design is to define the appropriate research philosophy because research philosophy can outline the theoretical assumptions and it affects the entire structure and organisation of the research (Machaner, 2002). Philosophy is the investigation of the truth and the principles of knowledge (Crotty, 1998), so research philosophy is the development of fundamental background and knowledge of the nature of the research (Saunders, et al., 2007). Simply speaking, research philosophy is a specific process that enables researchers to establish a connection between research objectives and research methods. Many researchers define their research philosophy by selecting a clear research paradigm approach (Cohen, et al., 2000; Gliner, et al., 2000; Momoh, 2016; Al-Sulaiman, 2014). According to Saunders et al. (2007), there are four core types of research paradigm: Positivism, Realism, Interpretivism, and Pragmatism.

The Positivism is based on the idea that the reality can be observed directly and described objectively. In the positivism paradigm, a researcher makes the use of rational thought to obtain knowledge about the research object and presents their observation and evaluation by objective rather than subjective means (May, 2001; Cooper & Schindler, 2014). Hence, in the positivist philosophical approach, researchers often choose quantitative methods for empirical evaluation (Buttery, 1998), and empirical studies and observation are generally adapted to acquire data for quantitative research (Guba & Lincoln, 1994). Moreover, the researcher in this type of philosophical position often employs the deductive approach to apply theories to test the hypothesis.

The Interpretivism relies on the idea that the reality of phenomena can be explained according to the individual understanding of a worldview from their frame (May, 2001; Collis & Hussey, 2009). It is important to note that the interpretative paradigm is the explanation of the meaning rather than measurements of the objective phenomena. Therefore, interpretative researchers tend to employ inductive approach for qualitative research to provide the interpretation of the social lifeworld (Crotty, 1998; Saunders, et al., 2007; Al-Sulaiman, 2014).

The Realism highlights that reality is entirely independent of human minds. May (2001) stated that the realism shares the commons of objectivity and the aim of explanation with positivism, while Keat and Urry (1975) argued that realism could not use the empirical methods but utilise a different definition of the science of positivism. More realists believe that whatever the researchers believe or find is only an approximation of the reality.

The Pragmatism believes that concepts are accepted if they support practical action. Thus, pragmatists emphasise the practical application and the idea's application by actual test (Gerald, 2014). The essence of a pragmatist ontology is that the meaning of a concept is the practical consequence of the concept (Goldkuhl, 2012). Therefore, in the pragmatism paradigm, the researcher tests and applies one concept into the real world by various investigation methods to generate constructive knowledge for general practice.

In academia, there is always an argument on which paradigm is the best. Some researchers insist that a single paradigm must be adopted to ensure the accuracy of research logic and results (Burrell & Morgan, 1979; Bryman, 2012; Collis & Hussey, 2009), while other researchers argue that the application of hybrid paradigms has more advantages, and they further emphasise that researchers can mix two or more kinds of paradigm and locate a domain between them (Gioia & Pitre, 1990; Lewis & Grimes, 1999; Creswell, 2013; Saunders, et al., 2007). Among the four paradigms, Positive Paradigm is adopted by more researchers. Alavi and Carlson (1992) identified that more studies choose the positivism paradigm based on a systematic analysis of 908 MIS articles published between 1968 and 1988. Also, Chen and Hirschheim (2004) pointed out that the positivist research dominates 81% of published works after examining 1893 articles published in eight major IS publication outlets between 1991 and 2001. Based on a broad review of existing studies on Sustainability and Climate Change, it was found that the situation is the same, and more studies are for positivism.

Therefore, ***this research followed the positivist paradigm***. Specifically speaking, ***the study proposed and tested a conceptual framework of sustainability evaluation of urban streets by applying it to the real world and then refined based on obtained data to promote its future development***.

4.2.2 Research Approach

The research approach is the methodology that has been adopted to carry out the study. Researchers generally agree that the research approaches can be divided into four types and two groups (Saunders, et al., 2007; Flick, 2011; Bryman, 2012), deductive VS inductive approach, and qualitative VS quantitative approaches:

Deductive approach

The deductive approach is "*developing a hypothesis based on existing theory, and then designing a research strategy to test the hypothesis*" (Wilson, 2010a, p. 7). Deductive approach is more focused on adopting propositions from existing theory and then testing them to understand the application of the theory in the real world, thereby promoting the theory development and practical application (Collis & Hussey, 2009; Saunders, et al., 2007; Momoh, 2016).

Inductive approach

Inductive approach is based on the observation of empirical data and aims to deliver a theory as a result of the observation (Goddard & Melville, 2004). Typically, no theory or hypothesis would apply at the beginning of inductive studies. The researcher begins with observation and investigation of individual instances and then identify patterns and relationships to build a theory (Easterby-Smith, et al., 2008). Therefore, an inductive approach is known to be a theory-developing process, and Dubois and Gadde (2002) further pointed out that it is more suitable for the research of grounded theory.

Qualitative approach

The qualitative approach is an interpretive naturalistic approach to the world by answering the whys and hows of human behaviour, opinion, and experiences (Denzin & Lincoln, 2000; Alasuutari, 2010). It is often employed in the social sciences and natural sciences to gather an in-depth understanding of human behaviours and natural rules that are difficult to obtain through more quantitatively-oriented methods of data collection. It primarily relies on the subjective interpretation, the skill, and experience of the researcher directly affect the outcomes (Denzin & Lincoln, 2000). Hence, the findings of the qualitative approach cannot be generalised and only reflect the essence of some cases.

Quantitative approach

The quantitative approach is based on quantitative data (Flick, 2011), and is considered as a classical scientific approach which depends on natural science perspectives (Pather & Remenyi, 2005). In general, quantitative research is to check the validity of one hypothesis, explain of causes and inter-relationships through statistical analysis. Although the quantitative approach is mainly applied to the study of positivist philosophy, it can also be used to study social phenomena, including feelings and subjective views. There are various specific methods underneath this approach, such as survey, laboratory experiments, and mathematical modelling (Bryman & Bell, 2003). It is important to note that the collection of data and numbers and interpretation of the numerical data are the critical parts in quantitative research.

Following the positivism paradigm, this study applied a deductive approach. Firstly, the study began with a broad literature review on the research topics for a thorough understanding of the leading theories that are related to the background and object of this research (*see in Chapter 2*), and then the search was narrowed down to build a preliminary model which was associated with the research hypothesis *(see in Chapter 3).* Secondly, a broad survey of Shanghai streets was employed to refine the initial model and adapt it to a practical context *(see in Chapter 6)*. Based on this, the research hypothesis was produced *(see in Chapter 7).* Thirdly, the research hypothesis was tested in three Shanghai streets through statistical data analysis methods *(see in Chapter 8).* Finally, all the findings and testing results were in-depth analysed and concluded to provide a series of summaries of theory optimisation and application *(see in Chapter 9 &10).*

Therefore, it can be seen that the study nature matches the characteristics of deductive research and the whole work follow the process of a typical deductive approach which is indicated by Robson (2002):

- To deduce a hypothesis from the theory
- To put the hypothesis in operational terms
- To test the operational hypothesis in the real world
- To exam the outcomes and effectiveness of inquiry
- To optimise the theory in light of the findings.

In general, the inductive approach tends to adopt qualitative data collection methods, while the deductive approach is always associated with quantitative methods (Maanen, 1983). The selection is not only related to the research paradigm and objectives but also influenced by the suitability and limitation regarding the necessary resources, time, skill, and information access (Punch, 2005). Therefore, in this research, a quantitative approach is more appropriate in regards to the philosophical paradigm and research objectives of this research.

To sum up, ***the research adopted a theory-driven deductive and quantitative approach based on the positivist paradigm.*** Specifically, the deductive approach was used to test the research hypothesis developed from the theory (the Indicator System of Sustainability Evaluation for Urban Streets) to practice (Shanghai application), while the quantitative approach was adopted as the method of data collection concerning achieving research objectives and answer research questions. So main research findings were obtained based on the quantitative data and statistical calculation regarding the nature of research questions, thereby providing substantial evidence for testing the Indicator System in Shanghai practices.

4.2.3 Research strategy

The research strategy is the specific methods and overall plan of how the researcher intends to carry out the work (Saunders, et al., 2007). The choice of an appropriate strategy is supposed to consider the research aims and objectives, the current literature available in the subject field, the timescale of the research topic, and the philosophical paradigm and overall research approaches (Saunders, et al., 2007; Yin, 2009). In the model of research onion, the research strategies include survey, case study, experiment, grounded theory, action research, and ethnography. Meanwhile, literature review, cross-sectional studies, longitudinal study and participative inquiry are also regarded as research strategies (Easterby-Smith, et al., 2008).

In this study, in order to identify the research hypothesis and test it in Shanghai application, two kinds of research strategies, namely the systematic literature review and the survey respectively, were employed.

Firstly, a systematic literature review, also known as the systematic review, is one type of literature review. The literature review is a process to gather information from existing studies, documents and articles through critical evaluation or structured summary. Therefore, all the data generated from the literature review are secondary (Cooper, 1998). The systematic review is to provide a complete, exhaustive overview of the current literature that relates to the research questions in a structured methodology (Bolderston, 2008). The critical point of the systematic literature review is to formulate precise questions at the beginning, and then to select literature relevant to the identified questions by systematic and explicit methods. The systematic review can address one or more research issues by identifying, critically evaluating, and integrating the findings (Baumeister, 2013; Baumeister & Leary, 1997), so it is an objective and systemic method to construct of concept model and produce research hypothesis for this research.

Secondly, the survey is an appropriate method concerning the hypothesis test in Shanghai, because it is considered as a reliable method that enables data to be analysed and compared statistically, as well as to be used for finding generalisations (Saunders, et al., 2007). This research utilised the deductive and quantitative methods, so the survey, as the most dominant research strategy in quantitative studies, could well reflect the representative features of many research subjects (Bryman & Bell, 2003; Dillon, et al., 1990). Meanwhile, the survey method is also considered as an economic, structured and a practical method of collecting massive amounts of data (Hair, et al., 2003). Regards to survey technique, the three primary methods of data collection are the questionnaire, observation, and interview respectively (Saunders, et al., 2007), and they were all adopted in this study.

The ***questionnaire*** is a widely used method to collect primary data because it is a less costly and notably way for large sample size and large extended geographic areas (De Vaus, 2002). More importantly, the data can be quickly examined and compared without the potential biases due to the uniformity of misinterpretation of questions presented; therefore, it can be said that the mechanism of questionnaire ensures the validity and reliability of the data gathering (Bernard , 2011). Furthermore, the results of the questionnaire can be acquired instantly and analysed statistically to support quantitative research and deliver the findings by objective interpretation.

The ***interview*** is a method of data collection through verbal questioning. The advantage of the interview is that it helps researchers to obtain more data and more details about the survey questions. The structured interview is the interview with all questions designed and structured in advance, and the answers are recorded in the questionnaire by the interviewer. The structured interview is often criticised for being too mechanical because the order and wording of the questions should be strict adherence to the initial design and keep the same for each interviewee. Therefore, the study employed semi-structured interview because it possesses not only the advantages of the structured interview but also the flexible forms. Also, it facilitates to uncover the potential issues that have not been considered previously but are raised during the process of open discussion (Gray, 2004; Robson, 2002). In the semi-structured interview, part of the interview questions and topics are structured in advance. The degree to which interviews are predesigned depends on the survey purpose, objectives, and resources (Sarantakos, 2005).

The ***observation*** is a systematic data collecting method in which the researcher gathers data by observing ongoing behaviour, so it is often used in the study of social science. However, the method of observation often causes bias because the human sense is subjective and qualitative (Brewe, 2008). During the observation, some details are recorded into the brain while others are forgotten, which mainly depends on the personal judgments of how crucial it is to the individual namely "an internal value system" (Azzouni, 2004). Therefore, in order to reinforce the validity and reliability of this research, the structured observation was employed for this study as it is more systematic and well organised. In the structured observation, the researcher observes and records data in a clear and procedural manner based on a detailed plan beforehand. Therefore, a well-designed recording sheet, like the observation guide, checklist, or investigation table, is necessary.

To sum up, this research employed the systematic literature review and the survey as two main research strategies. As the research of the positivism paradigm regarding adopting theory-driven deductive and quantitative approaches, the systematic literature review was selected as a conventional and appropriate method to build the concept model and produce research hypotheses. Meanwhile, the research strategy of the survey was chosen because it is a practical and reliable method to test the hypothesis in the real world because of its quantitative nature, representativeness, as well as objectiveness. ***Three survey methods, namely questionnaire, semi-structured interview, and the structured observation, were adopted in the research***.

4.3 Research Design

The research design will be introduced in detail in this section. Chapter 4.3.1 presents the four specific research objectives and a series of research questions accordingly based on the primary research aim, which is a fundamental design of the research contents. Subsequently, Chapter 4.3.2 integrates the research objectives into the whole research process and presents the development of critical concepts, thereby stating the design of research procedure and logic relationships of concept development. Based on this, Chapter 4.3.3 further links research objectives to research methods to clarify the research methods and techniques, data required and critical outcomes regard to four research stages, which further demonstrates a detailed research design.

4.3.1 Research aim, objectives, and questions

With the problems of lack of practical evaluation tools to guide the design work in a comprehensive and effective way, this research aims to build an evaluation system for sustainable streets in Shanghai to provide suggestions for street renovation.

Based on the overall aim, four research objectives are proposed and addressed by a series of research questions:

Objective 1: ***to form a theoretical basis for the design of sustainable streets and a preliminary evaluation framework of sustainable streets.*** *(Chapter 2&3)*

Q 1. What are the causes and effects of Climate Change, and how the global response to the threats? *(Chapter 2.2)*

Q 2. How to understand and interpret "Sustainability" in the built environment, and what is a sustainability assessment? *(Chapter 2.3)*

Q 3. What is the definition, functions and design elements of urban streets, and what kinds of threats they are confronted with under Climate Change? *(Chapter 3.2 & 3.3)*

Q 4. What is the theoretical framework of "Sustainable Streets" and the evaluation structure of sustainable streets? *(Chapter 3.4)*

Objective 2: ***to build the indicator system of sustainable evaluation for Shanghai streets.*** *(Chapter5, 6&7)*

Q 5. What is the past formation process, current features and classification, and future development orientation of Shanghai streets? *(Chapter 5)*

Q 6. What are the overall assessment results of Shanghai streets and what are the sample cases of further study? *(Chapter 6)*

Q 7. What is the indicator evaluation system of sustainable streets in Shanghai? *(Chapter 7)*

Objective 3: ***to apply and examine the indicator system of sustainability evaluation in sample streets.*** *(Chapter 8)*

Q 8. What are the results of sustainability evaluation of the sample streets by the indicator system? *(Chapter8)*

Q 9. What are differences and coherences between evaluation results of indicator system and appraisal results of questionnaire survey among the sample streets? *(Chapter8)*

Q 10. What are the improvement points of the Indicator System according to the cross-comparison of the evaluation results and the application experiences? *(Chapter8)*

Objective 4: ***to optimise the established indicator system of sustainability evaluation.*** *(Chapter 9)*

Q 11. What are the key findings of the expert interview regarding the system improvement? *(Chapter 9)*

Q 12. How to optimise the Indicator System based on the key findings of the above stages? *(Chapter 9)*

4.3.2 Conceptual Framework

It is significant to integrate the research objectives into the whole research process and reasonably design the development of the critical concepts. Figure 4. 2 illustrates the research procedure and logic process of concept development:

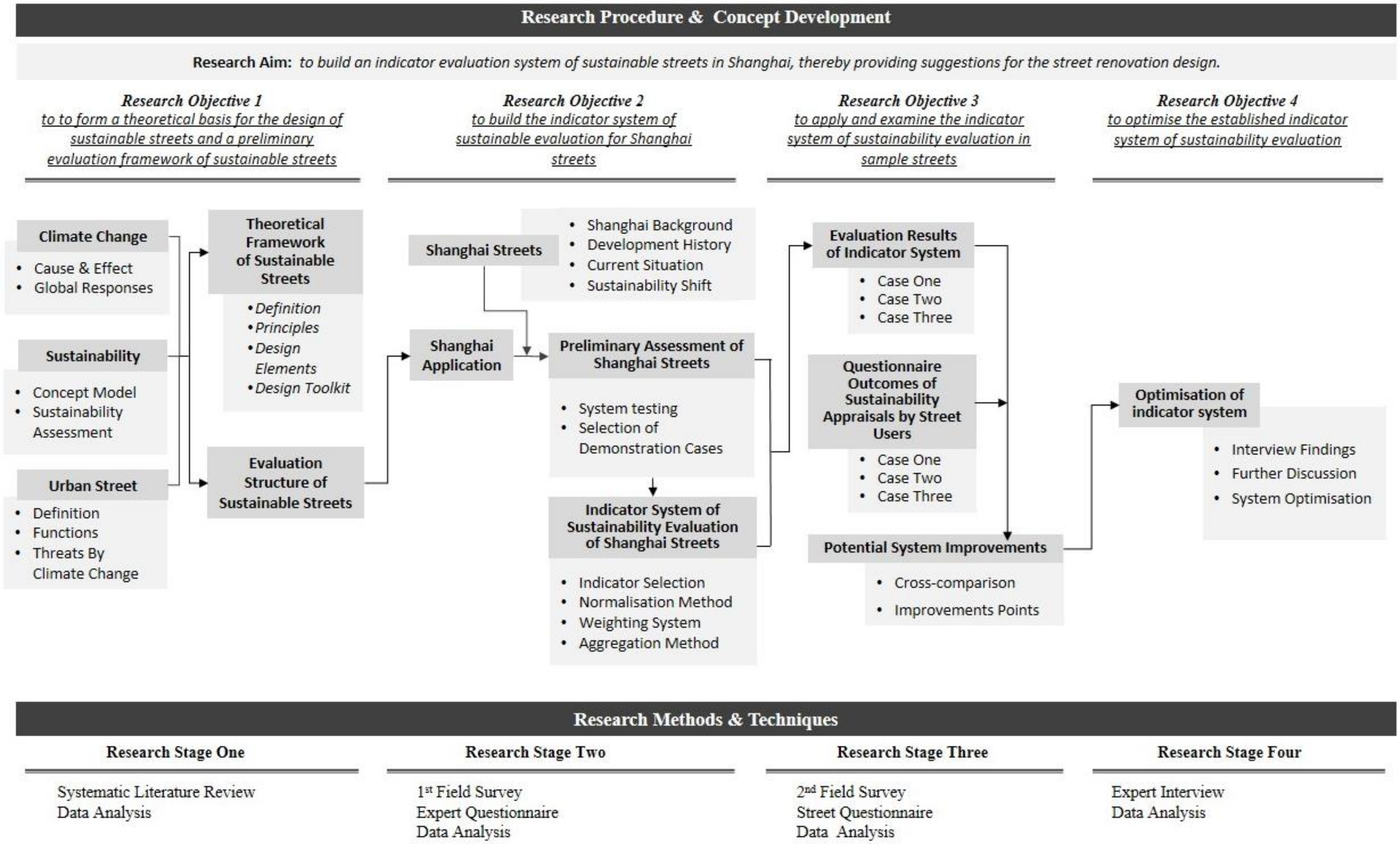
Firstly, three concepts, “Climate Change”, “Sustainability in Built Environment”, and “Urban Streets” were studies through the systematic literature review, thereby building up theoretical basis for the design of sustainable streets and a preliminary evaluation framework of sustainable streets *(Research Objective 1)*.

Secondly, in order to build the indicator system of sustainable evaluation for Shanghai streets. *(Research Objective 2)*, Research Stage Two began with the study of Shanghai background, road development, and street types, thereby putting the study into a Shanghai context. Then a broad survey of 236 Shanghai streets was conducted to test the preliminary evaluation framework of sustainable streets and select sample cases for the next stage.

Thirdly, in order to apply and examine the indicator system of sustainability evaluation in sample streets *(Research Objective 3)*, the established Indicator System was used to evaluate the sustainability of three sample streets in Shanghai. Questionnaires were handed out in the three streets to obtain the sustainability appraisals from street users. Then, the appraisal outcomes of street users were compared with the evaluation results of the Indicator System both quantitatively and qualitatively, and the differences and coherence were analysed and identified. Based on a comprehensive cross-comparison, a set of improvements points were summarised for the Indicator System.

Finally, in order to optimise the indicator system (*Research Objective 4*), a set of semi-structured interviews were conducted. The interview outcomes were integrated with the application experiences of this research, thereby providing an evidence-based proposal of system refinement. Ultimately, the Indicator System of sustainability evaluation of Shanghai streets was formed and optimised by empirical research.

Therefore, ***it can be seen in Figure 4. 2 that the whole study process was designed based on the four research objectives for achieving the overall research aim. The key concepts were built and developed gradually. Also, the graph also listed the research methods and techniques corresponding to four research objectives.***



The table was designed and made by the author.

Figure 4. 2: Research Procedure and Concept Development

4.3.3 Linking Research Objectives with Methods

In order to refine and clarify the specific methods at each stage and to check the rationality and reliability of each step, the research methods and techniques were linked to research objectives and analysed one by one. Table 4. 1 shows research methods and techniques, data required and critical outcomes regard to four research stages corresponding to four research objectives.

Table 4. 1: Linking Research Objectives with Methods

Overall Research Aim: *to build an indicator evaluation system of sustainable streets in Shanghai, thereby providing suggestions for the street renovation design*					
	Research Objectives	**Research Methods & Techniques**		**Data/Information Required**	**Research Outcomes**
Stage One	***Objective 1:*** to form a theoretical basis for the design of sustainable streets and a preliminary evaluation framework of sustainable streets	*Systematic Literature Review*		• Relevant studies on "Climate Change, Sustainability in Built Environment", and "Urban Streets". • Existing studies on the "Sustainable Streets".	• The theoretical framework of Sustainable Streets *(Chapter 3)* • Evaluation Structure of Sustainable Streets *(Chapter 3)*
Stage Two	***Objective 2:*** to build the indicator system of sustainable evaluation for Shanghai streets	*1st Field Survey*	*Structured Observation* *Photographing* *Field Notes* *Site Measurement*	• A preliminary rating table of sustainable streets assessment • A checklist of all potential indicators for sustainability evaluation	• Development and background of Shanghai streets *(Chapter 5)* • A preliminary assessment of Shanghai Street *(Chapter 6);* • Selection of sample cases for Research Stage Three *(Chapter 6);* • Indicator System of Sustainability Evaluation for Shanghai streets *(Chapter 7).*
		Expert Questionnaires		• A questionnaire table on weighting issue	
		Data Statistics	*Descriptive Statistics* *Multi-Criteria Analysis (MCA)*	• Primary data of quantitative results from the 1st Field survey; • Primary data of quantitative outcomes from Expert Questionnaires	
		Data Analysis	*Coding*	• Primary data of qualitative findings from 1st Field Survey • Background study of Shanghai Streets	
Stage Three	***Objective 3:*** to apply and examine the indicator system of sustainability evaluation in sample streets	*2nd Field Survey*	*Structured Observation* *Photographing* *Site Measurement*	• 3 sample streets in Shanghai (selected in 1st Field Survey); • The Indicator System of sustainability evaluation for Shanghai streets	• Evaluation results by the Indicator System of three Shanghai streets *(Chapter 8).* • Appraisal results of questionnaire survey from street users *(Chapter 8).* • Potential system improvements *(Chapter 8).*
		Street Questionnaire		• A questionnaire of sustainability appraisals	
		Data Statistics	*Descriptive Statistics* *Inferential Statistics* *Comparative Analysis*	• Primary data of qualitative findings from 2nd Field Survey • Primary data of qualitative outcomes from Street Questionnaires	

	Research Objectives	Research Methods & Techniques	Data/Information Required	Research Outcomes
Stage Four	***Objective 4:*** to optimise the established indicator system of sustainability evaluation	*Semi-Structured Expert Interview*	• A well-designed question for the interviews	• Optimisation schemes for the Indicator System of Sustainability Evaluation for Shanghai streets *(Chapter 9).* • Suggestions on street renovation *(Chapter 10).*
		Data Analysis	• Interview outcomes • Applicational experiences	

4.4 Data collection and Analysis

4.4.1 Research Stage One

In Research Stage One, the technique of data collection was the Systematic Literature Review, and data analysis was based on the qualitative techniques.

4.4.1.1 Systematic Literature review

As explained in Chapter 4.2.3, systematic literature review is one kind of literature review, but is not the same as the general literature review. The systematic literature review is a review of one or several clear question/questions by systematic and explicit methods to identify, critically evaluate and integrate the findings of all relevant, high-quality studies related to the research questions (Baumeister & Leary, 1997; Cooper, 2003).

The critical objective of stage one was to form a theoretical framework of "Sustainable Streets" and to devise a preliminary sustainability evaluation framework. Four specific research questions were formulated based on the research objective. Then, the four questions were broken down into individual concepts to create search terms. Furthermore, alternative terms which are similar to the core concepts and major questions were also used for searching, thus building a robust and comprehensive database and theoretical foundation.

The key concepts and its related terms which were used for literature searching are specified as below:

- ***Climate Change:***
  - *Cause and effect of Climate Change (vulnerability and impacts at city scale/urban system)*
  - *Global response to Climate Change*
  - *Climate Adaptation design/planning*
  - *Climate Mitigation design/planning*
- ***Sustainability in built environment***
  - *Sustainability, sustainable development, sustainable design*

- *Sustainability assessment (sustainability evaluation)*

- ***Urban streets***
  - *Street & road*
  - *Street functions/ street functions*
  - *Design elements of urban streets*
  - *Threats from Climate Change*

- ***Sustainable streets***
  - *Sustainable streets/complete streets/green streets*
  - *Principles and design objectives of sustainable street*
  - *Design toolkits for sustainable streets (design guideline/design handbook/pilot projects/sustainable street design/design manual)*
  - *Sustainable street evaluation framework (Sustainability evaluation/Sustainability assessment/ sustainable appraisal/ sustainability indicators/ sustainable street index/integrated evaluation framework/sustainability Economic benefits of sustainable streets/ environmental assessment of sustainable streets/ social benefit of sustainable streets)*

Literature searching mainly relied on electronic databases, including Springer, Elsevier Science, EBSCO, SAGE Premier, Wiley online library, ASCE (the American Society of Civil Engineers), ICE (Institution of Civil Engineers). The search literature included books, journal articles, reports, conference paper, design manuals, and policy documents. Meanwhile, some important books that were not available in electronic version were bought or borrowed through libraries.

In the beginning, a total of 1182 articles/books/documents were searched through keywords in the electronic database or the paper libraries and then were briefly overviewed by the researchers. During the browsing, the search results were screened according to the inclusion and exclusion criteria. In order to ensure the quality of searching results, the inclusion and exclusion criteria were designed as following (Greenland & O’Rourke, 2001; Siddaway, 2014)

- Correspondence of keywords
- The pertinence of the research objective
- Appropriateness for addressing the research objectives;
- Quality of articles
- Typicality and generalizability

Based on this, the pool of potential studies was narrowed down, and then an entirely of 526 eligible works were studied and critically evaluated according to the framework of concept development. Figure 4. 3 elaborates literature searching and sifting process of the work in this stage.

It is worth mentioning that some unpublished works are identified as potential research bias of systematic literature review (Siddaway, 2014; Begg, 1994; Vevea & Woods, 2005). Therefore, in order to minimise potential bias, the researcher emailed some researchers whose studies were reasonably relevant to this work to inquire about the newest development of their studies and any unpublished work in this field. For example, the article of "Return to Human-oriented Streets: The New Trend of Street Design Manual Development in the World Cities and Implications for Chinese cities" that discusses the implication of comprehensive famous street design manual for Chinese cities was published in 2012. Then the researcher sent emails to the leading author of this articles and have kept in touch with her to know the study's progress.

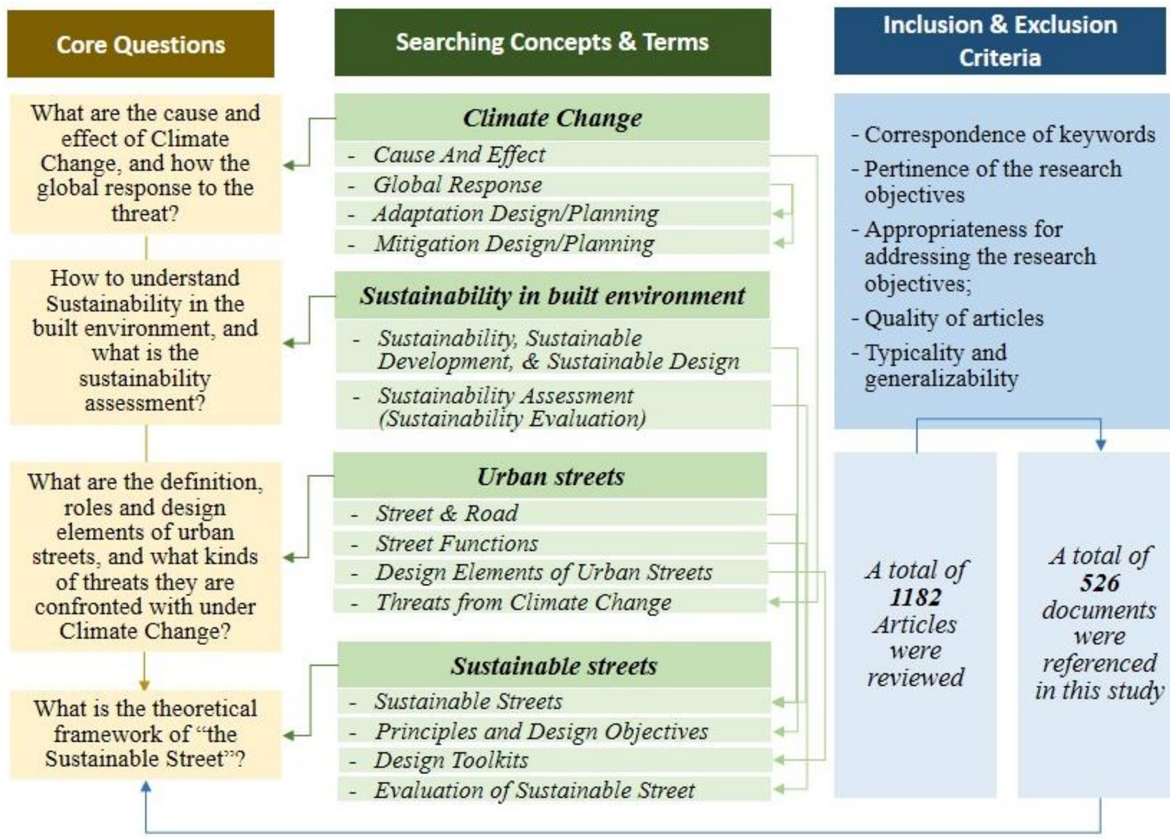


Figure 4. 3: Diagram of Literature Searching and Sifting Process in a Systematic Literature Review

4.4.1.2 Data analysis techniques

The work of stage one was mainly to review and induce the secondary data from existing studies, thereby building a theoretical framework and concept model. Therefore, the data analysis method of this stage relied on qualitative approaches. All the studies and articles were systematically arranged and integrated according to the logical framework of concept development.

In order to reinforce the reliability of this stage, the researchers recorded and described the whole procedure of keywords definition, literature searching, sifting criteria and screening process to enable the whole study to be tracked and reviewed. Furthermore, all articles were noted with the inclusion/exclusion decision, and the eligible works were systematically arranged into the table to record their essential contents, reference points, and study quality. Also, all the works were discussed with the supervisor and handed in school annual review panel to reinforce the reliability and objectivity of data analysis in this stage.

4.4.2 Research Stage Two

Data collected in stage two were mainly through the 1st Field Survey and Expert Questionnaires, and the techniques of data analysis were Descriptive Statistics, Multi-Criteria Analysis, and Coding approach.

4.4.2.1 1st Filed Survey

In order to ensure the preliminary evaluation framework that is devised from theoretical study adapt to Shanghai context, it is significant to understand the characteristics of Shanghai streets and to test the applications of the preliminary evaluation system in Shanghai. Therefore, the field survey is an appropriate and feasible approach. First, it possesses all the advantages of survey methods including representative, structured, and practical features for data collecting and gathering (Bryman & Bell, 2003; Dillon, et al., 1990; Hair, et al., 2003). Secondly, it can effectively enhance the understanding of Shanghai streets as well as the application of the evaluation prototype. Thirdly, this survey can facilitate the collection of primary data of Shanghai that is not available from existing documents or researches.

Figure 4. 4 illustrates the detailed design of the 1st Field Survey, including survey objectives, survey scope, tools and techniques of information collection, and survey outcomes.

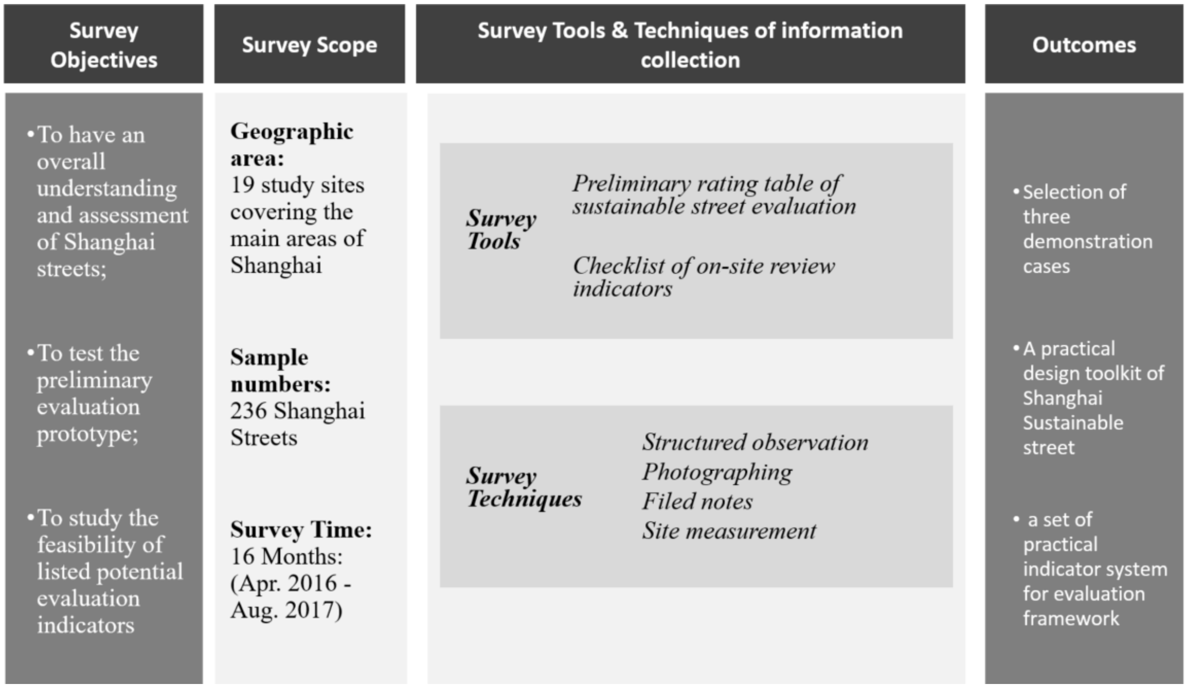


Figure 4. 4： Design of 1st Field Survey

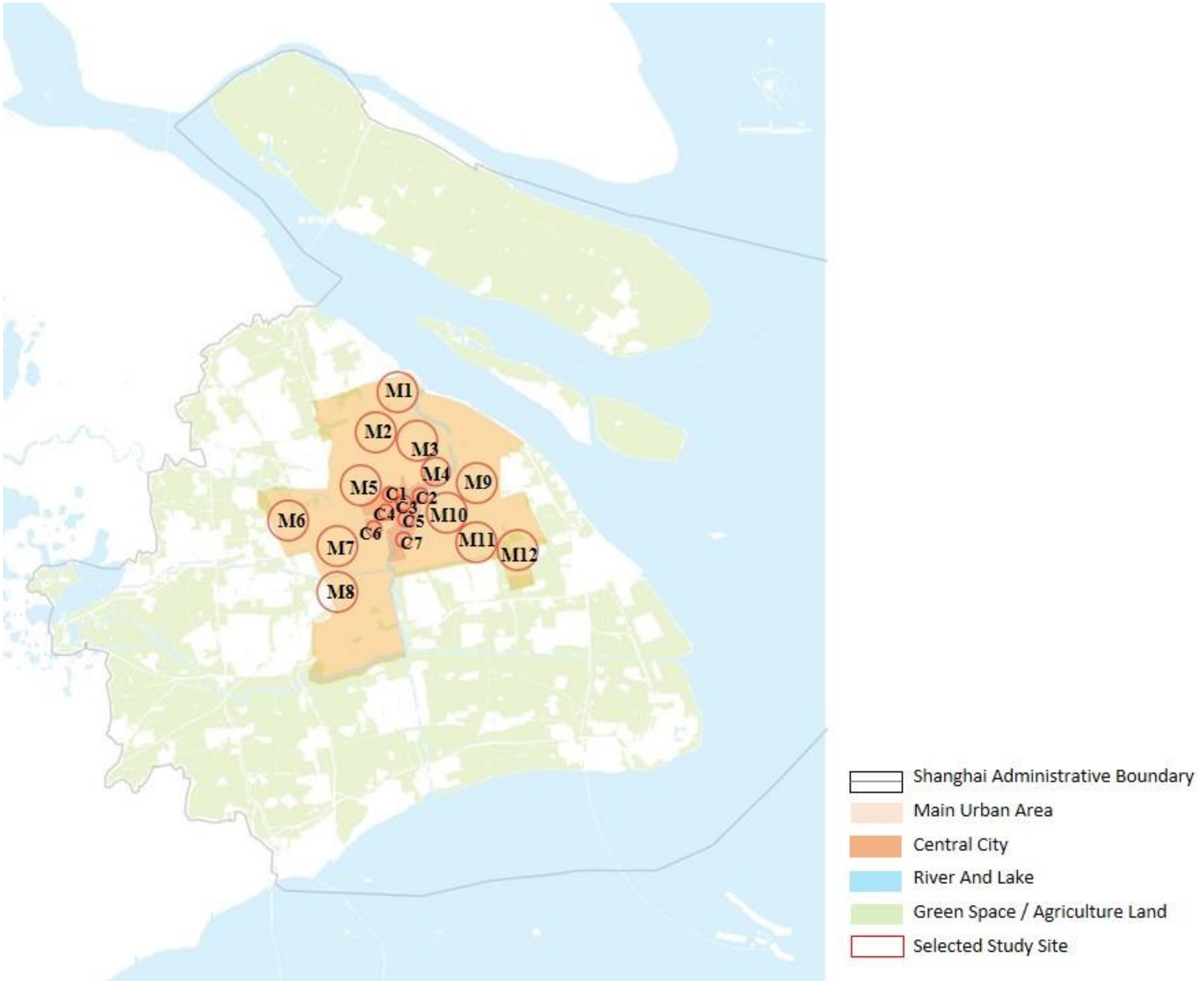
4.4.2.1.1 Survey Objectives

The following summarises the purposes of the 1st Field Study:

- To have an overall understanding and assessment of Shanghai streets so as to select the sample cases for next stage;
- To test the Evaluation Structure of Sustainable Streets so as to examine its application;
- To study the feasibility of listed potential evaluation indicators by fieldwork so as to select a set of the practical Indicator System for evaluation framework.

4.4.2.1.2 Sample Selection

A total of nineteen study sites within Shanghai main urban areas were selected for this survey. For each study site, approximately 10-15 streets were investigated, so totally 236 streets in Shanghai were studied in the 1st filled survey. Figure 4. 5 shows the distribution and location of these study sites in Shanghai.



The graph was made by the author.

Figure 4. 5: Distribution and Location of Survey Sites in Shanghai

The rationales of sample selection were:

1) From the perspective of sample geographic distribution, the selected streets could cover the main areas of Shanghai. It can be seen in Figure 4. 5 that seven pieces of sites (C1-C7) primarily covered the majority of Shanghai downtown areas and twelve pieces of sites (M1-M12) were evenly distributed in the central suburb area. All the survey sites were selected by the principle of main gathering places of population and activities.
2) From the perspective of sample generalisation, the sample size of this survey could provide an overall performance of Shanghai streets. The total length of Shanghai streets is about 5,100 km in 2016 (Eastday, 2017), and the total length of streets in 19 study sites is about 1200 km. That means the surveyed streets accounted for 23.5% of the complete Shanghai urban streets.
3) From the perspective of sample representativeness, the survey streets could show the natures and characteristics of Shanghai streets. 19 study sites (C1-C7 & M1-M12) covered various types

of Shanghai district. For example, People's Square (C1) is the commercial center of Shanghai, Lujiazui (C2) is Shanghai’s CBD with high-rises and extraordinary wide streets, Xintiandi (C3) is a place integrating historical conservation, commercial activities, and tourist attraction, Shibo (C7) is an area of urban renewal after the 2010 Shanghai EXPO, and Guibei (M6) is an international community. *Table 4. 2* illustrates the features of each study site and Chapter 6.2 elaborates the location, function, characteristics, and more detailed introduction of each site. The study of these streets in various types of areas can reflect the characteristics of different types of Shanghai streets in a more comprehensive way, and reflect the performance differences of streets in different types of areas.

Table 4. 2: Code, Area Name and Area Features of 19 Study Sites

Site Code	Area Name	Area Features	District Type
M1	Wusong	Heavy Industry, International Port, Workers Housing	Residential area
M2	Gongkang	Workers Village, Resettlement Areas	Residential area
M3	Jiangwan	Newly Development Community	Residential area
M4	Siping	University Community, Teachers’ Housing	Residential area
M5	Zhenru	Workers Village	Residential area
M6	Gubei	International Community	Residential area
M7	CaoHeJin	Technology Development Zone	Industry area
M8	XinZhuang	New Developed Community	Residential area
M9	JinQiao	International Community	Residential area
M10	HuaMu	Park, Exhibition, High-End Community	Exhibition and leisure area
M11	Zhang Jiang	High Tech Park	Industry area
M12	Chuan Sha	Suburb Community	Residential area
C1	People Square	City Center	Commercial area
C2	Lujiazui	Central Business District	Busniess area
C3	XinTianDi	Historic Tourist Attraction, Traditional Shanghai Housing	Commercial area
C4	FaHuaZhen	Mature Community	Residential area
C5	NanShi	The Old City Area	Residential area
C6	XuJiaHui	Commercial Centre	Commercial area
C7	Shi Bo	EXPO Renewal Area	Business area

4.4.2.1.3 Survey Time

The survey time was from April 2016 to August 2017. The reasons to spend 16 months conducting the 1st field study were:

1) ***To cover four seasons:*** Investigation throughout one year which experiences four seasons of spring, summer, autumn, and winter could ensure a comprehensive understanding of street performance and the changes in street activities;
2) ***To visit each street 1-3 times:*** A survey of 236 streets in 19 areas was a massive task. Furthermore, each street was visited for 1 to 3 times in each season of the year, so the whole duration of the survey was relatively long;
3) ***To start with a pilot study:*** A pilot study was adopted at the beginning. A totally 50 streets were preliminarily investigated to test the reliability and robustness of field study design, which is introduced in Chapter 4.4.2.1.5.

4.4.2.1.4 Survey techniques

In the 1st Field Survey, two sets of tables, namely the preliminary rating tables of sustainable street evaluation and the checklists of on-site review indicators respectively, were used in the survey as the primary survey tools and through the methods of structured observation, photographing, field notes, and site measurement, thereby achieving the survey objectives.

The preliminary rating tables*:* Table 4. 3 shows the table used to assess the sustainability of each street. This rating table was devised based on the Evaluation Structure of Sustainable Streets which was the outcome of Research Stage One, and it consisted of fifteen evaluation criteria that represent social, economic, and environmental sustainability (elaborated in Chapter 3.4.4). The rating standards and guidelines for each criterion were devised in detail in Appendix A. Regarding the rating standard of 3-points and 4-levels system, there were two reasons for designing such a rating system and rating scale. Firstly, considering the practicality and applicability of this evaluation work, the 3-points rating system was adopted because it is simple, direct, and easy to operate compared with the system of 100 points, 10 points, or 5 points. More importantly, the system possesses the advantages to convert qualitative judgments into quantitative values more directly. Compared with the rating scale of 5 or 10 points, the 3-points system is unable to show the middle of an expression, for example pretty good or not bad, but this also benefits to avoid the ambiguity. Meanwhile, a bright and explicit definition of the rating standard can improve the accuracy of judgment and evaluation.

Secondly, the designed rating system that starts from 0 and forms a four-levels-grading scale was beneficial for reflecting the sustainability evaluation objectively and better transforming quantitative judgment into numerical values directly as well. Because this research was based on the sustainability assessment, the score indicates the achievement in sustainability. Specifically speaking, the scores of 1, 2, and 3 meant the performance regarding sustainable perspective was medium, good, and excellent respectively, while the score of 0 meant no positive performance and even negative performance concerning sustainability assessment. Figure 4. 6 illustrates various rating systems and compares the differences between the systems of this research with others.

The rating standards were designed based on the definition and requirements of each criterion. Also, the pilot study helped to refine the standard. Concerning the rating methods, all criteria could be scored through the comparison between field observations and the rating standard. Among these 15 assessment criteria, it is worth explaining the scoring method of C2 (Mitigation UHI) and C15 (Added-Value). The criteria of C2 (Mitigation UHI) were involved in the intuitive feeling of field temperature, so the study was conducted in summer with the outdoor temperature above 30 Degree Celsius. Then, the researcher visited the streets and scored the streets' performance based on intuitive feeling. Furthermore, the criteria of C15 (Added-Value) are to judge if the street can provide added value to the sided real estate and business. So, except for observation the researcher also needed to visit the agencies nearby, compare the market prices, as well as have a brief interview with some agents, thereby giving the score accordingly.

Figure 4. 6: Analysis of Different Rating Systems and Rating Scales

Table 4. 3: Preliminary Rating Table of Sustainable Street Evaluation for 1st Field Survey

Street Code & Name:
Survey Date:
Time:
Weather

Evaluation Criteria				**Rating**
	Code	**Title**	**Definition**	
Environmental Sustainability	*C1*	Adaptability	*Adaptation ability to local climate and Climate Change.*	
	C2	*Mitigation UHI*	*Contribution to the mitigation of Urban Heat Island effects.*	
	C3	Pollution Reduction	*Contribution to reducing pollution of air, noise, lighting, and waste.*	
	C4	Ecological Balance	*Minimising impact on the environment and support the ecological systems in the built environment.*	
	C5	Green Life Promotion	*Promotion and publicity of green lifestyle.*	
Social Sustainability	*C6*	Equality	*Providing convenient arrival for all kinds of people to support social equality.*	
	C7	Safety	*Providing safe and reliable streets to all users at all times of the day.*	
	C8	Accessibility	*Providing high accessibility for various ways of arrival.*	
	C9	Diversity	*Encouraging the diversity of street functions and the variety of street activities*	
	C10	Culture Inheritance	*Being in accord with the historical characteristics and cultural identity, thereby preserving, inheriting, and even shaping local culture.*	
Economic Sustainability	*C11*	Intensive Land Utilisation	*Intensive land utilisation and promote mixed and sharing usage within the streets.*	
	C12	Efficiency	*Promoting the efficient mobility for all street users.*	
	C13	Business Creation	*Creating various opportunities for street businesses.*	
	C14	Job Creation	*Creating various and considerable employment opportunities along the streets.*	
	C15	Added-Value	*Increasing the values and attractions of land, real estate, and businesses along the streets.*	
Note:				

The table was designed and made by the author

The checklists of on-site review indicators: All potential indicators had been listed in the Evaluation Structure of Sustainable Streets (Table 3. 12). It can be seen that all indicators were sorted into two types according to their selection methods, namely the indicators which need to be tested by fieldwork (Type O), and the indicators which need to be reviewed by deskwork (Type D). Hence, the indicators of type O constituted the checklist so that they could be examined during the Field Survey. Table 4.4 is the checklist of on-site review indicators. Nineteen checklists were to be filled out through the overall observation or some measurement testing during the survey of 19 study sites (from M1 to M12, and from C1 and C7). They were to provide evident-based judgments on the potential indicators' feasibility of on-site evaluation through a comprehensive field survey. The necessary explanation was also recorded in the column of notes of the checklists to some indicators. Moreover, 4 streets were randomly selected in each study site to measure and record relevant street data, including Street Green Rate and Average emission of noise. Therefore, a series of relevant data of 76 streets were recorded, and Chapter 7.3 will introduce how to use these data for indicators' normalisation.

Table 4. 4: Checklist of Onsite Review Indicators in 1st Field Survey

Study Site Code:
Start Date:
End Date:
Check each item.
Place a "√" after each item to designate it can be measured or assessed on site.
Place a "×" after each item to designate it cannot be measured or assessed on site.
Place a "" after any item requiring more explanation and have a brief description in the note*

Sub-targets Layer	Criterion Layer		Indicators Layer		Check	Note
	Code	**Title**	**Code**	**Title**		
Environmental Sustainability	*C1*	Adaptability	*C1c**	Adaptable capacity to local climate		
			C1d	Adaptable capacity to extreme weather events		
	C2	*Mitigation UHI*	*C2b*	Street green rate		
			C2c	% Street tree shading		
			C2d	Air Temp. difference		
	C3	Pollution Reduction	*C3b*	Average emission of noise		
			C3k	Waste management		
	C4	Ecological Balance	*C4d*	Site vegetation		
			C4e	Ecological planting		
			C4f	Number of Planting types		
			C4g	Rainwater management		

Sub-targets Layer	Criterion Layer		Indicators Layer		Check	Note
	Code	Title	Code	Title		
Environmental Sustainability	*C5*	Green Life Promotion	*C5a*	Public conversation events for street safety		
			C5b	Public Campaigns for traffic safety		
			C5c	Green lifestyle promotion		
			C5d	Green travel support		
Social Sustainability	*C6*	Equality	*C6a*	Tactile pavement for the blind		
			C6b	Barrier-free facilities		
			C6c	Transparency of the Party Wall		
	C7	Safety	*C7c*	Designed Traffic speeds		
			C7d	Coverage proportion of street camera		
			C7f	Coverage safety equipment		
	C8	Accessibility	*C8a*	Quality of service in public transport		
			C8b	Number of parking lots		
			C8c	Volume of vehicles, bus passengers, bicycle riders and users of public space		
			C8d	Bus system service Quality		
			C8e	Ridership on Bus		
			C8f	Bus Lane network		
			C8g	Cycling lane network		
			C8h	Coverage of sharing bike		
Social Sustainability	*C8*	Accessibility	*C8i*	Pedestrian access		
			C8j	Bicycle access		
			C8k	Transit access		
			C8l	The variety of arrival ways		
			C8m	Clear sign and guidance system		
	C9	Diversity	*C9a*	Diversity of street activity		
			C9c	Number of public seats		
			C9d	Diversity of street function		
	C10	Culture Inheritance	*C10a*	Number of Urban arts		
			C10b	Aesthetic Quality of urban art		
			C10c	Aesthetic Quality of street furniture		
			C10d	Style consistency with surroundings		
			C10e	Historical inheritance & culture display		
Economic Sustainability	*C11*	Intensive Land Utilisation	*C11a*	Intensiveness of street space		
			C11b	Mixed-use of street land		
	C12	Efficiency	*C12a*	Efficiency in parking/loading		
			C12b	Actual traffic speed		

Sub-targets Layer	Criterion Layer		Indicators Layer		Check	Note
	Code	Title	Code	Title		
Economic Sustainability			*C12c*	Parking Smart program		
			C12d	Intelligent transportation system		
	C13	Business Creation	*C13d*	Shops density		
			C13e	Temporary business		
	C14	Job Creation	*C14a*	Employment Creation		
			C14b	Number of employments		
			C14c	Types of employment		
	C15	Added-Value	*C15a*	Added Value of Commercial leases & rents		
			C15b	Added-Value of Real Estate Transactions & Market Sales		

** Note: The codes of indicators are a continuation of coding in Table 3.12. Since some of the indicators belong to Type D that is reviewed by deskwork. Therefore, the codes of indicators are not numbered in order.*

The **primary survey techniques** included structured observation, photographing, field notes, and site measurement. In general, the survey of every street required structured observation according to the rating table and checklist. Meanwhile photographing was employed to record the investigation and details of street performance. A set of site measurements were also conducted during the field work of each study site, thereby testing the feasibility of some potential indicators. Also, the field notes were taken for every survey day as a supplementary recording of field work.

Structured observation: The advantages of structured observation had been elaborated in Chapter 4.2.3. The structured observation was the primary survey technique in the 1st Field Survey. The researcher observed the street performance according to the items and requirements of the Rating Table and the Checklist, and meanwhile filled in the table or make records during the survey.

Photographing: The significance of photographing in social research was highlighted by many researchers because it provides a visual, direct, and comprehensive recording of the survey subjects (Rose, 2012; Pole & Lampard, 2002; Flick, 2014). In the 1st Field Survey, all relevant information of streets, including section layout, street facilities, public activities, and sided building façade, were recorded by photography. Besides, every visit of each street was photographed, thereby recording the street's conditions in four seasons. Therefore, at least ten photos were taken for each street to reflect its performance comprehensively. The photos were the necessary materials for the invited volunteer to assess the streets. Furthermore, except for the function of recording, photography also possesses the nature of the demonstration, because the photos can help to prove the objectivity and accuracy of the judgments. Each photo was renamed to show the shooting location and time. So, all the photos could be traced back to examine whether the rating results of each criterion in sustainability evaluation was objective enough and if the judgments of every indicator were reliable enough.

Field notes: The regular, systematic, and on-time documentation of an observation process is essential in the field survey because the written notes are crucial for the researcher to summarise the survey findings comprehensively and objectively. (Bryman & Bell, 2003; Silverman, 2005; Flick, 2014). Therefore, a series of notes were taken for each survey day in the 1st Fieldwork. The formats and contents of these field notes were diverse: sometimes it was to explain the details of the feasibility of indicators in the checklist, sometimes it was to describe the assessment procedure and rating reasons of every criterion, and sometimes it was to take brief records of the characteristics of the streets in a particular study site. All notes were the handwritten format, but they were all labelled with date, place, and codings of keywords for future search and analysis.

Site Measurement: In order to test some indicators of the checklist during fieldwork, the site measurement is necessary. Among all 55 listed indicators in the checklist, 5 indicators, namely C2b (Street green rate), C2c (% Street tree shading), C2d (Air Temp. difference), C3b (Average emission of noise-day), and C3c (Average emission of noise-night) respectively, needed to be tested by site measurement. Three types of instruments were required at this stage, and they were linen tape, Ambience Temperature Detector, and Noise detector. The corresponding relationship between indicators and measurement instruments and the specific product models of each measurement instruments can be seen in Table 4. 5. The Linen Tape was used to measure the wide of the street and green belt, the Ambience Temperature Detector was used to measure the air temperature of the evaluated street, and the Noise Detector was to measure the noise level of the streets. The data obtained from site measurement was tackled according to the indicator types, which is to be introduced in Chapter 7.3.

Table 4. 5: Measured Indicators and Measurement Instruments

Indicators	**Code**	***C2b***	***C2c***	***C2d***	***C3b***	***C3c***
	Name	Street Green Rate	% Street Tree Shading	Air Temp. Difference	Average Emission of Noise-Day	Average Emission of Noise-Night
Measurement Instruments	**Name**	*Linen Tape*		*Ambience Temperature Detector*	*Noise Detector*	
	Product Model	*WENXIN-100m*		*Testo 410-2*	*iPhone 7 "Decibel 10": Version 5.3.3 (2172)*	
	Photo					

Note: the table was designed and made by the author.

4.4.2.1.5 Volunteer participation

Because the rating system of this stage is primarily a qualitative judgment, the personal influence is an inevitable factor in the judgment process. Therefore, in order to reduce the personal subjectivity and reinforce the scoring mechanism, one volunteer was invited to participate in the sustainability assessment of 236 Shanghai streets.

This volunteer has sufficient background knowledge and rich research experiences to complete the preliminary assessment. He has a master degree in architecture and a master degree in urban planning. Moreover, he has rich experience in urban researches, especially on public streets. Besides some published papers on urban streets, he also participated in a national research project on the retrofit of Shanghai streets as a leading researcher. Table 4. 6 shows the detail description of the volunteer's information. Concerning the data protection, he also signed a consent form to declare his understanding of voluntary participation and relevant right (Appendix I).

Table 4. 6: Background Introduction of the Volunteer

Gender	Age	Position	Company	Education Background
Male	37	CEO	Shanghai Hui Agricultural Science & Technology Co., Ltd	- MSc. Green Building. Wales School of Architecture. Cardiff University - MSc. Urban planning and design, College of Architecture and Urban Planning (CAUP), Tongji University - Bachelor, Urban Planning, CAUP. Tongji University

This volunteer was well informed of the research purpose, survey objective and the rating standard. Then he was asked to look at the streets' photos and comparing the street performance with the rating standard, thereby rating 236 streets. The street photos which had been taken by the researcher during the site visit were provided to the volunteer. Moreover, he was also asked to check the streetscape via Baidu Map (https://map.baidu.com/) to have a comprehensive understanding of the street performance. It must be acknowledged that the volunteer did not rate C2 (Mitigation UHI) and C15 (Added-Value) because of the specificity of their evaluation requirements (explained in Chapter 4.4.2.1.4).

Then, the assessment scores from the volunteer were averaged with those from the researcher, thereby calculating the final assessment results. The average method was used to synthesize the scores of the researcher and the volunteer, which was mainly based on the following two considerations: the first was that the volunteer had as rich academic background and research experience as the author; and the second was that the average calculation method was conducive to reducing the subjectivity of the researcher who had designed the evaluation system and relevant criteria. A potential problem might be on how could the volunteer give an overall assessment regarding the various performance of seasonal situations of the streets. The street photos taken by the author during site investigation showed the seasonable varieties of the streets, and the online street views could also reflect the streets' performance in different seasons. Therefore, theoretically speaking, the volunteer could basically have a comprehensive understanding of the actual situation of the streets and made an objective evaluation. The specific method of combination and calculation will be introduced in Chapter 4.4.2.3.

4.4.2.1.6 Pilot Survey

The pilot study is to conduct a "*small-scale version or trial run in preparation for a major study*" (Polit, et al., 2001, p. 467). According to Baker (1994), 10%-20% of the sample size for the actual study is a reasonable number of sample size enrolling in a pilot. Therefore, a pilot survey was conducted in March 2016. Also, a total of 50 streets, accounting for 20% of the total sample size, were randomly selected from the 19 pieces of study sites and visited by the researcher. The primary purpose of the pilot survey was to detect the problems concerning survey instruments, procedure, and validity, and to find relevant solutions.

Firstly, the pilot survey was to pre-test the research instruments. Above all, the researcher was to fill in the Rating Table of sustainability evaluation through the field observation according to the designed Rating Standard for the 50 streets of the pilot survey. So, some optimisations were made to the rating standard based on the rating experience and observation findings in the pilot survey, and they included a more detailed description and constraints of the quantitative definition of some rating levels. Meanwhile, the researcher also needed to pre-test the usage of the indicator checklists and to compare the measurement instruments in this pilot survey.

Secondly, the pilot survey was to check the efficiency and reasonability of the survey procedure. With regarding the sustainability rating process of each street, the whole process of street visit, photographing and rating recording was refined several times to make it accurate and efficient. Based on several times' testing, the survey procedure was first to walk on both sides of sidewalks and to take photographs, then filling the rating table afterwards. According to the experiences of pilot survey, the street types and features were roughly the same within one study site, so it was enough to choose 2-3 streets to check the feasibility of the evaluation indicators in the checklists at the end of the survey in each study site.

Thirdly, the pilot survey was to examine the validity of the statistics and analysis of survey data. The pilot study of 50 streets shows that the data statistics and analysis in excel was feasible. However, the rating results were not objective enough if outcomes only relied on the on-site grading of the researcher. Therefore, in order to reinforce the data validity and also consider the limitation of resources and labour, the rating mechanism was optimised based on the discussion with the supervisor. More photos were taken during the site survey of each street, so all the rating results were traceable. Meanwhile, one volunteer, who has the educational background and working experiences of urban researches, was invited to fill in the rating table based on the comparison of the streets' photos and the same rating standard. The approach was proved to be feasible through the test of 50 streets.

In summary, the pilot survey pre-tested the feasibility of the research instruments, checked the efficiency of the survey procedure, and examined the validity of the statistics of survey data. All the testing results and optimisations had been reflected in the survey design of the 1st Field Survey. And the researcher visited a

4.4.2.2 Expert Questionnaires

4.4.2.2.1 Survey Objective

The method of Expert Questionnaires was adopted to collect the first-hand data for the calculation of the weights for the establishment of the Indicator System. In other words, the questionnaires were to obtain a certain number of experts' judgments on the importance of fifteen criteria in the Indicator System, thereby calculating the weighting system for the evaluation framework.

4.4.2.2.2 Method rationale

Why was the Expert Questionnaire selected as the method to construct the weighing system?

There are various methods to construct the weighing system, and these methods can be sorted into three types in general, namely statistical models, participatory approaches, and equal weights. All have their pros and cons. The Statistical Model, which relies on a mathematically formalised way to calculate weights, is considered to object, rational, and direct, but also is criticised of its mechanical and straightforward system without the consideration of flexibility (OECD & JRC, 2008). Principal components analysis (PCA), Factor Analysis (FA), Unobserved Components Model (UCM), and Data

Envelopment Analysis (DEA) are the techniques derived from Statistics Models. The Participatory Approach, which is to involve and empower the stakeholders' opinions to constructing weighting system, is often adopted because of the sharing of knowledge and experiences, and better reflection policy priority or theoretical factors (OECD & JRC, 2008; Guijt, 2014). Also, the typical cases include Budget Allocation Processes (BAP), Conjoint Analysis (CA), and Delphi Method (DM). Equal weighting (EW) is to give all variables the same weight. It is often used as there is no statistical or an empirical basis for choosing weights (Jacobs, et al., 2004).

Comparing the features and application of these weighting methods, the Participatory Approach is more suitable for this research. Because the correlation and benchmarks of selected indicators are limited, the fundamental data are not enough to build the statistic models. Furthermore, the characteristics of the Participatory Approach can better reflect the theoretical factors. This research is to evaluate sustainable streets, and the whole procedure of constructing the theoretical structure, selecting the Indicator System, and designing the normalisation methods is exploratory. Therefore, the Participation Approach can not only collect valuable opinions from the professionals but also help to optimise the evaluation framework.

Based on this, the three typical techniques in the Participatory Approach, namely the Delphi Method (DM), the Analytic Hierarchy Process (AHP), and the Expert Questionnaire respectively, were studied in depth. Finally, the Expert Questionnaire was selected for this study.

Delphi Method (DM) was not employed in this study due to time-consuming and repeated survey and modification. The DM is a structured survey technique that follows a prescribed procedure and relies on a panel of experts (Dalkey & Helmer, 1963; Sackman, 1974; Linstone & Turoff, 1975). When the technique is applied to solve the weighting issue of an evaluation system, a group of experts is firstly selected. These experts are asked to answer questionnaires on the importance of the evaluated item back-to-back for two or more rounds. The questionnaire results of each round are analysed and summarised into an anonymised feedback and send back to the experts' panel with a series of related questions. Then, the experts are encouraged to review or revise their answers based on the questionnaire statistics of last round. Then, the range of the answers will decrease, and the expert group will come out with the "correct" answer through several rounds of feedback and review, thereby forming the weighting system for the evaluation framework. The DM requires 6-12 experts who have fairly authority in the field. These experts are to participate in at least three rounds' questionnaires and modify their answers accordingly. More importantly, the evaluated variables for the DM are below 10. However, the evaluation framework contains 15 criteria and a total of 30 indicators. During the stage of research design, the researcher invited ten Chinese experts who were famous and authoritative in the field of evaluation and management of sustainable streets in China. However, eight of them refused this invitation due to the time-consuming and complicated procedure.

The Analytic Hierarchy Process (AHP) is another structured technique for dealing with complex decision making. When it is used to determine the weights of the evaluation system, the first step is to build a hierarchical structure of the selected criterion in the evaluation system, and then a group of experts is asked to compare the importance to form the matrix of comparison judgments. Finally, the weights of each criterion are calculated based on a particular method, such as a geometric method or Standard Column Averaging Method. It is generally believed that the number of evaluated elements should be less than 4, and not exceed 9 (Pecchia, et al., 2013; Wu & Li, 2004). Too many evaluated elements tend to cause massive workload because the participated experts are to modify and review their answers repeatedly once the matrix does not meet the consistency. Therefore, the AHP method was not adopted in this study because of the nature of the evaluation framework and substantial potential workload.

The expert questionnaire was finally selected because of its simple procedure, easy operability, and high adaptability. Based on a comprehensive comparison, the expert questionnaire is the most suitable method to build the weighting system for the established evaluation structure. Also, it is the fundamental and essential technique to collect the direct and primary judgments from respondents, which is also the primary technique adopted by both Delphi and AHP.

Table 4. 7 shows a summary and comparison of the available weighting methods.

4.4.2.2.3 Sample Selection

50 authoritative experts and scholars in the field of China were selected as the respondents of the Questionnaire Survey. The sample size was set based on the time and ability limits of the researcher. All the selected participants have background knowledge of urban planning and designing and obtain at least the bachelor degree from architecture school. Also, the working experiences of all selected respondents were at least ten years, so they possessed rich experiences and deep insights in the study, planning, and management of Shanghai streets. Appendix A lists the details of invited experts.

Table 4. 7: A summary of different weighting methods

Types of Methods	Brief	Pros & Cons	Main Techniques	Brief	Application
Statistical Models	*Mathematically-formalised way to calculate weights*	***Pros:*** *- A pure mathematical calculation to minimise subjectivity;* *- Rational & direct.* ***Cons:*** *- The definition of basic condition must be precisely and clearly;* *- A simple system without integrity;* *- Mechanical.*	**Principal components analysis (PCA)** **Factor Analysis (FA)**	*It is to group individual indicators according to the correlation and then to calculate the weighting matrix with the idea of accounting for the highest possible variation in the indicator set using the smallest possible number of factors.*	*The Indicator System in which the correlation between indicators is strong*
			Unobserved Components Model (UCM)	*Individual indicators are assumed to depend on an unobserved variable plus an error term. This method resembles the regression analysis.*	*The Indicator System with sufficient data and the correlation of indicators is not high.*
			Data Envelopment Analysis (DEA)	*It employs linear programming tools to estimate an efficiency frontier that would be used as a benchmark to measure the relative performance of countries/cities.*	*The Indicator System in which there are benchmarks for all indicators.*
Participatory Approaches	*Involvement and empowerment of stakeholders' opinions on constructing the weighting system*	***Pro:*** *- Sharing knowledge and experience;* *- Better reflection policy priorities or theoretical factors;* *-Combination of the qualitative judgments into the quantitative calculation.* ***Cons:*** *- Inevitable impact of subjectivity.*	**Delphi Method (DM)**	*A panel of experts are asked to fill out the questionnaire, and then modify the answers according to the feedbacks until the panel reaches a consistent answer.*	*The expert in the panel should be 6-12. The evaluated indicators should be less than 10.*
			Analytic Hierarchy Process (AHP)	*Experts are asked to compare between pairs of individual indicators. The relative weights of the individual indicators are calculated using an eigenvector. The core of AHP is an ordinal pairwise comparison of attributes.*	*The number of evaluated indicators should be less than 4, no more than 9.*
			Expert Questionnaire	*A group of experts are surveyed by questionnaires regarding the importance of evaluation criteria or indicators, and the weights are calculated accordingly.*	*It is a flexible and straightforward method.*
			Conjoint Analysis (CA)	*It is a decompositional multivariate data analysis technique, and it asks for evaluation (a preference) of a set of alternative scenarios. A scenario might be a given set of values for the individual indicators. The preference is then decomposed by relating the single components to the evaluation*	*The number of evaluated indicators is limited, typically 4 to 5.*
			Budget Allocation Processes (BAP)	*Experts are given a "budget" of N points, to be distributed over many individual indicators, and asked to "pay" more for those indicators whose importance they want to stress, thereby calculating the weights accordingly.*	*The Indicator System with maximum10-12 indicators.*
Equal Weighting	*Variables are given the same weight*	***Pro:*** *- Simple system;* *- An approach as there is no statistical or an empirical basis for choosing weights;* ***Cons:*** *- Unsuitable to the variables with a high degree of correlation.*			

The table is made by the author, and the contents were adapted from (Jacobs, et al., 2004; OECD & JRC, 2008; Pecchia, et al., 2013; Sackman, 1974; Vithala, 2011; Charnes, et al., 1994)

4.4.2.2.4 Procedure design

Before the survey, formal invitation letters were sent to all selected experts by email in September 2017. The invitation included details of the project as well as information about data protection and voluntariness of participation (see Appendix C).

The questionnaires were handed out via a survey online survey platform (Wenjuanxing https://www.wjx.cn/). The questionnaire was inputted into the online database. As soon as the respondent accepted the survey, a survey link was sent to him/her. So, he/she could open the questionnaire link and complete the questionnaire online. As the respondent clicked the button of "Done", the survey result was uploaded to the online database. All survey results could only be accessed and download via the username and password that were registered by the researcher. Completion of the questionnaire was not to exceed ten minutes.

4.4.2.2.5 Questionnaire design

The questionnaire consisted of three parts (see Appendix D):

1) A brief introduction to the research purpose.
2) 15 questions: The main body of the questionnaire was to ask the respondent to judge the importance of the 15 evaluation criteria. There were five judgment levels of the importance for the respondent to choose, namely very important, important, medium, unimportant, no relationship respectively.
3) The gratitude of the respondents' time and devote.

Considering all the respondents were experts and scholars in this field who possessed sufficient professional knowledge, the wording of the questionnaire was kept the same as that in the research, including the description and definition of these criteria.

4.4.2.2.6 Pre-test

A pre-test of the questionnaire instrument before the data collection is necessary to ensure the results' validity and process efficiency (Crouch, 2003; Blair, 2014; Baines & Chansarkar, 2002). As a pre-test population, 5%-10% of the final sample is common (Perneger, et al., 2015). Hence, ***a pre-test with a group of 5 respondents who were also involved in the final survey was undertaken in August 2017.***

The functions of this pre-test study were:

1) To test the rationality of the questionnaire design: After collecting the pre-test questionnaire, phone calls were made with five respondents to obtain their feedback about this questionnaire, including if the wording of this questionnaire was appropriate, the overall layout was clear, and the filling was convenient. Based on the feedback, a slight modification of the question layout was made for the final version, including changing the professional vocabularies into simple wordings, condensing the questions' expression, and presenting a more reader-friendly layout.
2) To test the reliability of the online questionnaire platform: The pre-test was also used to check the reliability and efficiency of the platform for the electronic questionnaire survey, including whether the web page could be open in time, whether all contents were shown clearly, and whether the survey results could be upload in time as the respondent completes the answer. Finally, the platform of Wenjuanxing (https://www.wjx.cn/) was proved to be reliable.
3) To test the availability of all raw data: The last objective of the pre-test was to check if all the raw data of the questionnaire results could be downloaded from the platform and be easily analyzed for the further data statistics by the researcher. The test results proved that the download was convenient and downloaded data was complete. Also, these data could be analyzed accordingly.

4.4.2.3 Data Analysis Techniques

The data collected in the research stage two from the 1st Field Survey and Expert questionnaire could be categorised into two types: one was qualitative data, and the other one was quantitative data. These two types of data were all systematically organised into two digital formats, namely Microsoft Word and Microsoft Excel, for easy searching, sorting, and analysing.

Descriptive statistics were employed to analyse the data collected from the sustainability rating of 236 Shanghai streets. The researcher inputted the rating results into excel after fieldwork, and meanwhile, the volunteer inputted his evaluation results accordingly. The final assessment scores of each criterion (except for C2 and C15) were calculated by 50% of the author's score and 50% of the volunteer's score. The details of volunteer participation and the reason why the average method was used for this study had been explained in chapter 4.4.2.1.5. Through analysis and comparison, the scores of researchers and volunteers were similar overall.

As soon as the values of 15 criteria in the evaluation framework were inputted in the data file of Excel, all the other values could be calculated accordingly. Table 4. 8 shows the data file of Excel and the calculation formulas for each layer. The arithmetic average was employed to calculate the average performance of criteria and sub-target for each study site. Then, the arithmetic summation was adopted to calculate the values of Street Sustainability Indexes (SSIs). Therefore, the SSIs equalled to the summation of the values of fifteen criteria.

The descriptive statistics were also employed to analyse these data since it is an efficient technique to summarise and describe the features of a collection of quantitative data (Mann, 1995). The measures of central tendency and dispersion, such as mean, median, standard deviation, minimum and maximum values, were used to describe the sustainability evaluation results with an aim to understand the overall performance of Shanghai streets as well as to find the sample cases for further study.

Concerning the weighting calculation from expert questionnaires, the Multi-Criteria Analysis (MCA) was adopted since it is a clear and easy to follow approach to assigning relative weights based on the level of importance (Ahire & Rana, 1995; Dyer, et al., 1992). The Expert Questionnaire possessed the fundamental essence of MCA, and its statistics followed the principle and mechanism to calculate weights of different criteria. Explicitly speaking, all raw data were downloaded online with the version of excel. After a simple data inspecting and cleaning, the questionnaire results were organised into one excel for statistics. Then, based on the principle that the sum of weights' values of five criteria in the same sustainable aspect equal to 0.333, the weighting coefficient of each evaluation criterion was calculated accordingly.

Regarding the qualitative data obtained in Research Stage Two, the Coding method was employed as the primary technique for data analysis. Coding is an essential approach for data analysis in social sciences, especially in the sorting, analysing, and summarising of qualitative data (Hay, 2005; Saldana, 2015). Firstly, the context study of Shanghai streets was conceptualised through "pattern codes" technique. The keywords and text threads that were related to the main research questions of this stage were identified as codes and their clusters, which effectively constitutes the "prior codes" of the coding system. Then the text passages were analysed through "topic coding". Therefore, all the data were recorded and sorted systematically and digitally, which not only allowed an initial corroboration of the theory but also benefited for further comparison and summary.

Figure 4. 7 provides a whole picture of the methods and techniques of data collection and analysis in Research Stage Two.

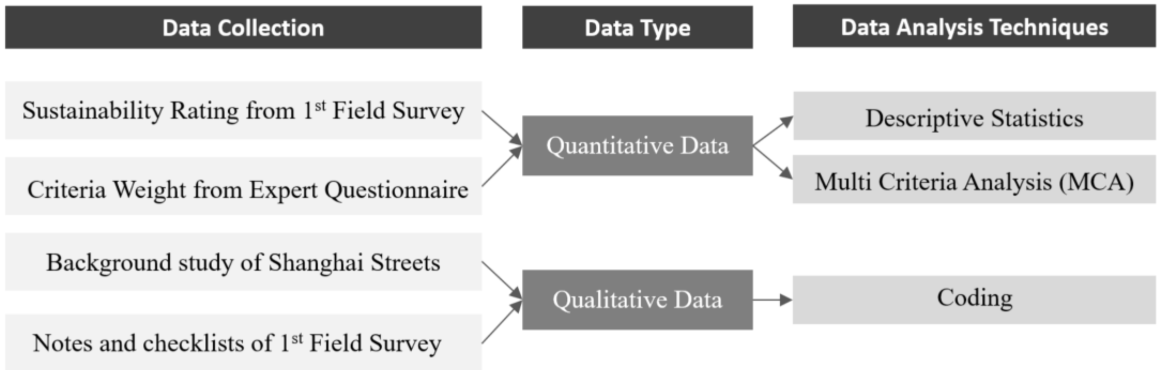


Figure 4. 7: Data Collection and Analysis in Research Stage Two

Table 4. 8: Formulas of the Evaluation Framework of Sustainable Streets for the 1st Field Survey

Street Code	Environmental Sustainability					Social Sustainability					Economic Sustainability					Final
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
Mx-1	$C1_{(x-1)}$	$C2_{(x-1)}$	$C3_{(x-1)}$	$C4_{(x-1)}$	$C5_{(x-1)}$	$C6_{(x-1)}$	$C7_{(x-1)}$	$C8_{(x-1)}$	$C9_{(x-1)}$	$C10_{(x-1)}$	$C11_{(x-1)}$	$C12_{(x-1)}$	$C13_{(x-1)}$	$C14_{(x-1)}$	$C15_{(x-1)}$	**SSI_{Mx-1}**
Mx-2	$C1_{(x-2)}$	$C2_{(x-2)}$	$C3_{(x-2)}$	$C4_{(x-2)}$	$C5_{(x-2)}$	$C6_{(x-2)}$	$C7_{(x-2)}$	$C8_{(x-2)}$	$C9_{(x-2)}$	$C10_{(x-2)}$	$C11_{(x-2)}$	$C12_{(x-2)}$	$C13_{(x-2)}$	$C14_{(x-2)}$	$C15_{(x-2)}$	**SSI_{Mx-2}**
Mx-3	$C1_{(x-3)}$	$C2_{(x-3)}$	$C3_{(x-3)}$	$C4_{(x-3)}$	$C5_{(x-3)}$	$C6_{(x-3)}$	$C7_{(x-3)}$	$C8_{(x-3)}$	$C9_{(x-3)}$	$C10_{(x-3)}$	$C11_{(x-2)}$	$C12_{(x-2)}$	$C13_{(x-2)}$	$C14_{(x-2)}$	$C15_{(x-2)}$	**SSI_{Mx-3}**
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Mx-n	$C1_{(x-n)}$	$C2_{(x-n)}$	$C3_{(x-n)}$	$C4_{(x-n)}$	$C5_{(x-n)}$	$C6_{(x-n)}$	$C7_{(x-n)}$	$C8_{(x-n)}$	$C9_{(x-n)}$	$C10_{(x-n)}$	$C11_{(x-n)}$	$C12_{(x-n)}$	$C13_{(x-n)}$	$C14_{(x-n)}$	$C15_{(x-n)}$	**SSI_{Mx-15}**
Mx Average	**$C1_{Mx}$**	**$C2_{Mx}$**	**$C3_{Mx1}$**	**$C4_{Mx}$**	**$C5_{Mx}$**	**$C6_{Mx}$**	**$C7_{Mx}$**	**$C8_{Mx}$**	**$C9_{Mx}$**	**$C10_{Mx}$**	**$C11_{Mx}$**	**$C12_{Mx}$**	**$C13_{Mx}$**	**$C14_{Mx}$**	**$C15_{Mx}$**	**SSI_{Mx}**
	EnSI = Average [$C1_{Mx}$,$C2_{Mx}$,$C3_{Mx}$,$C4_{Mx}$,$C5_{Mx}$]					**SoSI** = Average [$C6_{Mx}$,$C7_{Mx}$,$C8_{Mx}$,$C9_{Mx}$,$C10_{Mx}$]					**EcSI** = Average [$C11_{Mx}$,$C12_{Mx}$,$C13_{Mx}$,$C14_{Mx}$,$C15_{Mx}$]					

$C1_{M1}$ =Average [$C1_{(x-1)}$, $C1_{(x-2)}$, $C1_{(x-3)}$,… $C1_{(x-n)}$]	SSI_{Mx-1} = Sum [$C1_{(x-1)}$, $C2_{(x-1)}$, $C3_{(x-1)}$, … $C15_{(x-1)}$]
$C2_{M1}$ = Average [$C2_{(x-1)}$, $C2_{(x-2)}$, $C2_{(x-3)}$,… $C2_{(x-n)}$]	SSI_{Mx-2} = Sum [$C1_{(x-2)}$, $C2_{(x-2)}$, $C3_{(x-2)}$, … $C15_{(x-2)}$]
$C3_{M1}$ = Average [$C3_{(x-1)}$, $C3_{(x-2)}$, $C3_{(x-3)}$,… $C3_{(x-n)}$]	SSI_{Mx-3} = Sum [$C1_{(x-3)}$, $C2_{(x-3)}$, $C3_{(x-3)}$, … $C15_{(x-3)}$]
……	……
Cn_{M1}= Average [$Cn_{(x-1)}$, $Cn_{(x-2)}$, $Cn_{(x-3)}$,… $Cn_{(x-n)}$]	SSI_{Mx-15} = Sum [$C1_{(x-15)}$, $C2_{(x-15)}$, $C3_{(x-15)}$, … $C15_{(x-15)}$]
SSI_{Mx} = Sum [$C1_{Mx}$, $C2_{Mx}$, $C3_{Mx}$, … $C15_{Mx}$]	

Made by the author.

4.4.3 Research Stage Three

In Research Stage Three, the methods of data collection included the 2nd Field Survey and Street Questionnaires, and the techniques of data analysis were Descriptive Statistics, Inferential Statistics, and Comparative Analysis.

4.4.3.1 2nd Filed Survey

4.4.3.1.1 Survey Objectives

The primary objective of the 2nd Field survey was to apply the Indicator System of Sustainability Evaluation to three selected Shanghai streets and evaluate their sustainability.

4.4.3.1.2 Sample Selection

Three Shanghai streets which were outstanding from the 1st field survey were selected as survey samples in this stage. They were Daxue Rd, Sujiatun Rd, and Madang Rd respectively. The features and details of these three sample streets are to be elaborated in Chapter 6 and Chapter 7.

4.4.3.1.3 Survey Time

A total of 30 indicators were surveyed in each street at this stage. Some of the indicators were unvaried with the survey time, but the others changed with day and night or workday and weekend. Therefore, Table 4. 9 lists the changing situation and the demand of survey time for each indicator. It can be seen that the survey time of three indicators, namely C2-2 (Air Temp. Difference), C9-1(Diversity of Street Activities), and C13-2(Types of Temporary Business) respectively, needed to be designed particularly. Based on the survey requirements, the survey time of these indicators was designed in Table 4. 10.

Furthermore, it had been found in the 1st Field Survey that the average performance of urban streets shows in spring and autumn since the weather is pleasant and street performance is relatively stable. Therefore, considering the requirements, the specific survey time of each street was determined as follows:

- **Madan Rd:**

  Survey Day 1: *25th July 2017 (10 am to 2 pm): Sunny day, the measurement of C2-2*
  Survey Day 2: *3rd November 2017 (8 am to 8 pm): sunny weekday (Fri.);*
  Survey Day 3: *5th November 2017 (8 am to 8 pm): sunny weekend (Sun.).*

- **Daxue Rd:**

  Survey Day 1: *12th July 2017 (10 am to 2 pm): Sunny day, the measurement of C2-2*

  Survey Day 2: *27th October 2017 (8 am to 8 pm): sunny weekday (Fri.);*

  Survey Day 3: *28th October 2017 (8 am to 8 pm): sunny weekend (Sat.).*

- **Sujiatun Rd:**

  Survey Day 1: *22nd July 2017 (10 am to 2 pm): Sunny day, the measurement of C2-2*

  Survey Day 2: *2nd Novermber.2017 (8 am to 8 pm): sunny weekday (Thu.).*

  Survey Day 3: *4th November 2017 (8 am to 8 pm): sunny weekend (Sat.).*

Table 4. 9: Analysis of Survey Time of Indicators in the Evaluation Framework

Sub-target Layer	Criteria Layer		Indicators Layer		Analysis of Survey time	
	Code	Title	Code	Title	Changing with time	Requirements of Survey time
Environmental sustainability	C1	Adaptability	*C1-1*	Adaptable Capacity to Local Climate	×	
			C1-2	Adaptable Capacity to Extreme Weather Events	×	
	C2	*Mitigation UHI*	*C2-1*	Street Green Rate	×	
			C2-2	Air Temp. Difference	√	*Summer days; Sunny; Air Temp. >30 ℃*
	C3	Pollution Reduction	*C3-1*	Average Emission of Noise	×	
			C3-2	Pollution Reduction	×	
	C4	Ecological Balance	*C4-1*	Rainwater management	×	
			C4-2	Ecological Planting	×	
	C5	Green Life Promotion	*C5-1*	Green Lifestyle Promotion	×	
			C5-2	Green Travel Support	×	
Social sustainability	C6	Equality	*C6-1*	Tactile pavement for the blind	×	
			C6-2	Barrier-Free Facilities	×	
	C7	Safety	*C7-1*	Coverage Proportion of Street Cameras	×	
			C7-2	Coverage of Safety Equipment	×	
	C8	Accessibility	*C8-1*	The Variety of Arrival Ways	×	
			C8-2	Clear Sign and Guidance System	×	
	C9	Diversity	*C9-1*	Diversity of Street Activities	√	*Weekdays & Weekends*
			C9-2	Diversity of Street Functions	×	
	C10	Culture Inheritance	*C10-1*	Aesthetic Quality of Street Furniture	×	
			C10-2	Style Consistency with Surroundings and Local History	×	
Economic sustainability	C11	Intensive Land Utilisation	*C11-1*	Intensiveness of Street Space	×	
			C11-2	Mixed-Use of Street Space	×	
	C12	Efficiency	*C12-1*	Intelligent Transportation System	×	
			C12-2	Traffic Performance Index	×	
	C13	Business Creation	*C13-1*	Density of Shops	×	
			C13-2	Types of Temporary Business	√	*Weekdays & weekends*
	C14	Job Creation	*C14-1*	Employment Creation	×	
			C14-2	Types of Jobs	×	
	C15	Added-Value	*C15-1*	Added-Value of Commercial Rents	×	
			C15-2	Added-Value of Housing Prices	×	

Table 4. 10: Plan of Survey Time for Selected Indicators

Indicator Code	Indicator Title	Survey Time	Survey Techniques
C2-2	Air Temp. Difference	In Summer, sunny days, Air Temp. >30℃ - *Morning(10am);* - *Noon(12am);* - *Afternoon (2pm).*	On-site measurement
C9-1	Diversity of Street Activity	Both on Weekdays & Weekends - *Morning (10 am);* - *Noon(12am);* - *Afternoon (2 pm);* - *Night (7-8pm).*	On-site observation
C13-2	Temporary Business	Both on weekdays & weekends; - *Weekday: 8-9am & 5-6pm;* - *Weekend: 2-3pm & 7-8pm.*	On-site observation

4.4.3.1.4 Survey Techniques

The sustainability evaluation framework included 30 quantitative indicators. Table 4. 11 illustrates the details of the acquisition mode, necessary survey instruments and data processing of these indicators. There are three types of indicators concerning the acquisition mode:

Type One - Observation and Normalisation: The first types of indicators were the indicators that were linked to the use and accomplishment degree of sustainable design methods or technologies. Hence, the primary survey method of these indicators was to observe on-site firstly to fill in the evaluation tables and then to rate these indicators according to the relevant normalisation methods. The indicators of Type One included:

1) *C1-1 Adaptable capacity to local climate*
2) *C1-2 Adaptable capacity to extreme weather events*
3) *C3-2 Pollution reduction*
4) *C4-1 Rainwater management*
5) *C4-2 Ecological planting*
6) *C5-1 Green lifestyle promotion*
7) *C5-2 Green travel support*
8) *C6-1 Tactile pavement for the blind*
9) *C6-2 Barrier-free facilities*
10) *C7-2 Coverage safety equipment*
11) *C8-1 Variety of arrival ways*
12) *C8-2 Clear sign and guidance system*
13) *C9-2 Diversity of street functions*
14) *C10-1 Aesthetic Quality of street furniture*
15) *C10-2 Style consistency with surroundings and local history*
16) *C11-1 Intensiveness of street space*
17) *C11-2 Mixed-use of street land*

18) *C12-1 Intelligent transportation system*

Type Two - Measurement and Normalisation: The indicators of Type Two were the indicators linked to measured values. The initial diagnoses of these indicators were obtained by on-site measurement. Then, these initial diagnoses were transformed into evaluation results according to the designed normalisation methods. This type of indicators included:

1) *C2-1 Street green rate*
2) *C2-2 Air Temp. difference*
3) *C3-1 Average emission of noise*
4) *C7-1 Coverage proportion of street cameras*
5) *C9-1 Diversity of street activities；*
6) *C13-1 Shops' density*
7) *C13-2 Temporary business*
8) *C14-1 Employment Creation*
9) *C14-2 Types of jobs*

Type Three - Data Searching and Normalisation: The third type of indicators were indicators linked to normative values which were published officially by some agency or government department. Hence, in order to obtain the rating of these indicators, the first step was to search and record the relevant data from the online information or relevant documents, and then to transform them into rating results based on some normalisation methods. This type of indicators included:

1) *C12-2 Traffic Performance Index*
2) *C15-1 Added-Value of Commercial rents*
3) *C15-2 Added-Value of housing prices*

Based on the analysis of indicator types, it can be summarised that the survey techniques in the 2nd Field Survey included structured observation, site measurement, and photographs respectively.

Structured Observation: The researcher was to observe 18 indicators labelled as Type One Group of "*Observation and Normalisation*", and meanwhile recorded the observation findings accordingly on site.

***Site Measurement*:** The researcher was to measure 9 indicators labelled as Type Two Group of "*Measurement and Normalisation*". In addition to the general counting, Table 4. 12 lists the instruments to the measurement of temperature, length, and noise.

Photographing: Photographing was employed as the critical survey techniques in the 2nd Field survey to record the whole survey process.

Table 4. 11: Analysis of Data Acquisition Methods for the Indicator System

Sub-target Layer	Criteria Layer		Indicators Layer		***Data Acquisition & Processing***	
	Code	**Title**	**Code**	**Title**	***Acquisition Mode***	***Necessary Instruments***
Environmental Sustainability	C1	Adaptability	C1-1	Adaptable Capacity to Local Climate	*Type One*	-
			C1-2	Adaptable Capacity to Extreme Weather Events	*Type One*	-
	C2	*Mitigation UHI*	C2-1	Street Green Rate	*Type Two*	*Linen Tape*
			C2-2	Air Temp. Difference	*Type Two*	*Temp. Detector*
	C3	Pollution Reduction	C3-1	Average Emission of Noise	*Type Two*	*Noise Detector*
			C3-2	Pollution Reduction	*Type One*	-
	C4	Ecological Balance	C4-1	Rainwater management	*Type One*	-
			C4-2	Ecological Planting	*Type One*	-
	C5	Green Life Promotion	C5-1	Green Lifestyle Promotion	*Type One*	-
			C5-2	Green Travel Support	*Type One*	-
Social Sustainability	C6	Equality	C6-1	Tactile pavement for the blind	*Type One*	-
			C6-2	Barrier-Free Facilities	*Type One*	-
	C7	Safety	C7-1	Coverage Proportion of Street Cameras	*Type Two*	-
			C7-2	Coverage of Safety Equipment	*Type One*	-
	C8	Accessibility	C8-1	The Variety of Arrival Ways	*Type One*	-
			C8-2	Clear Sign and Guidance System	*Type One*	-
	C9	Diversity	C9-1	Diversity of Street Activities	*Type Two*	-
			C9-2	Diversity of Street Functions	*Type One*	-
	C10	Culture Inheritance	C10-1	Aesthetic Quality of Street Furniture	*Type One*	-
			C10-2	Style Consistency with Surroundings and Local History	*Type One*	-
Economic Sustainability	C11	Intensive Land Utilisation	C11-1	Intensiveness of Street Space	*Type One*	-
			C11-2	Mixed-Use of Street Space	*Type One*	-
	C12	Efficiency	C12-1	Intelligent Transportation System	*Type One*	-
			C12-2	Traffic Performance Index	*Type Three*	*Official information*
	C13	Business Creation	C13-1	Density of Shops	*Type Two*	-
			C13-2	Temporary Business	*Type Two*	-
	C14	Job Creation	C14-1	Employment Creation	*Type Two*	-
			C14-2	Types of Jobs	*Type Two*	-
	C15	Added-Value	C15-1	Added-Value of Commercial Rents	*Type Three*	*Official information*
			C15-2	Added-Value of Housing Prices	*Type Three*	*Official information*

Table 4. 12: Indicators and Measurement Instruments

Indicators		Measurement instruments	
Code	**Name**	**Name**	**Product Model**
C2-1	Street Green Rate	Linen Tape	WENXIN-100m
C2-2	Air Temp. Difference	Ambience Temperature Detector	Testo 410-2
C3-1	Average Emission of Noise	Noise Detector	IPhone 7 "Decibel 10": Version 5.3.3 (2172)

Note: the measurement instruments in Stage Three are the same as those used in Stage Two which are illustrated in Table 4. 5.

4.4.3.1.5 Pilot Survey

The sample streets had been investigated in the 1st Field Survey already. Also, the survey techniques and measurement instruments had also been familiar by the researcher in previous fieldwork. Nevertheless, a pilot survey was still designed before the formal survey, thereby ensuring the reasonability and efficiency of survey design. ***Daxue Rd was selected for the pilot survey, and it was visited and surveyed on 13th October (Friday) 2017 by the researcher.*** The principal purposes and conclusions of the pilot survey were:

1) *Confirmation of the survey time:* The results of the pilot survey showed the plan of survey time was reasonable and the data collected on site in the designed time and day could comprehensively and objectively reflect the regular performance of sample streets.
2) *Detailed design of the survey procedure:* A pre-test helped to refine the survey procedure, including the way to record data and the sequences of site measurements, which enabled the survey more effectively and efficiently.
3) *A trial of the indicatory system:* The pilot study was also a significant trial of the Indicator System, thereby ensuring the system to be practical and workable.

4.4.3.2 Street Questionnaire

4.4.3.2.1 Survey Objective

The primary objectives of the Street Questionnaire were to obtain the appraisals of street sustainability from street users. Then the questionnaire results were to compare with the evaluation results of the Indicator System.

4.4.3.2.2 Sample Selection

The street questionnaires were conducted in three Shanghai streets, namely Madang Rd, Daxue Rd, and Sujiatun Rd respectively. 50 respondents who were in the street were randomly selected in each street. The sample size was set based on the time and ability limits of the researcher.

4.4.3.2.3 Procedure Design

The questionnaires were handed out by the researcher in the streets. After an oral introduction of the survey purpose and duration, the researcher asked politely if the respondent agree to participate in the survey. If the respondent agreed with this survey, one piece of questionnaire hardcopy and a pen were given to him/her to answer the questions. Completion of the questionnaire was within ten minutes.

4.4.3.2.4 Questionnaire design

In order to avoid bias resulting and misunderstanding, the questions and the wording should be direct and straightforward to the respondents (Oppenheim, 1966). Also, the questionnaire results needed to be compared with the outcomes of indicator evaluation system, so the same structure as the Indicator System was used in the design of the questionnaire.

The questionnaire consisted of three parts (Appendix E):

1) A brief introduction to the research purpose.
2) 15 questions. The main body of the questionnaire was to ask the respondents to judge the street's performance according to 15 evaluation criteria. Four appraisal levels, namely "Very Good", "Good", "Medium", and "bad", could be chosen for each criterion.
3) The gratitude of the respondents' time and devote.

4.4.3.2.4 Pre-test

A pre-test was conducted before the formal survey of the street questionnaire was issued. ***The survey time was 13th October (Friday), 2017, five questionnaires which accounted for 10% of the final sample were handed out in Daxue Rd.*** Moreover, the five respondents were asked to take a short interview regarding the layout, wording, and contents of the questionnaire.

The principal conclusions of the pre-test were:

1) *Test of survey procedure:* The whole process of conducting public questionnaires in urban streets were examined through the pre-test questionnaire, and the key experiences were noted for the formal survey. For example, in the pre-test of Daxue Rd, local security guards

asked the researcher to fill in a set of application forms of allowing the Questionnaire survey to ensure the questionnaire survey process not to affect the public activities and regular traffic of the street.

2) *Refinement of the questionnaire design:* The wording of the original questionnaire was modified to be simpler and more straightforward. For example, the respondent pointed out that "intensive land use" and "multi-functional usage" were "too professional" and "a bit ambiguous". Consequently, all the wordings of the questionnaire, especially the description of each criterion, were double-checked and refined. Besides this, the respondents provided positive feedback regarding the overall layout, questions length, and rating levels.
3) *Being familiar with the procedure of tabulation:* All the questionnaire results needed to be digitalised into Microsoft Excel. Hence the tabulation and data interpretation should be pre-tested before the final survey.

4.4.3.3 Data Analysis Techniques

The primary analysis techniques of Research Stage Three were Descriptive Statistics, Inferential Statistics, and Comparative Analysis.

Firstly, Descriptive Analysis was employed to study the quantitative data since it is an efficient technique to summarise and describe the features of numerical data (Mann, 1995). The data, including the evaluation results of the Indicator System and the survey outcomes of the Street Questionnaire, were first organised into the tables in Excel. Then they were analysed through a series of descriptive statistics, thereby providing an evidence-based summary.

Furthermore, *Comparative Analysis* and *Inferential Statistics* were adopted to study these data and to interpret the relationships and potential reasons behind. Comparative analysis is a well-developed and formalised technique to compare the objective things for better understanding the essence and providing a critical assessment (Ragin, 1987; Yengoyan, 2006). Hence, it was first employed to compare the evaluation results between the Indicator System and user's appraisal of each sample street, thereby summarising the coherence and difference between two sets of data. Meanwhile, the evaluation results of different samples were studied together by cross-comparison for the understanding of problems and reasons behind. Besides, in order to propose the optimisation suggestions for the Indicator System, all collected data and the descriptive summary were analysed and compared together with the technique of Inferential Statistics. Because different from Descriptive Statistics, Inferential Statistics is to explore and summarise the general principles of the population from the selected sample cases, and it is an important technique to test the statistics hypothesis (Liese & Miescke, 2008).

4.4.4 Research Stage Four

The principal task of Research Stage Four was to conduct a set of semi-structured interviews to optimise the Indicator System as well as* summarise suggestions for street renovations*.

4.4.4.1 Semi-structured Expert Interview

Expert Interview was employed as an important technique to collect professional opinions concerning the system improvement, because it was regarded as an efficient way to gain sophisticated information and insightful suggestions from experts on a specific topic (Grillham, 2000; Bogner, et al., 2009). The semi-structured form enables the researcher to discuss the potential improvements of the Indicator System which had been summarised in previous research stages. Also, the open discussion could facilitate to uncover other issues that had not been.

4.4.4.1.1 Participants

Four experts were invited to participate in the interview. Table 4. 13 shows the introduction and selection reasons of the selected interviewees.

Table 4. 13: Introduction of Interviewees for the Semi-Structured Expert Interview

NO.	Age	Name	Gender	Position	Company	Selection Reasons
1	62	Dr. Cao	Male	Professor	Tongji University	- Possessing PhD in Urban Study and 32-year teaching experiences in college. - Having conducted many profound studies on urban open space, especially on the public streets; - Having insightful knowledge and rich experiences of sustainable streets from the theoretical perspective.
2	45	Dr. Ge	Female	Director/ Senior Engineer	Shanghai Urban Planning and Design Institute	- Possessing MSc Degree in Urban Planning and 15 years' working experiences in Shanghai Planning Bureau; - Being a leading author to write "the Shanghai Street Design Guide"; - Having engaged in the design and renovation of Shanghai streets for more than ten years.

NO.	Age	Name	Gender	Position	Company	Selection Reasons
3	35	Mr. Zhao	Male	Director	Shanghai Pudong Planning and Land Resource Management Bureau	- Possessing MSc Degree in Urban Planning and ten years' working experiences in Shanghai Pudong Planning Bureau; - As a director in the Planning and Land Resource Management Bureau, in charge of the management of public streets; - Having rich experiences in street renovation and improvement from the practical perspective.
4	38	Dr. Jin	Male	Director	Shanghai Urban Planning and Design Institute	- Possessing PhD in Architecture and 10 years' working experiences in Shanghai Planning Bureau; - Being a leading author to write "the Shanghai Street Design Guide"; - Having presided over a number of monographic researches on Shanghai streets.

4.4.4.1.2 Procedure Design

The face-to-face and one-to-one were the primary forms of the interview survey. The interview lasted between 30 and 60 minutes. The researcher had prepared four questions in advance (See Appendix F). Therefore, the researcher asked the prepared questions firstly. Some new issues that arose during the interview were also discussed in the interview.

Before the interview, a formal invitation email had been sent to the interviewees (See Appendix G). The invitation included details of the project as well as information about data protection and voluntariness of participation. After receiving the accepted response to the interview from the respondents, the researcher booked interview time with the experts and initiated the interview accordingly. Moreover, consent forms (Appendix H) of confidential data had also been signed by the respondents before the interview.

4.4.4.1.3 Interview Time

Table 4. 14 shows the interview data and duration of each respondent.

Table 4. 14: Introduction of Interviewees for the Semi-Structured Expert Interview

Interview NO.	Time of interview	Duration
1	14^{th} Sep. 2018	35 mins
2	25^{th} Sep. 2018	45 mins
3	30^{th} Sep. 2018	45 mins
4	11^{th} Oct. 2018	60 mins

4.4.4.2 Data Analysis Techniques

The data collected in Research Stage Four were mainly from the semi-structured expert interview, so ***the data analysis mainly relied on the qualitative methods***.

The interview contents were recorded in the form of Interview Notes. These written records were not transformed into a digital file because the amount of data was not large and it was easier to work on the original version. The keywords were extracted by sorting out the Interview Note to induce the primary findings of each interview. Also, the findings of different interviews were compared crossly to summarise the consistency and differentiation. Therefore, the techniques of data analysis in this stage included induction and comparative analysis.

Except for the hand notes, the voice of whole interviews was recorded. During data analysis, the hand notes were double-checked by the voice record to ensure the reliability and validity of interview summary.

4.5 Ethics, reliability, and validity

4.5.1 Ethical consideration

The researcher attached great importance to the ethical issues that might be involved in this study. Also, the researcher was very careful when dealing with human participation and human data at all stages of the study, including data collection, data analysis and presentation of the results. The whole research process followed the ethical standards and relevant codes of ethics, including the General Data Protection Regulation (GDPR) (EU) 2016/679, the Data Protection Act 2018 (DPA 2018), and the Universal Ethical Code for Scientists.

Four projects in this research were directly related to ethical issues, namely Expert Interview *(Project One),* Expert Questionnaire *(Project Two),* Street Questionnaire *(Project Three),* and Voluntary Task *(Project Four)* respectively (See Table 4. 15).

Table 4. 15: Projects that Related to Ethical Issues in this Research

Project NO.	Project Type	Title	Start and Duration of Projects
1	Expert Interview	A semi-structured interview on the improvements of Indicator System of sustainability evaluation for Shanghai streets	Conducted in September 2018
2	Expert Questionnaire	A survey on the importance of the selected criterion in the sustainability evaluation framework	Conducted in September 2017

Project NO.	Project Type	Title	Start and Duration of Projects
3	Street Questionnaire	A survey of the appraisals of street sustainability from street users	Conducted between October and November 2017
4r	Voluntary Task	The sustainability assessment of 236 Shanghai streets	Conducted in August. 2017

Concerning these four projects, the researcher adhered to the fundamental principles of research ethics including explaining the purpose of the research to participants, seeking and obtaining informed consent, ensuring voluntary participation and confidentiality and determining access and data storage.

Firstly, the participation of respondents in the research was entirely voluntary, and all participants were well informed that they could withdraw from the study at any time without giving a reason. The participants were interviewed or surveyed only after they consented to take part. The consent's patterns might be varied. Regarding the Expert Questionnaire, a formal invitation email was sent to the interviewees (See Appendix G). The invitation email included the details of the survey project as well as information about data protection and voluntariness of participation. Only after the researcher had received acceptable responses, either an oral agreement, a cell phone message or email reply, the online questionnaire link was sent to them. Because the sample number was 50 and it was an online questionnaire survey, the signed consent form was not used for this project. The researcher perceived the individual's acceptance and completion of the questionnaire, in combination with the information provided as implied consent to participate in the study. Also, in the project of the Street Questionnaire, the survey purpose, duration, data protection, and voluntariness of participation was introduced orally by the researcher before the survey. The questionnaires were given to the respondents only if they had agreed to participate in the survey. Hence the oral agreement and completion of the questionnaire were regarded as the consent of the voluntary participation. Concerning the Expert Interview, except for the invitation email (See Appendix G), the formal consent forms (Appendix H) were also signed by the participants to confirm that they had fully understood their voluntary participation and other rights in the survey. Moreover, the volunteer who participated in Project Four also signed a formal consent form. Therefore, it can be said that the research ensured the voluntary participation of all respondents in the research.

Secondly, no offensive, discriminatory or other unacceptable language and wording were in the questionnaires and interview survey. The four ethical related projects in the research did not pose any risk of any participants experiencing either physical or psychological distress or discomfort. The questionnaire and interview only contained items of purely informative characters about the assessment of sustainable streets. No sensitive data was collected that could trigger upset, anxieties or any other adverse emotional reactions. It is worth noting that most of the respondents were Chinese (all interviewed experts are Chinese and 3 out of 161 street questionnaires were English speakers), so the invitation email and questionnaires were firstly designed in Chinese and translated into English. Both versions had been double-checked to ensure they were identical and did not involve any participant deception, manipulation, distraction, or misleading information.

Thirdly, the confidentiality of participants was another issue that required serious consideration. This research highly protected the privacy and anonymity of the participants. No personal information was collected or used in this research. Regarding Expert Interview, Expert Questionnaire, and the Voluntary Task, all personal information, such as name, email address, and cell phone number, were only be used to contact and book survey time, and not be shown in any place of the thesis. To the Street Questionnaire, the survey did not contain any questions related to personal information. In order to record the survey process, some photos were taken during the investigation. However, all the photos were taken with the consents of the respondents. Also, all the photos used in this thesis did not show the respondents' faces.

It is worth to note that the project of Expert Interview obtained the formal approval from the School Research Ethics Committee (SREC) (*Reference Number: EC1808.365*). Appendix J shows the approval form. The other three projects, namely Expert questionnaire, Street Questionnaire, and the Voluntary Task did not apply for the formal approvals from the SREC. Firstly, both the General Data Protection Regulation (GDPR) (EU) 2016/679 and Data Protection Act 2018 (DPA 2018) were implemented in May. 2018. With the implementation of new regulations, the relevant requirements have been strengthened. So, the researcher applied for the formal approval from the SREC for the project of Expert Interview which was conducted after the implementation date of these. Concerning the other three projects, their introductions, including the brief description and ethical considerations, were attached in the application form of Expert Interview, and checked by the Committee. The last but not the least, the survey process and whole study of all four ethical related projects strictly followed the ethics guidance from SREC of Welsh Scholl of Architecture (WSA).

Furthermore, in the process of data collection, some ethical issues might also arise in the literature review and citation. The works of other scholars and authors should be highly respected, and their copyright should be well protected. Therefore, the works of other authors referenced in any part of this dissertation were cited systematically and sorted by the Harvard referencing system. Some pieces of literature, which were not referenced directly in the article but had given the author inspiration to this study, were also listed in the Bibliography, thereby showing respect for other's work.

In addition to data collection, the objectivity of data analyses throughout the research was also a critical ethical issue. Objectivity and comprehensiveness were highly valued in the entire study. Specifically speaking, in the literature review, the citation of sentences maintained the context and logic of the original work to deliver an objective and complete analysis. In the process of statistics and analysis of questionnaire results, the techniques like descriptive analysis, comparative analysis, and inferential statistics were adopted to avoid subjective judgements and to reinforce the objectivity of data analysis.

4.5.2 Reliability and Validity

All researches should convince people that the undertaken study generated valid results through reliable methodologies (Silverman, 2005). The issue of validity and reliability are often the main areas of criticism in academic studies (Denzin & Lincoln, 2000). Therefore, the reliability and validity are considered as two vital points to be demonstrated regarding research methodology.

Reliability refers to the extent to which the same findings can be obtained using the same instruments and methods more than one time (Dudovskiy, 2016; Gibbs, 2007). The promotion and guarantee of research objectivity can be embodied in the entire research process.

Regarding data collection, including literature review, fieldwork, interview, and questionnaire survey, various methods were adopted to maximise the reliability of the study. The systematic literature review was employed in this study. All keywords for literature searching, the database, and the principles and techniques of selection were listed. Also, all references were strictly cited and systematically organised into the database, thereby ensuring that the whole process of the literature review is traceable and its findings are reliable. As for the fieldwork and questionnaire survey, the means to promote the research reliability included the increase of sample size, the specification of survey methods and techniques, photo recording of the on-site assessment, and digitalisation of the field notes, and pre-test before the real survey. Taking the 1st Field survey as an example, firstly, the number of survey samples was expanded to 236 Shanghai streets, and the rationales of sample selection were clearly stated, thereby ensuring the survey results comprehensive and objectively reflect the actual situation. Secondly, the survey time, techniques and equipment were systematically listed and explained in this study. Meanwhile, a large number of on-site photos taken by the researcher recorded the whole survey and worked as the evidence to demonstrate the reliability of the assessment results. Also, the Field Notes were used to record the critical findings of daily work, thereby guaranteeing the reliability of the assessment results. Thirdly, in order to enhance the reliability of the assessment outcomes, a volunteer was invited to evaluate the sustainability of 236 Shanghai streets, and all the original data were retained for tracing and comparing. Finally, the pilot surveys were also employed as a pre-test to examine the reliability and robustness of the designed system. In the process of data analysis, the quantitative data were processed by Microsoft Excel, which ensured the accuracy and reliability of the data statistics.

As for the analysis of qualitative data, the coding method was adopted. The keywords of the findings were systematically organised and logically analysed to reach conclusions. The whole process of induction and analysis was traceable and repeatable. Therefore, it can be seen that the researcher minimised the uncertainties and reinforced the research reliability by all means. However, some uncertainties were inevitable due to the limitation of time and ability. For example, the uncertainties of the established Indicator System of sustainability evaluation is to indicated in detail in chapter 7.6, and the dimensions and impacts of these uncertainties are to be analysed objectively.

Research validity refers to the truthfulness of findings and their reliability and stability (Altheide & Johnson, 1994; Siddaway, 2014). The reliability and stability of research findings are the foundation of research validity. The research reliability has been elaborated in the previous paragraph already. Also, the stability is primarily influenced by the potential uncertainties in the research. The uncertainty issues have been explained in the last paragraph. The third factor that affects research reliability is the truthfulness of the findings. The results' truthfulness can be ensured by scientific research methodologies, transparent research data, traceable research process, and objective research conclusions. These are the fundamental principles of this research, and the detailed implementation of these principles have been richly embodied in the elaboration of research design (Chapter 4.3), the methods and techniques of data collection and analysis (Chapter 4.4), and ethics consideration (Chapter 4.5.1).

4.6 Summary

This chapter has described in detail on the research methodology of this study.

First, Chapter 4.2 clarified the methodological framework of this research. The study adopted a theory-driven deductive and quantitative approach based on the positivist paradigm and employed the systematic literature review and the survey as two main research strategies. Specifically speaking, the study proposed a conceptual framework of sustainability evaluation of urban streets by applying it to the real world and then optimised based on data analysis to promote the development of its theory and application. The deductive approach was used to test the research hypothesis developed from the Indicator System of Sustainability Evaluation into Shanghai application, while the quantitative approach was adopted for data collection concerning achieving research objectives and answer research questions. Concerning the research strategies, the systematic literature review was selected to build the concept model and produce research hypotheses. Meanwhile, the research strategy of the survey was used to test the hypotheses in the real world, and three survey methods, namely questionnaire, semi-structured interview, and the structured observation, were adopted in the research.

Furthermore, Chapter 4.3 elaborated the research design. The whole research design was determined by the primary research aim, four research objectives and a series of research questions. Based on the four objectives, the research procedure was divided into four stages, and the development of critical concepts was specified. Figure 4. 2 demonstrated the research process and concept development. Meanwhile, Table 4. 1 further linked research objectives with methods and illustrated research methods and techniques, data required and critical outcomes regard to four research stages corresponding to four research objectives.

Moreover, Chapter 4.4 specified the methods and techniques of data collection and analysis in four research stages. Specifically speaking, the methods of data collection included the Systematic Literature Review, the 1st Field Survey, Expert Questionnaire, the 2nd Field Survey, Street Questionnaire, and Expert Interview. Also, the survey objectives, sample selection, survey time, survey techniques, questionnaire design, and pilot survey were further elaborated accordingly. Meanwhile, the techniques of data analysis included Descriptive Statistics, the Multi-Criteria Analysis (MCA), Coding method, Descriptive Analysis, Comparative Analysis, and Inferential Statistics.

Finally, Chapter 4.5 expounded the ethical considerations. The overall research methodology was reviewed again, and potential uncertainties were identified and controlled within the acceptable degrees to demonstrate the reliability and validity of this research.

Chapter 5. Shanghai and Its Urban Streets

5.1 Introduction

Chapter Five is to place the study of sustainable streets into a Shanghai practical framework through the analysis of Shanghai background and street development. Therefore, this chapter presents the past formation process, current features and classification, and future development of Shanghai streets, thereby demonstrating the significance and necessity of sustainability shift to Shanghai streets.

Above all, Chapter 5.2 gives an overview of Shanghai background, including its size, population, location and climate features. Chapter 5.3 further explores the relationships between city texture and street development to clarify the development history and main characteristics of Shanghai streets. Then, Chapter 5.4 introduces the current situation of Shanghai streets, including road classification, street types, features, and issues. Based on the in-depth analysis of historical development and current situation, Chapter 5.5 demonstrates the necessity and significance of sustainability shift to Shanghai streets.

5.2 Brief of Shanghai

5.2.1 Size and Population

Shanghai is one of four direct-controlled municipalities of the People's Republic of China. It is known as the centre of international economic, financial, trade, shipping, and scientific and technological innovation. Shanghai is one of the largest metropolitan areas in the world. Its total area is 6340.5 km^2, with 120 km long (north to south) and 100 km wide (west to east). Within the land of Shanghai, the urban area is 2643.06 km^2, and the suburban area is 3697.44 km^2; the land area is 6219 km^2, and the waters are 122 km^2. The area within the Outer Ring of Shanghai is defined as the central city, with an area of 660 km2. The central city includes eight districts, namely Huangpu, Changning, Xuhui, Yangpu, Hongkou, Putuo, Jingan, and Pudong District respectively (See Figure 5. 1).

Note: the graph was drawn by the author, and the data was from (SMSB, 2017)

Figure 5. 1: Spatial Distribution of Population and Land Scale in Shanghai

Table 5. 1: List of Population, Land Use, and Economic Scale of 16 Districts in Shanghai

Shanghai Districts	**Area** *(km$^{2)}$*	**Population -2016** *(Million)*	**Population Density** *(Persons/km^2)*	**GDP -2016** *(Billion RMB)*
Huangpu	20	0.68	34100	201.92
Xuhui	55	1.11	20176	152.22
Changning	38	0.69	18187	131.62
Jing'an	37	1.10	29651	166.22
Putuo	55	1.29	23418	97.39
Hongkou	23	0.84	36443	88.98
Yangpu	61	1.32	21684	162.95
Minghang	371	2.54	6841	210.12
Baoshan	271	2.02	7465	104.87
Jiading	464	1.57	3379	187.59
Pudong	1211	5.37	4432	873.25
Jinshan	586	0.80	1360	92.29
Songjiang	606	1.76	2905	104.04
Qingpu	670	1.21	1804	93.97
Fengxian	687	1.16	1688	72.72
Chongming	1185	0.70	592	31.17
SHANGHAI TOTAL	**6340**	**24.15**	**3810**	**2771.32**

Data source: (SMSB, 2017)

Shanghai is the most populous city in China. By the end of 2016, Shanghai's total population is 24.2 million, and the population of the permanent resident is 14.4 million (SMSB, 2017). Over the past decade, Shanghai's population has been growing at a rate of nearly 0.6 million per year. That is to say, Shanghai's population has grown by nearly 6 million over the past decade (SMSB, 2018).

Shanghai is also one of the most densely populated cities in the world with a population density of 3809 persons/km^2. The actual density is much more dramatic than that. The majority of people concentrate in 660 km^2 of the central city rather than an average distribution in 6340 km^2 of entire Shanghai. Consequently, it can be found that the population density in the central districts, such as Huangpu, Hongkou and Jingan district, reached 34,000 persons/km^2 (See Table 5. 1 & Figure 5. 1).

Under such a high-density living environment, streets are very important public space in Shanghai. Due to the high population density and the limited living space per person, a lot of daily life in Shanghainese historically took place on the streets, including neighbours chatting, children playing, and sometimes even the summer dinners. Therefore, it can be said that the streets have been important places for their social life of Shanghai people for a long time.

In addition to the land and population, Shanghai's economic scale is also considerable. Shanghai has the largest economy in China. In 2016, GDP reached 2.82 trillion RMB, ranking first in Chinese cities and second in Asian cities, just after Tokyo, Japan (SMSB, 2017). Between 1992 and 2007, Shanghai's economy continued to grow at double-digit rates for 16 years, with the average rate of 12.7%. Over the past ten years, GDP growth in Shanghai has been increasing at about 7% per year. In 2008, Shanghai experienced the transformation mode of economic development, from extensive and resource-oriented development mode to intensive and smart development mode. With the shift, the growth rate of Shanghai GDP slowed down to the rate between 6% and 9%.

Therefore, ***the super scales of land, population, and economy of Shanghai shape the natures of Shanghai streets to be the important public space in the high-density living environment***. With the transformation of economic development mode, the concepts of delicacy management and quality enhancement have also extended to the public streets.

5.2.2 Location and Climate

Shanghai lies in the Yangtze River Delta, in the east of China. It is west of Taihu Lake, east of the ocean, with the Yangtze River in the north and Hangzhou Bay in the south. The north of Shanghai connects to the Bohai Sea Region, and the south of Shanghai is opposite to the Pearl River Delta.

The west of Shanghai connects to the heart of China through the Yangtze River and railway, and its east links to other continents through the ocean and surrounding Asia islands. The location that the Yangtze River on the north and Hangzhou Bay on the south makes Shanghai more like a peninsula, while the Taihu Lake makes it separate to the west to some extent. Therefore, the particular location and surrounding situation shape Shanghai into a relatively independent geographical unit and provide various and convenient transportation condition. The Beautiful Huangpu River passes through the city and brings abundant fresh water and pleasant natural landscape. In the north of Shanghai, there are some fertile islands on the river, like Chongming Island, Changxin Island, and Hengsha Island. In the southeast of Shanghai, there are rocky archipelagos on the sea, like the Zhoushan Islands. The island on the river provides valuable land resources for further development, and the islands in the sea provide the deep-water harbour and opportunities for international trade.

The location of Shanghai not only provides advantageous development resources but also determines its climate condition. Shanghai has a humid subtropical climate and experiences four distinct seasons, full sunshine, and abundant rainfall. The most pleasant seasons are spring (April, May, and June) and autumn (September, October, and November) and they account for half of the year. Considering that the comfortable temperature of outdoor activities is between 16℃ and 28℃ (Humphreys, et al., 2016), these six months that are within the comfortable temperature and with pleasant breezes are suitable for street activities.

The hottest period is in July and August with an average temperature of 29℃. According to the records, there are average 8.7 days exceeding 35℃ annually, and the highest temperature in Shanghai is 40.9 on 21 Jul. 2017 (SMS, 2018). The ground temperature can reach 57.7 ℃ if the street is without shading, so the summer period in Shanghai is unadaptable to street activities. The hot and humid condition can be improved if the street can provide the breezes from in the south-east. During summer the street should provide as much shade as possible to alleviate the Urban Heat Island Effect and reduce the all-day heat. Shanghai winters are chilly and damp with an average temperature between 5℃ and 10℃.

The coldest month is January, with an average temperature of 9℃. According to the records, the lowest temperature in Shanghai was -12.1℃ on 19th Jan. 1893 (Sina Shanghai, 2017). The northwesterly winds from Siberia can cause the temperature to drop below freezing in the nighttime. However, the average temperature in winter is not very low, and there are only one or two days of snowfall annually. If the street can provide sufficient solar radiation and effectively block the cold wind in the northwest direction, people can still have street activities with warm clothing.

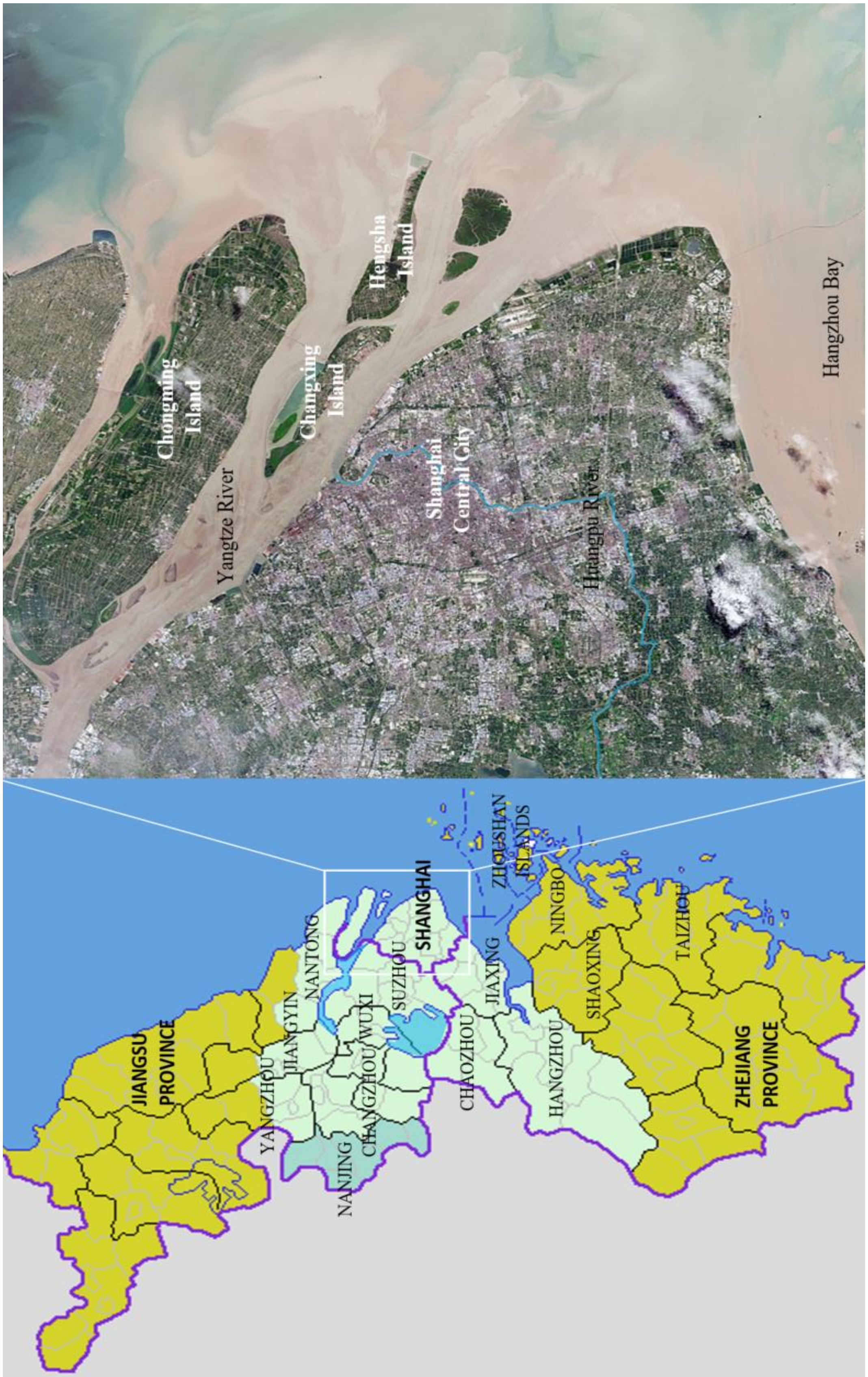
Shanghai has a relatively high humidity throughout the year, and its average relative humidity of the whole year is between 70% and 80%. Also, the annual solar radiation in Shanghai is relatively strong, and it receives 1,776 hours of sunshine annually (CMA, 2018). The average annual rainfall in Shanghai is about 1200mm, but 60% of the rainfall in a year is happened in the flood season from May to September (SMS, 2018). Especially during summer, there are often downpours and thunderstorms in the afternoon. Besides, in summer and early autumn, Shanghai is also susceptible to typhoons, which sometimes bring rainstorms and windstorms.

Hence, it can be seen from the analysis above that ***Shanghai's climate type can provide a comfortable outdoor condition to street activities for about half the time throughout the yea***r. In order to expand the comfortable period, ***it is necessary to provide shading and make the use of the breeze from the southeast in summer and to enlarge the solar radiation and block the cold air from the northwest in winter***. Furthermore, regarding the annual rainy season and typhoon***, the adaptable ability of urban streets to short-term rainstorms and windstorms should be reinforced thereby strengthening the capacity of disaster prevention and disaster recovery***.

Table 5. 2: Shanghai Meteorological Data

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Avg. High (°C)	8.1	10.1	13.8	19.5	24.8	27.8	32.2	31.5	27.9	22.9	17.3	11.1	**20.6**
Daily Mean (°C)	4.8	6.6	10.0	15.3	20.7	24.4	28.6	28.3	24.9	19.7	13.7	7.6	**17.1**
Avg. Low (°C)	2.1	3.7	6.9	11.9	17.3	21.7	25.8	25.8	22.4	16.8	10.6	4.7	**14.1**
Avg. Precipitation (mm)	74.4	59.1	93.8	74.2	84.5	181.8	145.7	213.7	87.1	55.6	52.3	43.9	**1,166.1**
Avg. Precipitation Days (⩾0.1mm)	9.9	9.2	12.4	11.2	10.4	12.7	11.4	12.3	9.1	6.9	7.6	7.7	**120.8**
Avg. relative Humidity (%)	74	73	73	73	73	79	77	78	75	72	72	71	**74**
Mean monthly sunshine hours	114.3	119.9	128.5	148.5	169.8	130.9	190.8	185.7	167.5	161.4	131.1	127.4	**1,775.8**

Data source: China Meteorological Administration (based on the records between 1981 and 2010)



The graph was drawn by the author, and satellite map was from Baidu Map, 2018.

Figure 5. 2: Location and Layout of Yangtze River Delta and Shanghai

5.3 Development History of Shanghai Streets

City texture is the overall spatial layout of a city which are shaped by the combination of street network, block size, road pattern, as well as architecture style. It is also a unique display of city image in the context of the social, economic, and cultural environment. Different modes of transportation and lifestyle create and change the city texture. Likewise, the city texture also guides and affects the transportation mode and lifestyle of the people in the city. Therefore, it can be said that the streets are the main components of city texture, and meanwhile, they inherit and display the essential characteristics of urban development.

From a small fishing village to an international metropolis, Shanghai has experienced opening the port, foreign settlements and concessions, and a rapid development after Chinese economic reform. All the development process of Shanghai also reflects on the construction, development, and transformation of Shanghai streets. The analysis which combines the city texture and street development can not only summary the different development phases of Shanghai streets, but also be beneficial to understand the evolution and variation of Shanghai streets better. The existing studies on the development history of Shanghai streets are limited (Pott, 2010; SLHO, SHM, 2013; Tao & Chen, 2001). Based on an in-depth analysis of existing articles, ***the research divided the main characteristics of Shanghai development and its street evolution into four phases.*** It must be acknowledged that the division of four phases was referenced from "Shanghai Street Design Guide" (SPLRAB/SMTC/SUPDRI, 2016), but the interpretation and analysis methods were not the same.

5.3.1 Before 1843: Traditional Streets in Jiangnan Water Town

Shanghai used to be a coastal town which developed from a small fishing village. According to historical records, in the middle of Tang Dynasty (between 715 and 820), Huating Village was established in Songjiang area, currently the remote suburb area of Shanghai, for the production of salt (SLHO, SHM, 2013). With the expansion of population and industry, it was upgraded to Songjiang Town in about 1277. In 1292, Shanghai was established as a county, which means the official establishment of Shanghai. At that time, Shanghai was mainly engaged in shipping, fishery, and salt industry, but its prosperity and population were far from those of Yangzhou, Suzhou, and Hangzhou.

During that period, Shanghai was surrounded by city walls, and there were many streets and alleys within the walls (Figure 5. 4). It can be seen in the earliest existing ancient map of Shanghai (Figure 5. 3), that the streets and the rivers together formed the transportation system of Shanghai at that time. The network of river and waterways were dense. Broad rivers could carry goods by boat, and narrow rivers served people daily traffic. The streets and alleys were mostly built along the river, so they were generally narrow and twists. The general width of one street was only about 2 meters, and they usually were used for people walking, sedan chairs and wheelbarrows (SPLRAB/SMTC/SUPDRI, 2016). Furthermore, the streets were often named after the people who lived in this place. Many of these ancient names have been used until now.

To sum up, ***Shanghai was still a small county relying on shipping, fishery, and salty before 1843, and the alleys and rivers shaped the narrow and twist transportation network,*** which exactly showed the picture of a typical Jiangnan waterfront context and street pattern.

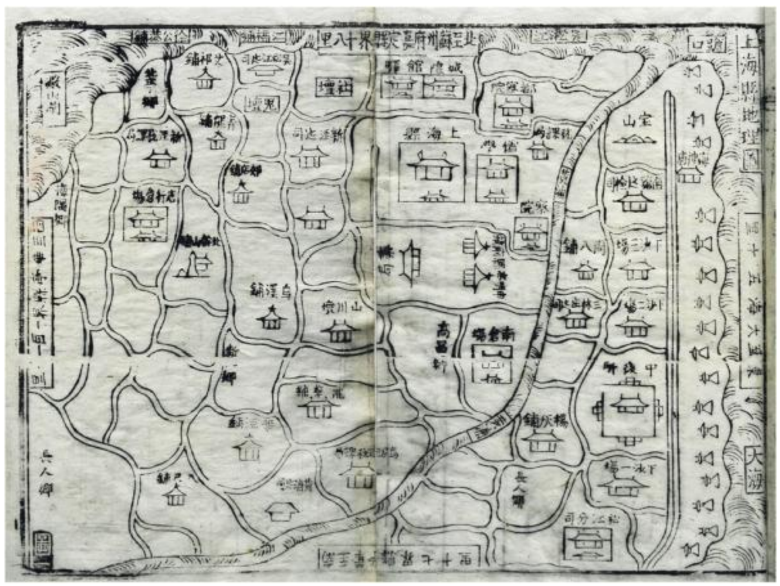


Figure 5. 3: Shanghai Map of 1504 *Map Source:* (thepaper.cn, 2017)

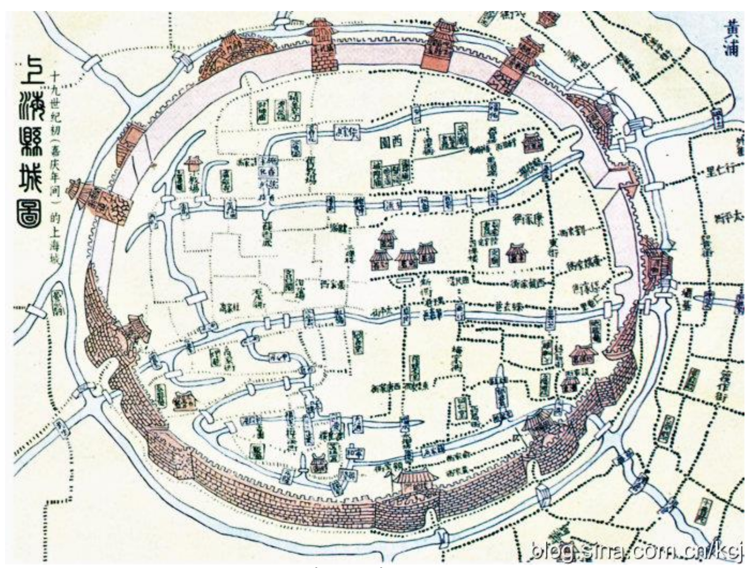


Figure 5. 4: Map of Shanghai in Ming Dynasty (1800) *Map Source: Shanghai Xianzhi*, *Shanghai 1871*

5.3.2 From 1843 to1948: Diverse but Unsystematic Streets in Colonial Background

In 1840 the Opium War broke out. Shanghai opened its port in 1843. After that, the British concession, American Concession, and French Concession were successively established in Shanghai and expanded rapidly. The British Concession and American Concession merged in 1863 and were named as “the International Settlement of Shanghai” in 1899 (Pott, 2010). During this period, the introduction of the vehicles from the West and the increasingly prosperous international trading pushed the transformation and development of Shanghai. Consequently, Shanghai’s population snowballed and the real estate industry also increased substantially. The multinational colonisation and intense domestic political situation had a significant influence on the development of Shanghai and its streets.

After Shanghai opened its port in 1843, the construction and renovation of city streets were mainly driven by colonists. In the 1850s, when horse-drawn carriages were introduced to the Concession, street widths began to be built according to standard modules. For example, the streets in the international settlement were 30-40 feet wide, and most streets in the French Concession were 43 feet wide (SPLRAB/SMTC/SUPDRI, 2016). After the 20th century, the trams became the primary means of transportation in Shanghai, and cars also increased considerably. As a result, the original road width was not able to meet the demand at that time. Therefore, many streets were widened in several times and some streets were changed from a winding line to the straight line, which caused the discontinuity of interfaces of many streets. Moreover, the French brought the Platan as the street trees in French concession of Shanghai. Today, the Platan trees are still often used for the street trees in Shanghai, and people prefer to call them “French Platan”. The framework of Shanghai streets was gradually shaped by about 1925 (Figure 5. 5), which reflected the colonial background. The street network in two significant concessions was basically like the checkerboard in shape. Many streets in the International settlement were built by filling in rivers, so they were typically zigzagged. The streets in French Concession were relatively straight and linked directly to the streets of the checkerboard (SPLRAB/SMTC/SUPDRI, 2016).

Outside the Concession, Shanghai government raised a series of road construction campaigns after 1900. In 1930, Shanghai government formulated the “Greater Shanghai Plan” (See Figure 5.6), and a centre of political and administration was planned in Jiangwan area (currently in Yangpu District) with a fine road network and grand public buildings to compete with the concession. Most of the planned streets were later built and are still used now.

In short, ***multinational colonisation, multicultural interaction, and national revolution drove the rapid development of Shanghai as well as shaped the characteristics of Shanghai streets between 1843 and 1948***. Furthermore, the colonial experience had a profound impact not only on the overall layout, spatial design and width module of Shanghai streets but also on the streetscape and even selection of street trees. ***However, the street networks were diverse but unsystematic in this period due to political unrest and the lack of overall control and a long-term plan***.

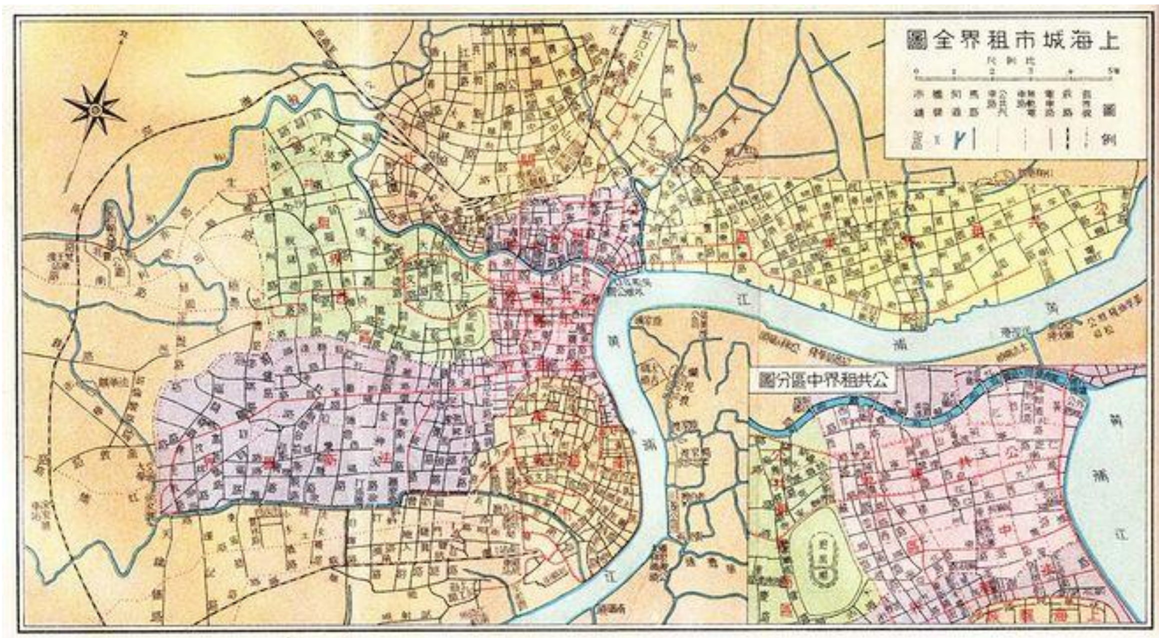


Figure 5. 5: Map of Shanghai Concession in 1930 *Photo Source:* (Huaban, 2018)


Figure 5. 6: Greater Shanghai Plan (1930)
Map Source: (SSMJ, 1999)

5.3.3 From 1949 to 2000: A Massive Road Construction in Rapid Developing Shanghai

After the foundation of P.R. China in 1949, Shanghai, like other China's cities, experienced reform, regression, and then rapid development. All these changes not only reflected in the urban construction of Shanghai but also the street pattern. In 1953, Soviet experts proposed the overall master plan of Shanghai road system and put forward the overall layout of "*Checkerboard format within the Ring of Zhongshan Rd, Radiative Roads pattern outside of Zhongshan Rd*" (SPLRAB/SMTC/SUPDRI, 2016, p. 22). However, the master plan was revised for many times and finally discarded due to the Cultural Revolution. The city construction was in chaos in the revolution.

With the Reform and Opening up Policy and the end of the Cultural Revolution, the urban construction in Shanghai began to recover. In the 1980s, the Workers New Village which was built by the government and provided housing for workers was very successful in Shanghai. The Workers New Village was a large scale of the residential areas which consisted of 10 or more blocks. The block was generally a square with the side length of 150-200 meters. The street width was 12 meters. The residential buildings were usually 3-6 floors and designed in a determinant layout. The service facilities, like market and schools, were located at the intersection of the main streets. The construction of the Workers' New Villages lasted until about 1990s. This particular development mode and housing layout formed a unique type of street space and streetscape in Shanghai.

After 1990, because of the Reform and Opening up, the market of real estate in Shanghai was warmed up. Compared with previous Worker Village, the plan of new development was much more flexible and diversified. The flexibility and diversity were not only reflected in the building's heights, landscape, and buildings' façade, but also were embodied by the layout of public streets.

Shanghai witnessed a decade of rapid construction between 1990 and 2000. Large chunks of land were developed as new districts, like Hongqiao Economic Development Zone, Gubei New District, Lujiazui CBD and so on. The fast construction promoted remarkable economic growth and meanwhile brought the dull urban image and monotonous streetscapes. Increasingly researchers and planners pointed out that Shanghai had become more and more mechanised, and its streets were less pleasant and vibrant.

In summary, ***the political revolution, cultural reflection and Opening up Policy had a profound influence on the development of Shanghai from 1949 to 2000. These impacts not only successfully promoted the rapid development and massive construction in Shanghai but also brought a series of social and environmental problems to the advancement of the city and its streets***.

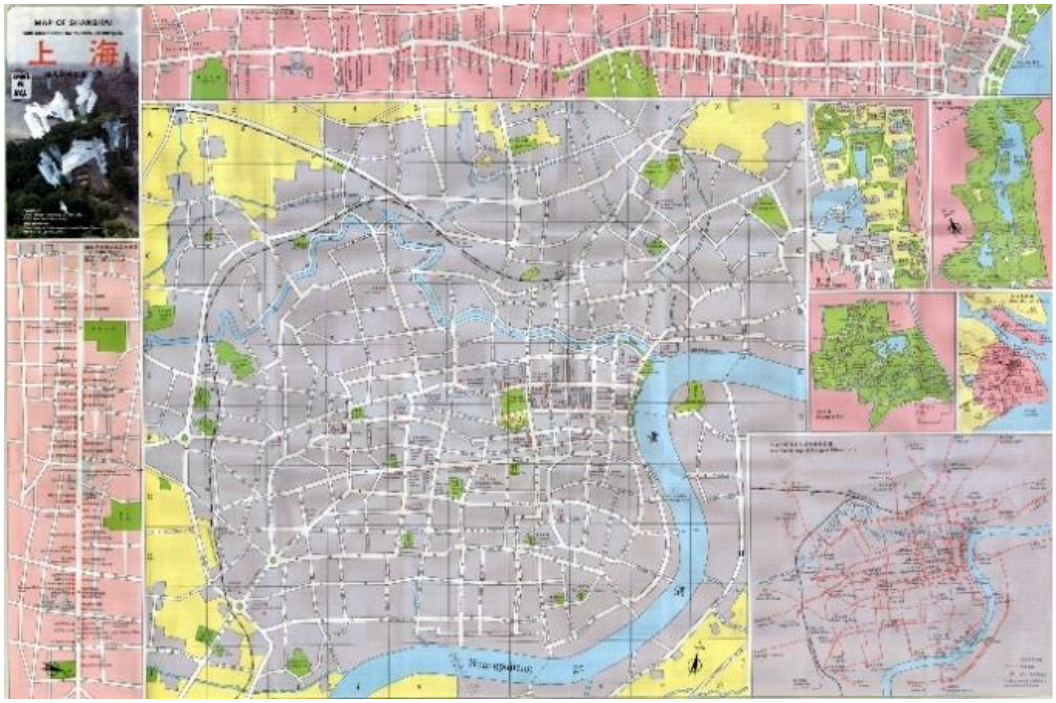


Figure 5. 7: Map of Shanghai (1985) *Source: (Virtual Shanghai, 1985)*

Figure 5. 8: Comprehensive plan of Shanghai Pudong (1991) *Source:* (Visual Shanghai, 1991)

5.3.4 From 2000: A Shift Period in Modern Shanghai

With the further acceleration of Shanghai development after 2000, the construction of new areas and the transformation of old areas have brought significant influences and changes to city texture and road network. However, in the process of rapid development and diversified exploration, more and more problems have been exposed: city texture is broken into pieces and becomes disorder; the street space lacks of human care; street vitality decreased considerably, and the urban life becomes to be cold and mechanical. The lifestyle of over-reliance on private cars and the extensive development of new urban areas leads to more traffic consumption, energy waste and massive emissions, which has resulted in severe traffic congestion, air pollution as well as the severe effect of people’s health. Meanwhile, in the period of the rainy seasons of Shanghai, the significant instantaneous rainfall stall transportation, which often causes considerable economic losses.

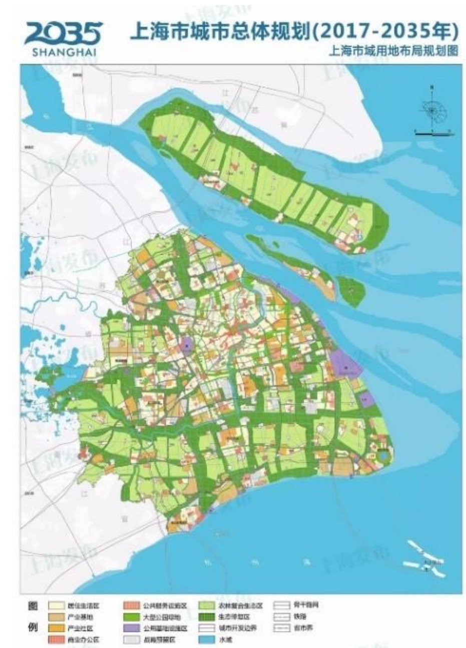
Confronted with a series of problems, increasing scholars call for the development shift of Shanghai streets. Xu researched the relationship between walking activity quality and built environment and the relationship between pedestrian behaviours and the spatial features along the ground-floor commercial streets with an aim at promoting the vitality of Shanghai streets (Xu & Kang, 2014; Xu & Shi, 2017). Wang. et al. (Wang, et al., 2015) proposed the “human-oriented streets” and used the survey methods of PLPS (Public Life and Public Space) to study the streets in Huangpu District, Shanghai with the aim of creating world-class public streets. Qiao raised the concept of “Green Street” to analyse and unscramble the future streets from the perspective of sustainable development (Qiao, 2009).

Furthermore, many practices of street transformation have also been carried out in Shanghai since 2000. The Zhongshan Rd in the Bund Area was retrofitted in 2005 by decreasing the motor lanes from ten to four on the ground and moving six lanes underground, which has greatly increased the walkable space on the ground and enlarged the overall landscape of the Bund in Shanghai. In 2007, a total of 144 Shanghai streets were listed as the Landscape and Historical Streets to protect the spatial patterns and historical elements within the streets and inherit their humanistic characteristics and historical culture (SPLRAB/SMTC/SUPDRI, 2016; Guo, 2012; Guo, et al., 2009). Also, since 2010, many Shanghai districts, like Yangpu district, Xuhui District, Huangpu District and so on, have actively advocated the design concept of “Humanized streets” and gradually implemented street renovation.

In summary, ***Shanghai and its streets have entered a shift period after entering the new millennium***. This shift emphasises that the social harmony, environmental impacts, and economic growth should be considered and valued equally. Also, the shift of Shanghai streets has been supported by increasing academic studies and practical exploration. Importantly, the release of "The Guidelines for Shanghai Streets Design" in 2016 officially indicates that Shanghai streets enter the period of a comprehensive and systematic transformation.

Source: (SPLRAB/SMTC/SUPDRI, 2016)

Figure 5. 9: Shanghai Street Design Guide.



Source: (SUPLRAB, 2017)

Figure 5. 10: Shanghai Land Use Plan (2017-2035)

5.4 Current Situation of Shanghai Streets

Shanghai, as a massive global city with a population of 24.2 million and a total area of 6340.5 km^2, has rich and diversified street types. Therefore, Chapter 5.4.1 is to present the traditional Road Classification. Chapter 5.4.2 will introduce the four street types, their main features, and typical cases of Shanghai streets. Based on this, Chapter 5.4.3 will analyse the primary features and primary issues of Shanghai streets, thereby providing a summary of the current situation of Shanghai streets.

5.4.1 Road Classification and Street types

In China, the road classification is mainly based on traffic efficiency. The urban roads are divided into four grades according to the driving speed, namely Fast Road, Major Road, Secondary Road, and branch respectively (MOHURD, 2016). So, the detail design of the street, including the street width and the numbers of travel lanes, is formed according to the overall classification which is dominated by the driving speed (Table 5. 3).

Table 5. 3: China Road Classification List

Road Classification	Traffic Function	Driving Speed	Recommended Road Width	Typical case
Fast Road	*The Fast Road has strong characteristics of transit traffic, with large traffic capacity and fast driving speed. It serves the rapid traffic and rapid external traffic in the municipal district.*	60-80 km/h	50-70 m	*North Zhongshan Rd* 
Major Road	*The Major Road is the framework of the urban road network, and it is a traffic trunk road connecting different functional district of the city.*	50-60 km/h	40-55 m	*Siping Rd* 
Secondary Road	*The Secondary Road is the interregional communication trunk road within the city, and it has the function of distributed transportation and service.*	40-50 km/h	24 -36 m	*West Nanjing Rd* 
Branch	*The Branch Road is the connecting line between the secondary road and the inner road of the neighbourhood.*	≤ 30 km/h	≤ 24m	*Zhengyue Rd* 

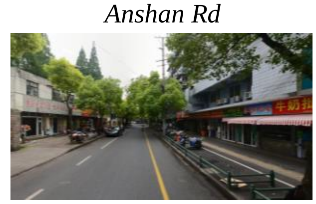
The classification was quoted from (MOHURD, 2016), and illustrated photos were taken by the author.

Such road classification and design standards are easy to practice, but they bring many problems. First of all, the classification mainly emphasises the efficiency of motor vehicles traffic, so the service condition of slow-speed traffic, like pedestrian and cycling, is often inadequate. Secondly, the road classification is based on the driving speed of motor vehicles, so the road width and travel lanes are often overestimated, which results in considerable land waste and unpleasant scale of urban roads. Finally, such a vehicle-oriented concept and mechanical method of road classification inevitably leads to neglect of other functions of urban streets like social space, commercial place, cultural hub, political stage, and ecological framework. So the “Code for design of urban road engineering” (MOHURD, 2016) that gives the design requirements according to the road classification cannot adapt to the current traffic characteristics, social development mode, and the promotion of green travel.

In this context, “Shanghai Street Design Guide” was released in 2016 and divide streets into five types, namely Commercial Street, life Service Street, Landscape and Leisure Street, Traffic Street, and Integrated Street respectively (Table 5. 4). The guideline highlights that the design of street elements should be combined with particular activities and functions of surrounding buildings for different types of streets rather than simply depend on the road classification and vehicle speed.

It can be seen from the analysis above that firstly both the traditional road classification and the five street types are only classified the urban streets from different angles, and they are not contradictory. Moreover, comparing with the vehicle-oriented concept of the traditional classification, the five street types classified from street functions provide a multi-dimensional and people-oriented perspective to study and design the streets. Last but not least, ***the changes from traditional classification and codes to the newly-released design guidelines of Shanghai streets indicate a reflection of conceptual advancement and street development***.

Table 5. 4: Street Types List

Street Types	Features	Typical case
Commercial Streets	*Along the street, there are many small- and medium-sized retail, catering, and other stores with some specific business characteristics. Also, the service scope is the regional and above scale.*	*West Huaihai Rd* 
Life Service Streets	*Along the street, there are various service-oriented business (such as convenience stores, barbershop, and laundry) and many public service facilities (such as clinics, community centre).*	*Anshan Rd* 
Landscape & Leisure Streets	*The street is featured by the waterfront, unique landscape, or historical location, along which there are many recreational facilities with a particular scale.*	*Xinhua Rd* 
Traffic Streets	*The street is with strong traffic function, and the interface is mainly non-open.*	*East Jinxiu Rd*

Street Types	Features	Typical case
		
Integrated Streets	*The street is integrated two or more functions and interface types which are mentioned above.*	*Madang Rd* 

The classification was quoted from (SPLRAB/SMTC/SUPDRI, 2016), and photos were taken by the author.

5.4.2 Features and Issues

As analysed above, the formation of Shanghai streets are not only the results of historical development and urban pattern evolution but also the outcomes of urban management and planning guidance. In 2016, the Shanghai government invested nearly 70 billion RMB in transportation infrastructure, and the total length of Shanghai roads has exceeded 5,100 kilometres by 2017 (STPDRC, 2017). Moreover, the traffic accident rate and the number of traffic fatalities in Shanghai have decreased gradually over the past ten years (STPDRC, 2017).

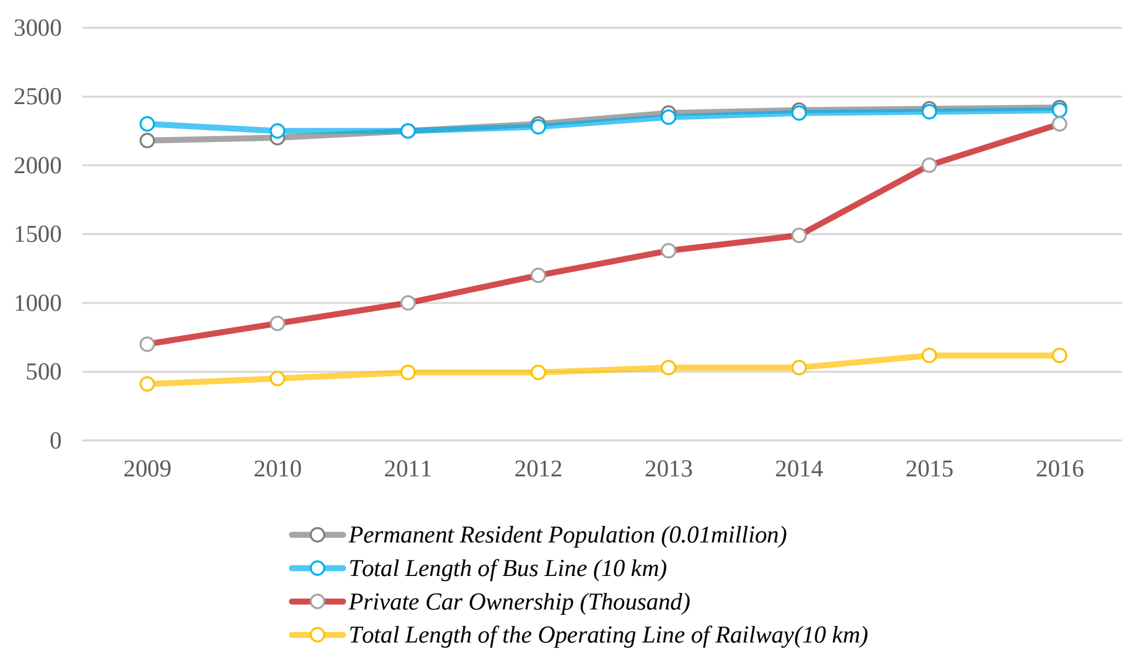
However, with the rapid growth of private cars and the increasing demand for transportation, especially in the context of Climate Change, Shanghai streets are still confronted with considerable challenges. The primary issues can be summarised below:

Severe Traffic Congestion: Though the road construction is accelerating, the traffic congestion in Shanghai is still severe due to the continuous growth of private cars (see in Figure 5. 11). According to statistics, the average travel speed of Shanghai major roads during rush hours in 2016 is only 18km/h, and the average daily one-way commute in Shanghai takes 43 minutes (SRIURCTD, 2017).

Poor public transportation service: Shanghai public transportation system mainly includes public bus, railway, and taxi. The total length of the bus line and the railway has gradually increased over the past several years. However, the growth speed is much slower than that of private cars (see in Figure 5. 11). The infrastructure of public transportation is not adequate, and the transportation capacity is limit. Moreover, the public buses have no priority in most Shanghai streets, which leads to the unguaranteed timeliness and poor service. Shanghai government has actively taken various measures to curb this phenomenon, including the establishment of bus lanes, the implementation of intelligent bus stations, and the introduction of barrier-free buses. However, these measures are still insufficient to meet the enormous demand, especially during rush hours.

Limited street vitality: The previous planning pattern and street design often form large neighbourhood and over-wide roads. Consequently, urban roads become the source of noise and air pollution, rather than an attractive place for public activities. As mentioned in Chapter 5.2.1, street life in Shanghai has traditionally been diverse and rich. Pleasant streets lead to good neighbours' relationships and diverse social life. However, one of the key problems with Shanghai streets today is that enclosed neighbourhoods and narrow sidewalks drive the streets to be car-oriented space. The vigour of the urban streets declined gradually, and the streetscape become similar and dull (Zhao, 2004; Wang, 2013; Zhan, 2010)

Insufficient capacity to emergency events and climate adaptation: Too wide roads with the fully hardened surface makes the "city skin "can't release energy. Also, they not only increase the Heat Island Effect but also weaken the adaptable ability to emergency events or disaster climate. It is known to all that Climate Change brings more extreme weather events. Confronted with such rainstorms like the events of "913 Shanghai Extraordinary Rainstorm" (13th Sep. 2013) and "824 Shanghai Rainstorm" (24th Aug. 2015), the entire road system in Shanghai was completely paralyzed, indicating the limitation of Shanghai streets to cope with disaster weather and recover.



Data source: SRIURCTD, 2017; SPLRAB/SMTC/SUPDRI, 2016

Figure 5. 11： 2009-2016 Shanghai Road Data Statistics

5.5 Sustainability Shift

In October 2016, Shanghai officially released the “Shanghai Street Design Guide”, which has a profound impact on the sustainable shift of Shanghai streets. The guideline proposed the development orientation of “transformation from Roads to Streets”, and further set the four overall targets of “Safe Streets, Green Street, Vibrant Street, and Smart Street”. It can be seen that the development orientation and targets of the guideline are within the framework of sustainable streets.

From a comprehensive perspective of the development of Shanghai streets, the Sustainability Shift is the necessary trend of the historical development, a practical solution to the issues that Shanghai streets that currently have, as well as the significant booster for Shanghai 2040 Master Plan.

Firstly, sustainability shift is the consequence of the development reflection of Shanghai streets after 2000, as well as a practical solution to the issues of Shanghai streets. Chapter 5.3 expounded the relations between Shanghai city texture and street development. Shanghai develops from a small fishing village into an international metropolis. Shanghai streets also experience from the traditional Jiangnan style to diversified pattern. The rapid expansion and fast growth bring a series of issues, like severe traffic congestion, poor public transportation service, limited street vitality, and insufficient capacity to emergency events and climate adaptation (elaborated in Chapter 5.4.3). Therefore, a transformation of the development pattern is urgently necessary for Shanghai streets. As what is highlighted in the “Shanghai Street Design Guide” Shanghai streets should transform from “car-oriented, relying on engineering and mechanism, and efficiency dominance” to a development mode of “people-oriented, respect to nature, a balance between efficiency and fairness”. This transformation is in accord with the central concepts of sustainable development.

Secondly, the sustainability shift includes the development goal and core targets proposed in the “Shanghai Street Design Guide”, and the extension and connotation of sustainable streets are more significant and profound. The design guideline interprets the transformation as the requirements of refinement, humanisation, and intellectualisation of design, management, and evaluation of Shanghai streets. So, these requirements are in accord with the contents of sustainable streets that are proposed in this research. Furthermore, the design guidelines identify four design objectives as “Safe Streets, Green Street, Vibrant Street, and Smart Street”. According to the design guidelines, safe streets refer to the safe, orderly, peaceful, and sharing streets for all kinds of traffic participants. Green streets are to promote the intensive land resources, to advocate green and low-carbon lifestyle, and to form the harmony between the artificial environment and natural environment. Vibrant streets are to provide open, comfortable, and accessible public space for local people thereby promoting public communication and encouraging creativity and innovation. Also, smart streets refer to the integration of intelligent innovation of street furniture to provide execution assistance, security maintenance, and convenient life. It can be seen that the four objectives and their requirements are included in the fifteen evaluation criteria for sustainable streets that are established in this research.

Finally, the sustainability shift of Shanghai streets is in line with Shanghai 2040 development goals. Shanghai 2040 Plan proposes the overall goal as "Striving for excellent global city" and states three significant development strategies as "building a green transportation system, "cultivating an open-minded city glamour", and "improving urban security ability". Concerning the Green transportation system, there is a need to improve the low-carbon and public-oriented transportation system, to enhance the function and quality of non-motorized transportation, and to promote differentiated transportation strategies. Regarding the enhancement of public space, there is a need to improve the quality of cultural and recreational functions, to create distinct landscapes, and to build robust and dynamic public space. About the safety of disaster prevention, it should be emphasised that Shanghai, as a high-density metropolis, should actively cope with all sorts of risks and reinforce the adaptable ability to Climate Change to build a reliable and resilient city. These are all within the theoretical and practical framework of sustainable streets. Therefore, it can be said that the transformation of sustainable streets is the significant booster for the Shanghai 2040 vision.

5.6 Summary

Chapter 5 has described the historical development, current situation, and future trend, thereby providing a theoretical background for the sustainability study of Shanghai streets.

A brief introduction of the scale of land, population, and economy of Shanghai revealed the importance of streets as the public open space in the high-density living environment. The study of the location and the climate features showed that Shanghai's climate type could provide a comfortable outdoor condition to street activities for about half the time throughout the year. In order to extend the comfortable period of outdoor activities in Shanghai streets, it is necessary to provide shading and maximise the breezes from the southeast in summer and to enlarge the solar radiation and block the cold air from the northwest in winter. Furthermore, regarding the annual rainy season and typhoon, the adaptability of Shanghai streets to short-term rainstorms and windstorms should be reinforced, thereby strengthening the capacity of disaster prevention and disaster recovery.

Concerning the development history of Shanghai streets, the main characteristics of Shanghai development and its street evolution were summarised into four phases:

1) The alleys and rivers shaped the narrow and twisty streets in Jiangnan waterfront county before 1843;
2) The interaction of multi-culture and national revolution formed diverse but unsystematic streets in concession period between 1843 and 1948;
3) The rapid development of Shanghai and the massive construction of Shanghai streets brought a series of social and environmental problems from 1949 to 2000;
4) Various forces have pushed the shift of the development pattern of both Shanghai and its streets since 2000.

Concerning the current situation and characteristics of Shanghai streets, the traditional road classification and five street types classified by “Shanghai Street Design Guide” were introduced. By comparing two classifications, it was summarised that the changes from traditional classification and codes to the newly-released design guidelines of Shanghai streets indicate a reflection of conceptual advancement and street development. Moreover, the essential characteristics of Shanghai streets were analysed, and the primary issues of current Shanghai streets were summarised into four points, namely severe traffic congestion, poor public transportation service, limited street vitality, and insufficient capacity to emergency events and climate adaption respectively.

Therefore, the necessity and significance of sustainability shift of Shanghai streets were demonstrated: the sustainability shift is the necessary trend of the historical development, a practical solution to the issues that Shanghai streets are confronted with, the significant booster for Shanghai 2040 Master Plan, as well as in line with the real needs of the street life from the citizens.

Chapter 6. Preliminary Assessment of Shanghai Streets

6.1 Introduction

This chapter presents the evaluation results of 236 Shanghai streets of the 1st Field Survey. The overall performance of Shanghai streets is summarised based on the data analysis.

Firstly, Chapter 6.2 introduces the evaluation results of 236 Shanghai streets. The 236 assessed streets are in nineteen study sites (shown in Figure 4. 5), so the evaluation findings and statistical analysis of nineteen study site are introduced from Chapter 6.2.1 to Chapter 6.2.19 accordingly.

The analysis of each study site consists of three parts:

1) ***Brief of assessed streets:*** The background of the study site is briefly introduced, including its history, development context, and landscape characteristics, which helps to understand the features and construction context of assessed streets better. Then the number, layout, name, and streetscape of the assessed streets are presented to form an overall understanding of the selected streets within this study site.
2) ***Analysis of assessment results:*** The assessment results are analysed from three aspects. Firstly, the average scores of Sustainable Street Index (SSI) and their comparison with the average of 236 streets are presented, which demonstrates the streets' general performance of the study site. ***The max of the SSI is 45 and the range of SSI is 0-45.*** Secondly, the streets of the highest and the lowest score in the assessment are illustrated to present the extreme cases. Thirdly, the performance of three sustainability aspects (EnSI, SoSI, and EcSI) of the assessed streets are introduced, thereby reflecting the critical characteristics of the streets within this study site.
3) ***Introduction of the best street. T***he streets that get the highest score of SSI in the study site are analysed in detail, which is used to illustrate the selection process of sample cases as well as to display the details of the assessments.

Based on the statistical analysis and qualitative summary of the assessment results, the three streets that are selected as the demonstration cases for the study in the next research stage are presented and overall performance of Shanghai streets are summarised accordingly.

Urban streets can be divided into 5 types according to their functions, namely commercial streets, neighbourhood streets, landscape streets, traffic streets, and multi-function streets respectively.

There is no classified evaluation of 236 studied streets, however, the overall performance of different types of streets in Shanghai can be concluded basically through field investigation and data statistics. Firstly, 19 study sites have their own characteristics in function and location, so the streets' performance in different study sites can reflect the characteristics of different types of streets to a certain extent. Secondly, the in-depth analysis of the best streets in each study site reflects the features regarding street typology. Finally, the three demonstrative streets selected in the study are three different types of streets, so the evaluation results could also show the features and performance of the three street types.

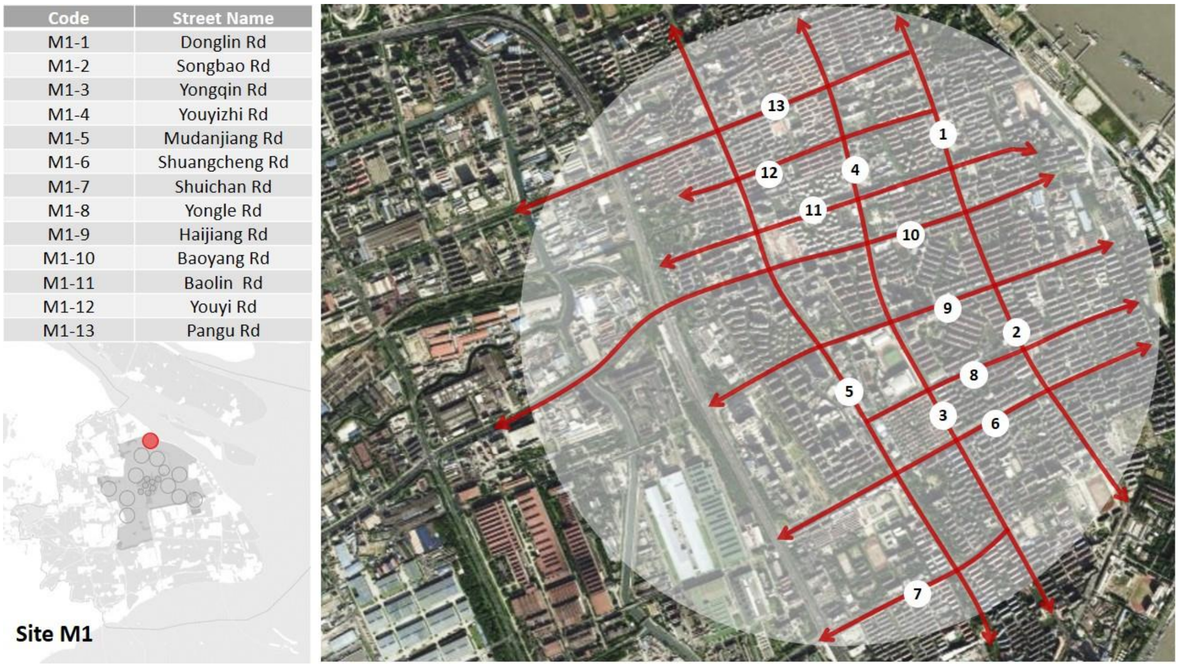
6.2 Assessment results of 19 study sites

6.2.1 Site: M1

6.2.1.1 Site Brief

Site M1 is in Wusong area where the Yangtze River and the Huangpu River converge together. Situated in the northern area of Shanghai, Wusong area is Shanghai major Heavy Industrial Zone, the centre of modern foreign trading port and the newly developed urban area.

Totally 13 streets were investigated within this area, and they were mainly distributed in the residential blocks of Wusong area. This was a workers' community for the urban industrialisation and was constructed in the 1980s. It still has a large working-class population and a moderate population living density nowadays. The surveyed streets were crisscrossed together, and the layout of these streets was mainly based on several urban branches constructed on three longitudinal roads. The name and photos of this 13 surveyed streets are illustrated in Table 6. 1. According to the street survey, the width of streets was about 20 meters and with pleasant street greening. There were wide sidewalks and some pocket gardens along the streets. Moreover, the traffic volume of surveyed streets was reasonably large during the peak period, especially for electric bicycles and bicycles. Hence many security fences were installed between motor lanes and cycling lanes or cycling lanes and sidewalks.



The satellite map was from Baidu Map (Baidu, 2017)

Figure 6. 1: Layout and Key Map of Investigated Streets in Site M1

Table 6. 1: Investigated Streets in Site M1

Code	Street Name	Photo	Code	Street Name	Photo
M1-1	Donglin Rd		***M1-2***	Songbao Rd	
M1-3	Yongqin Rd		***M1-4***	Youyizhi Rd	
M1-5	Mudanjiang Rd		***M1-6***	Shuangcheng Rd	
M1-7	Shuichan Rd		***M1-8***	Yongle Rd	
M1-9	Haijiang Rd		***M1-10***	Baoyang Rd	
M1-11	Baolin Rd		***M1-12***	Youyi Rd	
M1-13	Pangu Rd				

Some of the photos are from Baidu Streetscape (Baidu, 2017)

6.2.1.2 Street Evaluation

Thirteen streets in the Site M1 were investigated and assessed. Table 6. 2 and Figure 6. 2 show the statistics of assessment results, and the primary findings are summarised below:

- The overall performance of the thirteen streets on the Site M1 was above the average level of total 236 surveyed streets. Specifically speaking, the average SSI of M1's thirteen streets was 24.0 which was 1.0 higher than the average score of 236 streets;
- The street of M1-4 (Youyizhi Rd) achieved the highest score of SSI (28.5), while the street of M1-1 (Donglin Rd) achieved the lowest score (17.3). Standard Deviation of 13 streets was 3.66, which showed the performance of M1 streets was relatively stable.
- Regarding the three pillars of sustainability:
  - The average score of the EnSI of these streets in the Site M1 was 1.7, which was 0.3 higher than the average score of 236 streets. The scores of three criteria, namely C2 Mitigation (UHI), the C3 (Pollution Reduction), and C5 (Green life Promotion), were all higher than the average value.
  - The average score of SoSI of these streets in the Site M1 was 1.69, which was equal to the average score of 236 streets. The score of C7 (Safety) was relatively high because of a series of safeguards such as safety barriers between travel lanes and sidewalks, speed control cameras, and speed limit signs. Meanwhile, the scores of C9 (Diversity) and C10 (Culture Inheritance) were relatively low since few street activities were observed and streetscape looked similar.
  - The average score of EcSI of these streets in the Site M1 was 1.41 which was 0.08 lower than the average score of 236 streets. According to the site investigation and observation, the commercial atmosphere along the street was weak. Also, the shops and real estates along the streets did not have the premium effect.

Table 6. 2: Evaluation Statistics of M1 Streets

Street Code	**Environmental Sustainability**					**Social Sustainability**					**Economic Sustainability**					**SSI**
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M1-1 (min)	1.0	1.5	1.8	1.5	0.8	0.8	1.8	1.8	0.8	1.0	0.8	1.8	0.8	0.8	0.8	**17.3**
M1-2	1.8	1.5	1.8	1.5	1.5	1.0	1.8	1.8	2.3	1.8	2.0	1.8	1.8	1.8	1.8	**25.5**
M1-3	1.8	1.5	1.8	1.5	1.5	1.8	1.0	1.8	1.5	1.0	1.8	1.8	0.8	0.8	0.8	**20.8**
M1-4 (max)	1.8	3.0	2.0	1.8	2.8	1.8	2.0	1.8	1.8	1.8	2.0	1.8	1.8	1.8	1.0	**28.5**
M1-5	1.8	2.8	2.8	2.5	1.8	2.5	2.8	1.8	1.5	1.5	1.8	1.8	0.8	0.8	1.8	**28.3**
M1-6	2.0	2.0	1.3	1.8	1.0	1.0	2.0	2.0	0.8	1.0	1.0	2.0	1.0	0.8	0.8	**20.3**
M1-7	1.0	1.5	1.8	0.8	0.8	1.8	2.5	1.8	1.5	1.8	1.8	1.8	1.8	1.8	1.8	**23.8**
M1-8	1.8	1.5	1.8	1.5	0.8	1.0	2.0	1.8	1.5	1.8	1.8	1.8	1.8	1.8	1.0	**23.3**

Street Code	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M1-9	1.8	1.5	1.8	1.5	1.5	0.8	1.8	1.8	0.8	1.5	1.3	1.8	0.8	0.8	0.8	**19.8**
M1-10	1.8	1.5	1.8	1.5	1.5	2.5	2.8	2.0	1.5	2.5	1.8	1.8	1.5	1.5	1.0	**26.8**
M1-11	1.8	2.3	2.5	2.3	1.5	2.5	1.8	1.8	2.3	1.8	1.8	1.8	1.8	1.8	1.5	**28.8**
M1-12	1.8	2.3	2.5	1.5	1.5	2.5	1.8	1.8	1.5	1.8	1.8	1.5	0.8	0.8	0.8	**24.3**
M1-13	1.8	1.5	2.5	1.5	1.5	1.8	1.8	1.8	1.5	1.8	1.5	1.8	1.8	1.5	1.5	**25.3**
M1 Average	**1.7**	**1.9**	**2.0**	**1.6**	**1.4**	**1.7**	**2.0**	**1.8**	**1.5**	**1.6**	**1.6**	**1.8**	**1.3**	**1.3**	**1.2**	**24.0**
	EnSI=1.70					**SoSI=1.69**					**EcSI=1.41**					
											Standard Deviation					***3.66***
236 streets Total Average	*1.43*					*1.69*					*1.49*					*23.0*

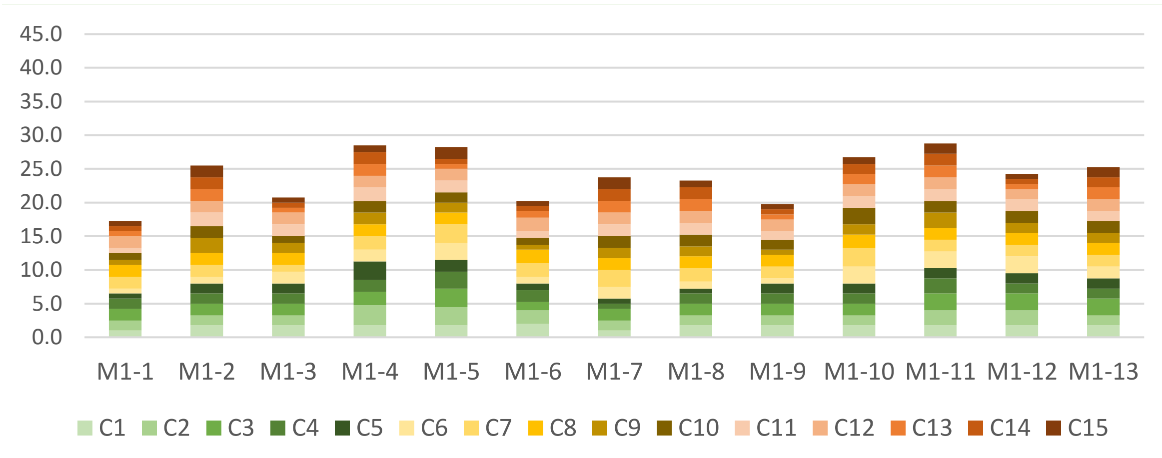


Figure 6. 2: Statistics Analysis of M1 Streets

6.2.1.3 Best Case: Youyizhi Rd (M1-4)

Table 6. 3 presents the assessment results and the statistical comparison of Street M1-4 (Youyizhi Rd). This is a multi-function street that integrates neighbourhood service and landscape function. The details of the rating results and evaluation illustration can be seen in Appendix K.

The SSI of M1-4 (Youyizhi Rd) was not very high (only 28.5) compared with other top streets, although it got the highest score in the Site M1. From the perspective of holistic sustainability, M1-4 got the highest score of 2.25 regarding the EnSI, mainly because of the high green rate within the street and many pleasant pocket gardens along the street. This green space not only created a good environment condition but also to some extent enhanced the adaptable ability to extreme events like the rainstorm and the extremely hot summer. However, the SoSI was slightly above the medium level. Moreover, the EcSI was also not high, and the score of C15 (Added-Value) only got 1.0 that was 0.3 lower than the Average Score of 236 surveyed streets.

In summary, M1-4 (Youyizhi Rd), as the best street in the Site M1, still had gaps in a genuinely sustainable street. Therefore, it was not selected as the sample case for the next stage.

Table 6. 3: Statistics of M1-4 (Youyizhi Rd) Sustainability Evaluation

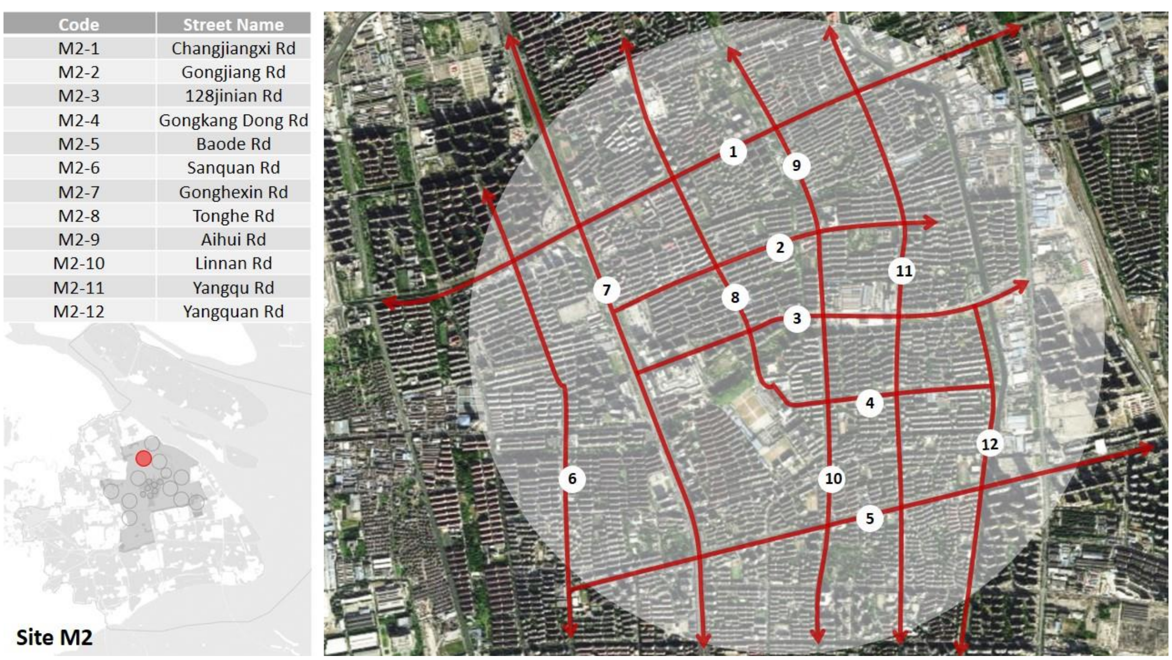
Street	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M1-4 ***Youyizhi Rd***	1.8	3.0	2.0	1.8	2.8	1.8	2.0	1.8	1.8	1.8	2.0	1.8	1.8	1.8	1.0	**28.5**
	EnSI=2.25					SoSI=1.80					EcSI=1.65					
236 *streets Average*	1.4	1.4	1.6	1.3	1.5	1.5	2.0	1.9	1.5	1.6	1.5	1.8	1.4	1.4	1.3	*23.0*
	EnSI=1.43					*SoSI=1.69*					*EcSI=1.49*					

6.2.2 Site: M2

6.2.2.1 Site Brief

M2-Gongkang Area, located in the north of Shanghai, is a new community built in the 1980s. The residents came here due to the renewal of the city centre and the northward expansion of city development. Most residents in Gongkang area are the workers of middle and low class, and the population density in this area is relatively high.

Totally 12 streets in the Site M2 were investigated. The layout and names of these streets are illustrated in Figure 6. 3 and Table 6. 4. According to the street survey, the traffic loads in this area were significant, and street congestion was severe especially during rush hour. Moreover, the overall performance of M2's streets was weak, and there were considerable gaps between these surveyed streets and sustainable streets, including street greening, safety issue, and streetscape.



Code	Street Name
M2-1	Changjiangxi Rd
M2-2	Gongjiang Rd
M2-3	128jinian Rd
M2-4	Gongkang Dong Rd
M2-5	Baode Rd
M2-6	Sanquan Rd
M2-7	Gonghexin Rd
M2-8	Tonghe Rd
M2-9	Aihui Rd
M2-10	Linnan Rd
M2-11	Yangqu Rd
M2-12	Yangquan Rd

The satellite map was from Baidu Map (Baidu, 2017)

Figure 6. 3: Layout and Key Map of Investigated Streets in Site M2

Table 6. 4: Investigated Streets in Site M2

Code	Street Name	Photo	Code	Street Name	Photo
M2-1	*Changjiangxi Rd*		***M2-2***	*Gongjiang Rd*	
M2-3	*128Jinian Rd*		***M2-4***	*Gongkang Dong Rd*	
M2-5	*Baoderd*		***M2-6***	*Sanquan Rd*	
M2-7	*Gonghexin Rd*		***M2-8***	*Tonghe Rd*	
M2-9	*Aihui Rd*		***M2-10***	*Linnan Rd*	
M2-11	*Yangqu Rd*		***M2-12***	*Yangquan Rd*	

Some of the photos are from Baidu Streetscape (Baidu, 2017)

6.2.1.2 Street Evaluation

Twelve streets in the Site M2 were investigated and assessed. Table 6. 5 and Figure 6. 4 show the statistics of assessment results, and the primary findings are summarised below:

- The overall performance of M2's streets was below the average of total 236 surveyed streets in the 1st Field Study. The average SSI of M2's 12 streets was 21.5 which was 1.5 lower than the average score of 236 streets;
- The street M2-5 (Baoderd Rd) achieved the highest score of the SSI (29.0), while the SSI of the street M2-10 (Linnan Rd) was the lowest (12.8). The Standard Deviation of M2's streets was 5.50, which meant the performance of surveyed streets in Site M2 was quite different, and the differences were relatively considerable.
- Concerning the three pillars of sustainability:
  - The average EnSI of the twelve surveyed streets in Site M2 was 1.45, which was slightly higher than the average score of 236 streets. There were street trees on both sidewalks, but the quality and diversity of street greening were just at the medium level.

- The average SoSI of the twelve streets in Site M2 was 1.41, which was 0.28 lower than the average score of 236 streets. The score of C6 (Equality) was the lowest (only 1.2) because of the absence of tactile pavement for the blind, barrier-free and other facilities for the street accessibility. Furthermore, the scores of C7 (Safety), C9 (Diversity) and C10 (Culture Inheritance) of M2's streets were also relatively low. Except for passing through, few public activities were observed, and the overall streetscape looked slightly cluttered.
- The average EcSI of the twelve streets in Site M2 was 1.43 which was 0.06 below the average of 236 streets. There were a few stores along the streets. According to the investigation, the transaction prices of real estate besides streets were even lower.

Table 6. 5: Evaluation Statistics of M2 Streets

Street Code	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M2-1	2.5	2.5	2.5	2.3	1.8	1.8	2.0	1.8	1.5	1.8	0.8	2.0	1.5	1.5	0.8	**26.8**
M2-2	1.8	1.5	1.8	1.5	1.5	2.5	1.8	1.8	2.3	1.8	1.8	1.8	2.5	2.5	1.8	**28.3**
M2-3	1.0	0.8	0.8	0.8	1.5	1.0	1.8	1.8	1.5	0.8	1.0	1.8	1.8	1.5	0.8	**18.3**
M2-4	1.0	1.5	1.8	1.5	1.5	1.0	1.8	2.5	1.5	1.5	1.5	1.8	1.8	1.8	1.5	**23.8**
<u>M2-5(max)</u>	<u>2.5</u>	<u>2.5</u>	<u>1.8</u>	<u>2.3</u>	<u>2.5</u>	<u>2.5</u>	<u>1.8</u>	<u>1.5</u>	<u>1.5</u>	<u>1.8</u>	<u>1.5</u>	<u>1.8</u>	<u>1.8</u>	<u>1.8</u>	<u>1.8</u>	**<u>29.0</u>**
M2-6	1.0	0.8	1.5	0.8	1.5	1.0	1.0	2.5	2.3	1.0	2.5	2.0	2.5	2.5	1.8	**24.5**
M2-7	2.8	1.3	1.3	1.0	2.0	1.8	1.3	2.3	0.8	0.8	0.8	2.3	1.0	0.8	1.0	**20.8**
M2-8	1.8	1.5	1.8	1.5	1.5	1.0	1.8	1.8	2.3	1.8	1.8	1.8	1.8	1.5	1.5	**24.8**
M2-9	1.0	1.5	1.8	0.8	0.8	0.0	1.0	1.0	0.8	1.0	1.3	1.0	0.8	0.8	0.8	**14.0**
<u>M2-10(min)</u>	<u>0.3</u>	<u>0.8</u>	<u>1.0</u>	<u>0.8</u>	<u>0.8</u>	<u>0.8</u>	<u>0.0</u>	<u>1.0</u>	<u>0.8</u>	<u>1.8</u>	<u>1.0</u>	<u>1.8</u>	<u>0.8</u>	<u>0.8</u>	<u>0.8</u>	**<u>12.8</u>**
M2-11	1.8	1.5	1.8	1.5	1.5	0.8	1.8	1.8	0.8	1.5	0.8	1.8	0.8	0.8	0.8	**19.3**
M2-12	0.8	1.5	0.8	0.8	1.5	0.3	1.0	1.8	0.8	0.8	1.8	1.5	1.5	0.8	0.8	**16.0**
M1 Average	**1.5**	**1.5**	**1.5**	**1.2**	**1.5**	**1.2**	**1.4**	**1.8**	**1.4**	**1.3**	**1.4**	**1.8**	**1.5**	**1.4**	**1.2**	**21.5**
	EnSI=1.45					**SoSI=1.41**					**EcSI=1.43**					
											Standard Deviation					**5.50**
236 streets Total Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					*23.0*

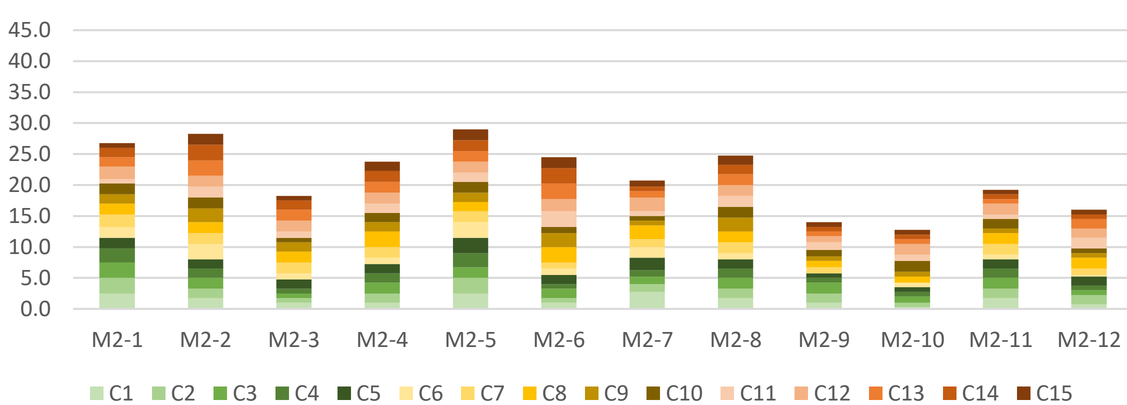


Figure 6. 4: Statistics Analysis of M2 Streets

6.2.1.3 Best Case: Baode Rd (M2-5)

Table 6. 6 presents the assessment results and the statistical comparison of Street M2-5 (Baode Rd). It is a multi-function street that integrates the function of serving the traffic and leisure activities of the surrounding residents. The details of the rating results and evaluation illustration can be seen in Appendix L.

The SSI of M2-5 (Baode Rd) got the highest score in the Site M2, but the score was only 29.0 which was not very high compared with other top streets. Baode Rd got the highest score of 2.30 in the EnSI. The rate of street green in Baode Rd was high, and tree canopies could cover most of the street, which not only contributed to UHI Mitigation and enhanced the adaptable ability to Climate Change but also promoted green lifestyle to some extent. However, the street's performance on social and economic sustainability was medium. There were some shops along the street, and some actives, like dog walking and shopping, were observed during the site investigation. However, the street activities were not diverse enough and the commercial atmosphere was not vibrant enough comparing with best cases of other study sites. Though there was a 2-meter-wide central green space, it neither served as open space for the public nor works as the ecologically functional garden like rain garden or an ecological corridor.

To sum up, though M2-5 (Baode Rd) got the highest score in the sustainability assessment of Site M2, there were still some distances from a genuinely sustainable street. Therefore, it was not selected as a sample case for the 2nd Field Survey.

Table 6. 6: Statistics of M2-5 (Baode Rd) Sustainability Evaluation

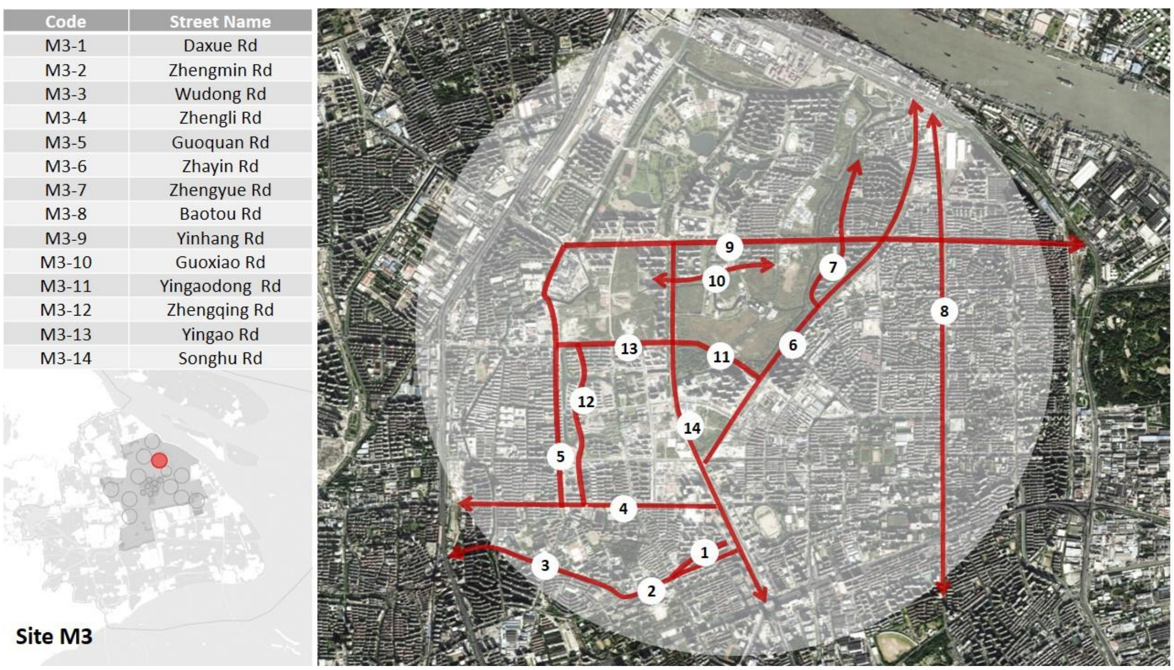
Street	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M2-5	2.5	2.5	1.8	2.3	2.5	2.5	1.8	1.5	1.5	1.8	1.5	1.8	1.8	1.8	1.8	**29.0**
Baode Rd	EnSI=2.30					SoSI=1.80					EcSI=1.70					
236 *streets*	1.4	1.4	1.6	1.3	1.5	1.5	2.0	1.9	1.5	1.6	1.5	1.8	1.4	1.4	1.3	***23.0***
Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					

6.2.3 Site: M3

6.2.3.1 Site Brief

Site M3 is in New Jiangwan city where is in the northeast of downtown Shanghai. The area is the former site of Jiangwan airport. New Jiangwan City is an international community with a certain number of middle-class residents, and its living density is relatively low. It was planned and built in about 2010s. This area is adjacent to the top universities in Shanghai, namely Fudan University, Tongji University, Shanghai University of finance and economics respectively. Moreover, as the site of an airport, the original landscape and nature resources on the site are well preserved, and then the overall master plan of this area highlights the ecological framework, such as the natural wetland, river system. Hence, this area is targeted to attract talents and become an ecological living garden.

Totally 14 streets were investigated in the Site M3, and they were mainly living streets. Figure 6. 5 and Table 6. 7 show the layout and names of these 14 streets. According to the street survey, it was found that the performance of these 14 streets varied a lot. Some streets, like Zhengyue Rd and Daxue Rd, were full of beautiful plants and vigorous street activities, while some streets, like Yingao Rd and Zhayin Rd, looked empty and lifeless.



The satellite map was from Baidu Map (Baidu, 2017)

Figure 6. 5: Layout and Key Map of Investigated Streets in Site M3

Table 6. 7: Investigated Streets in Site M3

Code	Street Name	Photo	Code	Street Name	Photo
M3-1	Daxue Rd		***M3-2***	Zhengmin Rd	
M3-3	Wudong Rd		***M3-4***	Zhengli Rd	

Code	Street Name	Photo	Code	Street Name	Photo
M3-5	Guoquan Rd		***M3-6***	Zhayin Rd	
M3-7	Zhengyue Rd		***M3-8***	Baotou Rd	
M3-9	Yinhang Rd		***M3-10***	Guoxiaord	
M3-11	Yingaodong Rd		***M3-12***	Zhengqing Rd	
M3-13	Yingao Rd		***M3-14***	Songhu Rd	

Some of the photos are from Baidu Streetscape (Baidu, 2017)

6.2.3.2 Street Evaluation

Fourteen streets in the Site M3 were investigated and assessed. Figure 6. 6 and Table 6. 8 show the statistics of assessment results, and the primary findings are summarised below:

- The overall performance of M3's streets was considerably below the average level of total 236 surveyed streets. The average Sustainability Index of M3 streets was only 18.4, which was 4.6 lower than the average of 236 streets.
- The SSI of the street M3-1 (Daxue Rd) was 35.5, which was the highest one in the Site M3 and the second highest score in 236 survey streets. M3-13 (Yingao Rd) got the lowest score of SSI (9.3). The Standard Deviation of M3's streets was 7.73, which reflected the performance of 14 surveyed streets in the Site M3 was quite variable. The performances of some streets were outstanding while the conditions of others were relatively weak.
- Regarding the three aspects of sustainability:
  - The average EnSI of the fourteen surveyed streets in the Site M3 was 1.13, which was considerably lower than the average of 236 streets (1.43). Some streets, such as Zhengyue Rd, Wudong Rd, showed a pleasant greening environment while some of the other streets, like Yingao Rd and ZhengQing Rd, looked chaotic and out of maintenance. Many street trees had been transplanted, and the green coverage of the streets was low.

- The average SoSI of the fourteen surveyed streets in the Site M3 was 1.41, which was still 0.28 lower than the average of 236 streets (1.69). The score of C6 (Equality) is the lowest (only 1.1) because of the absence of tactile pavement for the blind and other barrier-free facilities. Furthermore, the scores of C9 (Diversity) and C10 (Culture Inheritance) of these fourteen surveyed streets are also relatively low.
- The average EcSI of the fourteen surveyed streets in the Site M3 was 1.14, which was still 0.35 below the overall average score (1.49). The scores of C13 (Business Creation), C14 (Job Creation) and C15 (Added-Value) were relatively low. Hence it can be said that the economic vitality of M2's streets was relatively low.

Table 6. 8: Evaluation Statistics of M3 Streets

Street Code	Environmental sustainability					Social sustainability					Economic sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M3-1 (max)	1.8	2.0	2.0	1.8	2.8	1.8	2.8	1.8	2.8	2.8	2.8	2.0	3.0	2.8	3.0	**35.5**
M3-2	1.5	1.5	1.8	0.8	1.5	0.8	1.8	1.5	0.8	1.5	0.8	1.8	0.0	0.0	0.0	**15.8**
M3-3	1.8	1.5	1.8	0.8	1.5	0.8	1.8	1.8	1.5	0.8	1.5	1.8	0.8	0.8	0.8	**19.3**
M3-4	1.8	0.8	1.0	0.8	1.5	1.8	2.5	1.8	1.5	1.0	1.8	2.0	1.0	1.0	1.0	**21.0**
M3-5	0.3	0.0	0.0	0.0	0.8	1.0	1.8	1.8	1.5	0.8	1.0	1.8	1.8	1.8	0.8	**14.8**
M3-6	1.0	0.8	1.0	1.0	0.8	1.8	1.8	2.0	0.3	0.8	0.0	2.0	0.0	0.0	0.8	**13.8**
M3-7	2.5	2.8	2.8	2.8	2.8	1.8	2.8	1.5	1.5	1.5	2.0	1.8	0.0	0.0	2.0	**28.3**
M3-8	0.3	0.0	0.3	0.0	0.0	1.0	1.0	1.8	1.5	1.0	0.3	1.8	1.0	0.8	0.8	**11.3**
M3-9	1.0	1.5	1.0	0.8	1.5	1.8	2.5	1.8	2.3	1.8	2.5	1.8	2.5	2.5	1.5	**26.5**
M3-10	1.0	1.0	1.0	1.0	1.3	0.3	1.0	1.0	0.8	0.8	1.5	1.8	0.0	0.0	0.0	**12.3**
M3-11	1.0	0.8	0.8	0.8	0.8	1.0	1.0	1.3	0.8	0.8	0.3	2.0	1.3	1.3	1.3	**14.8**
M3-12	1.0	0.8	0.8	0.8	0.8	0.0	1.0	1.0	0.8	0.8	1.5	2.0	0.0	0.0	0.0	**11.0**
M3-13(min)	0.3	0.0	0.0	0.0	0.8	0.8	1.8	1.8	0.8	0.8	0.8	1.8	0.0	0.0	0.0	**9.3**
M3-14	1.8	2.0	2.0	1.8	2.0	1.8	2.8	1.8	1.5	1.5	1.5	2.0	1.5	0.0	0.3	**24.0**
M3 Average	1.2	1.1	1.1	0.9	1.3	1.1	1.9	1.6	1.3	1.2	1.3	1.9	0.9	0.8	0.9	**18.4**
	EnSI=1.13					**SoSI=1.41**					**EcSI=1.14**					
											Standard Deviation					**7.73**
236 streets Total Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					*23.0*

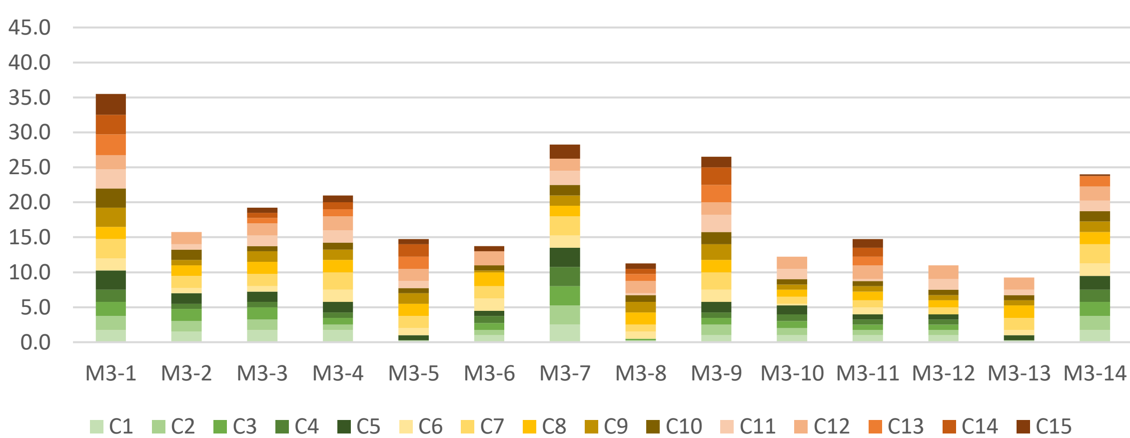


Figure 6. 6: Statistics Analysis of M3 Streets

6.2.3.3 Best Case: Daxue Rd (M3-1)

Table 6. 9 presents the assessment results and the statistical comparison of Street M3-1 (Daxue Rd). Daxue Rd is a typical commercial street in an innovative community of a new development area. The details of the rating results and evaluation illustration can be seen in Appendix M.

The SSI of M3-1 (Daxue Rd) was 35.5, which was the highest score in the Site M3 and second highest score among 236 surveyed streets. From a holistic sustainability perspective, the performance of Daxue Rd was relatively balanced. Daxue Rd got 2.7 in the EcSI. The sidewalks and the frontage zone of sided buildings were designed together to promote mutual interaction. Without influencing the pedestrians, this combination not only created the dynamic street business atmosphere and employment positions but also promoted the multifunctional and intensive use of urban land. Besides, the SoSI of Daxue Rd was 2.35. On the one side, the street controlled the car speed below 30km/h to enhance the safety of public streets, and on the other side, it provided cycling parking and two fixed sharing bike station to encourage people to arrive by cycling. It also promoted various street activates by pleasant streetscape as well as delicately designed street furniture. Furthermore, the EnSI of Daxue Rd was 2.05. Except for normal street trees, there were many flower fences and small plant pots in pavement café or hung on street lamps to build a natural and pleasant street environment. Besides, the street advertisements and regular weekend market in open space also actively promoted the green life and environmental preservation.

In summary, M3-1 (Daxue Rd) showed an excellent example of a diverse and vibrant urban street. Therefore, it was selected as a sample case for the 2nd Field Survey.

Table 6. 9: Statistics of M3-1 (Daxue Rd) Sustainability Evaluation

Street	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M3-1	1.8	2.0	2.0	1.8	2.8	1.8	2.8	1.8	2.8	2.8	2.8	2.0	3.0	2.8	3.0	**35.5**
Daxue Rd	EnSI=2.05					SoSI=2.35					EcSI=2.70					
236 ***streets***	*1.4*	*1.4*	*1.6*	*1.3*	*1.5*	*1.5*	*2.0*	*1.9*	*1.5*	*1.6*	*1.5*	*1.8*	*1.4*	*1.4*	*1.3*	***23.0***
Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					

6.2.4 Site: M4

6.2.4.1 Site Brief

Site M4 is in Siping Area. This area is made up of Tongji University and its surrounding residential blocks. The community was built in the 1970s and 1980s mainly for the workers and teachers from Tongji University. After decades of development, this area has gradually formed to be a mature community, and it shows a pleasant and peaceful overall atmosphere.

Totally 18 streets were investigated within this area. Figure 6. 7 and Table 6. 10 show the layout and names of these streets. Most of them looked tidy and clean, with clear signs and signals. All cars and bicycles went in order, and the street activities were diverse and dynamic, which was different from commercial streets in the city centre but showed a peaceful ambience of community.

The satellite map was from Baidu Map (Baidu, 2017)

Figure 6. 7: Layout and Key Map of Investigated Streets in Site M4

Table 6. 10: Investigated Streets in Site M4

Code	Street Name	Photo	Code	Street Name	Photo
M4-1	Miyun Rd		***M4-2***	Zhongshanbeier Rd	

Code	Street Name	Photo	Code	Street Name	Photo
M4-3	Chifen Rd		***M4-4***	Siping Rd	
M4-5	Zhangwu Rd		***M4-6***	Fuxin Rd	
M4-7	Dahushan Rd		***M4-8***	Dalianxi Rd	
M4-9	Dalian Rd		***M4-10***	Sujiatun Rd	
M4-11	Anshan Rd		***M4-12***	Tieling Rd	
M4-13	Jinxi Rd		***M4-14***	Fushun Rd	
M4-15	Kongjiang Rd		***M4-16***	Jiangpu Rd	
M4-17	Yanjixi Rd		***M4-18***	Changling Rd	

Some of the photos are from Baidu Streetscape (Baidu, 2017)

6.2.4.2 Street Evaluation

Eighteen streets in the Site M4 were investigated and assessed. Table 6. 11 and Figure 6. 8 show the statistics of assessment results, and the primary findings are summarised below:

- The overall performance of M4's streets was slightly above the average level of 236 surveyed street in the 1st Field Survey. The average SSI of M3's streets was 23.7 which was 0.7 higher than the total average of 236 streets;
- M4-10 (*Sujiatun Rd*) achieved the highest score of SSI (35.3), while M4-16 (*Jiangpu Rd*) achieved the lowest score of 13.8. The Standard Deviation of M3's streets was 5.07, which reflected the performance of eighteen surveyed streets in the Site M4 was relatively stable.
- Concerning the three aspects of sustainability:

- The average EnSI of the eighteen streets in the Site M4 was 1.49, which was 0.07 higher than the average score of 1.43 of 236 streets. Street greening in this area was pretty good, and the street trees could form the shading cover for most of the streets. Moreover, the trees were tall, and the planting types were diverse, so all of these contributed to the relatively good performance regarding environmental sustainability.
- The average SoSI of the eighteen treets in the Site M4 was 1.73, which was 0.05 higher than the average of 236 streets (1.69). The score of C7 (Safety) was 2.0 which was relatively high compared to other sites. Furthermore, the scores of C8 (Accessibility) and C10 (Culture Inheritance) of M4's streets were also relatively high.
- The average EcSI of the eighteen streets in the Site M3 was 1.54. C12 (Efficiency) got the highest score among the five criteria of economic sustainability. Because of the location and continuous renewal, the land usage of the streets was intensive and efficient, and many facilities along the streets were designed for multi-functions.

Table 6. 11: Evaluation Statistics of M4 Streets

Street Code	Environmental sustainability					Social sustainability					Economic sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M4-1	1.8	2.3	2.8	1.8	2.5	2.5	2.5	1.8	1.5	2.5	1.5	1.8	0.8	0.8	0.8	**27.3**
M4-2	1.3	0.3	1.0	0.8	0.8	1.0	1.8	1.3	0.8	0.8	0.8	2.0	0.8	0.8	0.8	**14.5**
M4-3	1.8	1.5	1.8	1.5	1.5	1.8	2.0	2.5	2.3	1.8	1.8	1.8	2.5	2.5	1.5	**28.3**
M4-4	1.3	0.8	1.3	0.8	1.8	1.8	2.8	2.3	0.8	1.5	0.8	2.3	0.8	0.8	1.0	**20.3**
M4-5	1.8	1.5	2.0	1.5	1.8	1.0	2.0	1.8	1.5	1.8	1.8	1.8	2.0	2.0	1.8	**25.8**
M4-6	1.0	1.5	1.8	1.5	1.5	1.8	1.8	1.8	1.5	1.8	1.8	1.8	1.5	1.5	1.5	**23.8**
M4-7	1.0	1.5	1.8	1.5	1.5	1.0	1.8	1.8	1.5	1.8	1.8	1.8	1.5	1.5	1.5	**23.0**
M4-8	1.8	0.8	1.8	1.5	1.5	1.8	2.0	2.0	1.5	1.8	1.0	1.3	1.8	1.8	1.8	**23.8**
M4-9	2.0	1.5	2.0	1.5	1.5	1.0	2.0	2.3	1.5	1.5	1.0	2.3	2.0	1.8	2.0	**25.8**
M4-10(max)	2.8	2.8	2.8	2.8	2.8	2.0	2.8	2.0	2.8	2.8	2.8	2.8	1.0	1.0	1.8	**35.3**
M4-11	1.0	2.3	1.8	1.5	1.5	1.8	2.5	1.8	1.5	1.5	1.8	1.8	1.8	1.5	1.5	**25.3**
M4-12	0.8	1.5	1.8	0.8	1.5	1.8	1.8	1.8	1.5	1.8	1.8	1.8	1.5	1.5	1.5	**22.8**
M4-13	0.8	1.5	1.5	0.8	1.5	1.8	1.8	1.8	1.5	1.8	1.5	1.8	2.0	1.8	1.5	**23.0**
M4-14	1.5	2.3	2.3	1.5	1.5	0.8	1.8	1.5	2.5	2.5	2.3	1.8	0.8	0.8	1.5	**25.0**
M4-15	1.8	1.5	1.8	1.5	2.3	1.8	2.8	1.8	1.5	1.8	1.8	1.8	1.8	1.5	1.5	**26.5**
M4-16(min)	1.0	0.0	0.0	0.0	0.8	0.8	1.0	1.8	0.8	0.8	1.5	1.8	1.5	1.5	0.8	**13.8**
M4-17	1.0	2.3	2.5	0.8	1.5	2.5	1.8	2.5	1.5	1.8	1.8	1.8	1.8	1.8	1.5	**26.5**
M4-18	1.0	0.8	0.8	0.8	1.5	1.0	1.8	0.8	1.5	1.5	1.8	1.8	0.8	0.8	0.8	**17.0**
M4 Average	*1.4*	*1.5*	*1.7*	*1.3*	*1.6*	*1.5*	*2.0*	*1.8*	*1.5*	*1.7*	*1.5*	*1.8*	*1.5*	*1.4*	*1.4*	**23.7**
	EnSI=1.49					**SoSI=1.73**					**EcSI=1.54**					
															Standard Deviation	**5.07**
236 streets Total Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					*23.0*

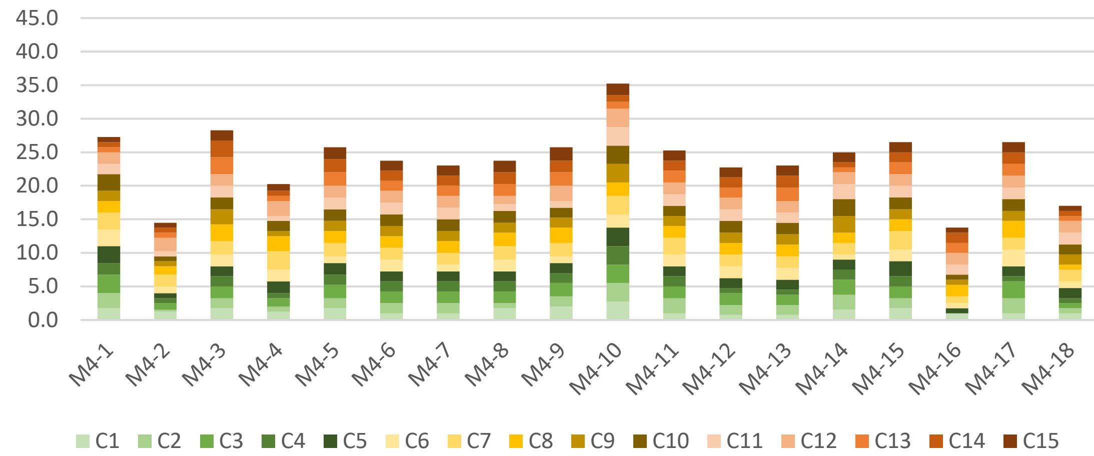


Figure 6. 8: Statistics Analysis of M4 Streets

6.2.4.3 Best case: Sujiatun Rd (M4-10)

Table 6. 12 presents the assessment results and the statistical comparison of Street M4-10 (Sujiatun Rd). Sujiatun Rd was a typical neighbourhood street in a mature community. The details of the rating results and evaluation illustration can be seen in Appendix N.

M4-10 (Sujiatun Rd) achieved the highest score in the sustainability assessment of Site M4, and its SSI was 35.3. Sujiatun Rd showed very excellent performance in environmental and social aspects, but only above average in economic sustainability. It got 2.75, 2.45, and 1.85 in the EnSI, SoSI, and the EcSI respectively. First, Sujitun Rd had a very high green rate and pleasant natural environment. The tree canopy could cover the whole street in summer. Belt gardens with diverse plants sided the street. Moreover, the street was one-way traffic, and the pavement of the sidewalk was different near the intersection to remind safety. There were many facilities, including streets seats, health and fitness facilities, jogging path, interactive installation art, to meet the needs of all kinds of street activities. All street elements were designed as a whole, and street furniture, like sculptures, seats, lamps, wall painting and bins, showed high aesthetic quality. However, the EcSI was only 1.85 which were just above the average level, because the stores and business along the street were limited.

To sum up, M4-10 (Sujiatun Rd), with the highest score of SSI in the Site M4 and third highest score in 236 surveyed streets, showed an excellent example of a quiet, pleasant, and green public street. However, the street was limited in the creation of commercial value, which might be an issue for holistic sustainability and deserves a further discussion. Therefore, it was selected as a sample case for the 2nd Field Survey.

Table 6. 12: Statistics of M4-10 (Sujiatun Rd) Sustainability Evaluation

Street	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M4-10 *Sujiatun Rd*	2.8	2.8	2.8	2.8	2.8	2.0	2.8	2.0	2.8	2.8	2.8	2.8	1.0	1.0	1.8	**35.3**
	EnSI=2.75					SoSI=2.45					EcSI=1.85					
236 streets Average	*1.4*	*1.4*	*1.6*	*1.3*	*1.5*	*1.5*	*2.0*	*1.9*	*1.5*	*1.6*	*1.5*	*1.8*	*1.4*	*1.4*	*1.3*	***23.0***
	EnSI=1.43					*SoSI=1.69*					*EcSI=1.49*					

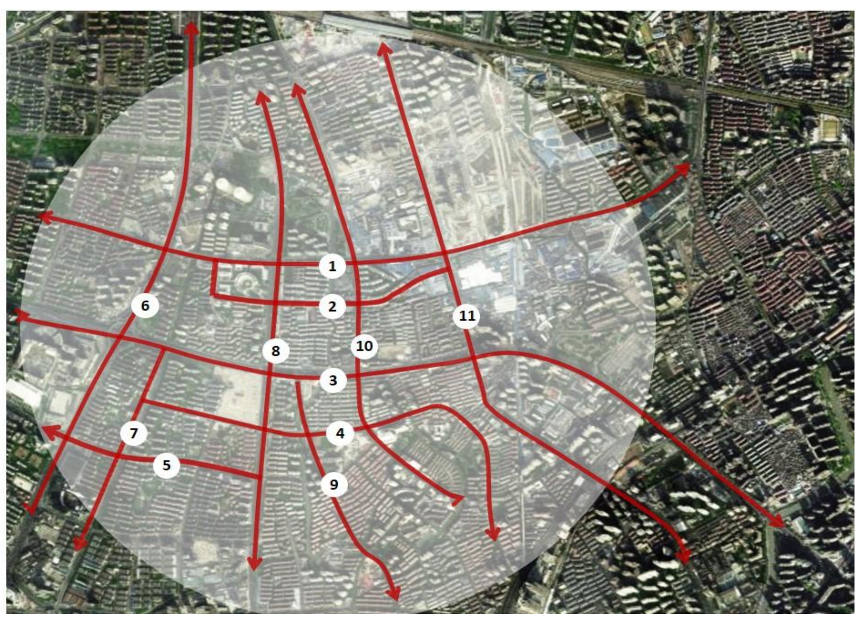
6.2.5 Site: M5

6.2.5.1 Site Brief

Site M5 is in Zhenru area where is in the northwest suburb of Shanghai. It was initially a small town of Shanghai suburban. Many worker's neighbourhoods were built in the 1980s because of urban expansion. Zhenru Temple, with a history of 800 years, is located here and has been preserved in good condition. Hence, this area has both the characteristics of the workers' community and the historic atmosphere.

Totally 11 streets were investigated in the Site M5. Figure 6. 9 and Table 6. 13 show the layout and names of these streets. It was found in the site survey that these streets were large traffic volume and a bit cluttered streetscape. Because of the high living density, the traffic volume was reasonably considerable, especially during rush hour. The congestion phenomena were severe and frequent. Moreover, the street network density and street width in this area was relatively limited. Hence some hidden dangers lied in the streets of this area.

Code	Street Name
M5-1	Tongchuan Rd
M5-2	Beishi Rd
M5-3	Wuning Rd
M5-4	Meilinbei Rd
M5-5	Meichuan Rd
M5-6	Zhenbei Rd
M5-7	Danba Rd
M5-8	Daduhe Rd
M5-9	Yangliuqing Rd
M5-10	Lanxi Rd
M5-11	Caoyang Rd



The satellite map was from Baidu Map (Baidu, 2017)

Figure 6. 9: Layout and Key Map of Investigated Streets in Site M5

Table 6. 13: Investigated streets in Site M5

Code	Street Name	Photo	Code	Street Name	Photo
M5-1	Tongchuan Rd		***M5-2***	Beishi Rd	
M5-3	Wuning Rd		***M5-4***	Meilinbei Rd	
M5-5	Meichuan Rd		***M5-6***	Zhenbei Rd	
M5-7	Danbard		***M5-8***	Daduhe Rd	
M5-9	Yangliuqing Rd		***M5-10***	Lanxi Rd	
M5-11	Caoyang Rd				

Some of the photos are from Baidu Streetscape (Baidu, 2017)

6.2.5.2 Street Evaluation

Eleven streets in the Site M5 were investigated and assessed. Table 6. 14 and Figure 6. 10 show the statistics of assessment results, and the primary findings are summarised below:

- The overall performance of M5's streets was remarkably lower than the average level of total 236 surveyed street in the 1st Field Survey. The average SSI of M5's streets was 19.2, which was 3.8 less than the total average of 23.0;
- M5-4 (Meilinbei Rd) achieved the highest SSI of 24.3 in the Site M5, while the SSI of M5-8 (Daduhe Rd) was the lowest score of 11.8. The Standard Deviation of M5's streets was 4.3, which showed the performance of 11 surveyed streets in M5 did not change much.
- Regarding the three aspects of sustainability:
    - The average EnSI of the eleven surveyed streets in the Site M5 was 0.96, which was remarkably lower than the average score of 236 streets (1.43). According to the site observation, the street greening in this area was poor, and there were even no street tree and plant in the street. For this reason, the scores of C2 (Mitigation UHI) and C4 (Ecological Balance) were only 0.9 and 0.8 respectively.

- The average SoSI of the eleven surveyed streets in the Site M5 was 1.39, which was also 0.3 lower than the average score of 236 streets (1.69). The score of C6 (Equality) was only 0.5, which was fairly low compared with the average of 236 streets. It was observed that many streets were lack of tactile pavement for the blind and barrier-free facility. Besides, the scores of C7 (Safety), C9 (Diversity), and C10 (Culture Inheritance) were 1.6, 1.4, 1.4 respectably, which were all low comparing to other 18 study sites. According to the observation, many points led to the poor safety performance, such as massive traffic volume of residents' daily commuting, massive transportation of trucks, the limited street land use, and poor street signs and management.
- The average EcSI of the eleven surveyed streets in the Site M5 was 1.57, and it was 0.06 above the average of 236 streets (1.49). After around 30 years' development, the business, and shops of buildings' bottom floors along streets had been very flourishing. Meanwhile, because of the limited street land use, the street section design was compact. Hence, the score of C13 (Business Creation) and C12 (Efficiency) were relatively high which were 1.8 and 1.7 respectively.

Table 6. 14: Evaluation Statistics of M5 Streets

Street Code	Environmental sustainability					Social sustainability					Economic sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M5-1	0.3	0.0	0.0	0.0	0.0	0.0	1.0	2.0	0.8	0.0	1.0	1.0	2.8	2.5	0.8	**12.0**
M5-2	1.0	0.0	0.0	0.0	0.8	0.3	1.8	1.8	1.5	1.8	1.5	1.8	2.0	1.8	1.8	**17.5**
M5-3	1.3	0.8	1.0	0.8	0.8	0.3	1.3	2.8	1.5	1.8	1.5	2.3	1.8	1.8	1.8	**21.0**
M5-4(max)	1.8	2.3	1.8	1.5	0.8	1.0	1.8	1.8	1.5	1.8	2.0	1.8	1.8	1.5	1.5	**24.3**
M5-5	1.0	0.8	0.8	0.8	1.5	0.3	2.0	2.5	2.3	1.8	1.8	1.0	2.5	2.5	1.5	**22.8**
M5-6	2.0	1.0	1.0	0.8	0.8	2.0	2.0	2.0	1.5	1.5	1.8	2.0	1.8	1.5	1.8	**23.3**
M5-7	1.8	1.5	1.8	1.5	1.5	0.3	1.8	1.8	0.8	1.0	1.5	1.8	0.8	0.8	0.8	**19.0**
M5-8(min)	0.5	0.0	0.0	0.8	0.8	0.3	1.0	2.0	0.8	0.8	0.8	2.0	0.8	0.8	0.8	**11.8**
M5-9	1.0	1.5	1.8	0.8	0.8	1.0	1.8	1.8	0.8	1.8	1.5	1.8	0.8	0.8	0.8	**18.3**
M5-10	1.8	1.5	1.0	0.8	1.5	0.3	1.0	1.8	2.3	2.5	1.5	1.0	2.5	2.3	1.5	**23.0**
M5-11	1.3	0.8	1.8	0.8	1.5	0.5	2.0	2.8	1.5	0.8	1.3	2.3	2.0	2.0	2.0	**18.0**
M5 Average	*1.2*	*0.9*	*1.0*	*0.8*	*1.0*	*0.5*	*1.6*	*2.1*	*1.4*	*1.4*	*1.5*	*1.7*	*1.8*	*1.6*	*1.3*	**19.2**
	EnSI=0.96					**SoSI=1.39**					**EcSI=1.57**					
											Standard Deviation					**4.30**
236 streets Total Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					*23.0*

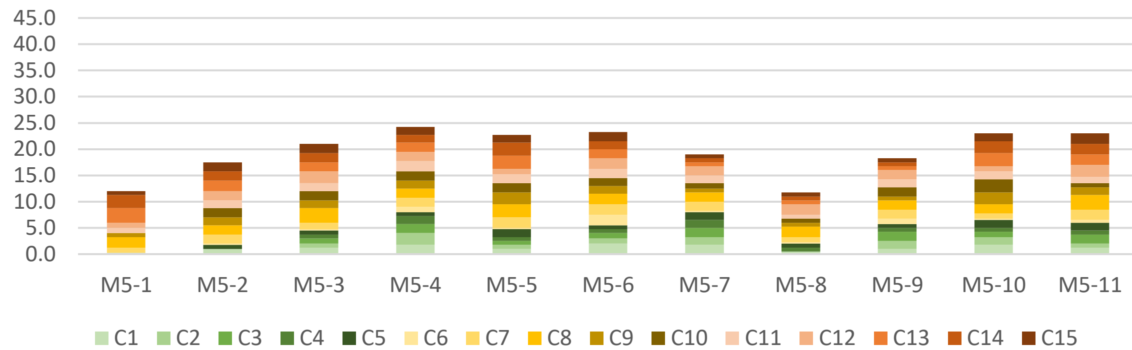


Figure 6. 10: Statistics Analysis of M5 Streets

6.2.5.3 Best case: Meilinbei Rd (M5-4)

Table 6. 15 presents the assessment results and the statistical comparison of Street M5-4 (Meilinbei Rd). It is a neighbourhood steet in a mature community. The details of the rating results and evaluation illustration can be seen in Appendix O.

The SSI of M5-4 (Meilinbei Rd) was 24.3. The score was the highest among the 11 surveyed street in the Site M5, but it was just above the average of 236 streets (23.0). The performance of Meilinbei Rd was relatively balanced, and all three aspects of sustainability were close to the average level. It was found that nice and big street trees were on both sidewalks, and the overall streetscape was neat and pleasant. The street was made up of two 3.75-meter-wide motor lanes, two 2-meter-wide cycling lanes, and 5-meter-wide sidewalks on both sides. However, due to high parking demand, both cycling lanes and sidewalks were used for car parking, which caused many potential dangers for cyclists and pedestrians.

To sum up, M5-4 (Meilinbei Rd) was a typical middle-level street concerning sustainability evaluation. It was initially a clean, green, and pleasant street. However, the vehicle-oriented concept drove the street to be a vehicle-dominated space. So, it was not selected as the sample case for the 2nd Field Survey.

Table 6. 15: Statistics of M5-4 (Meilinbei Rd) Sustainability Evaluation

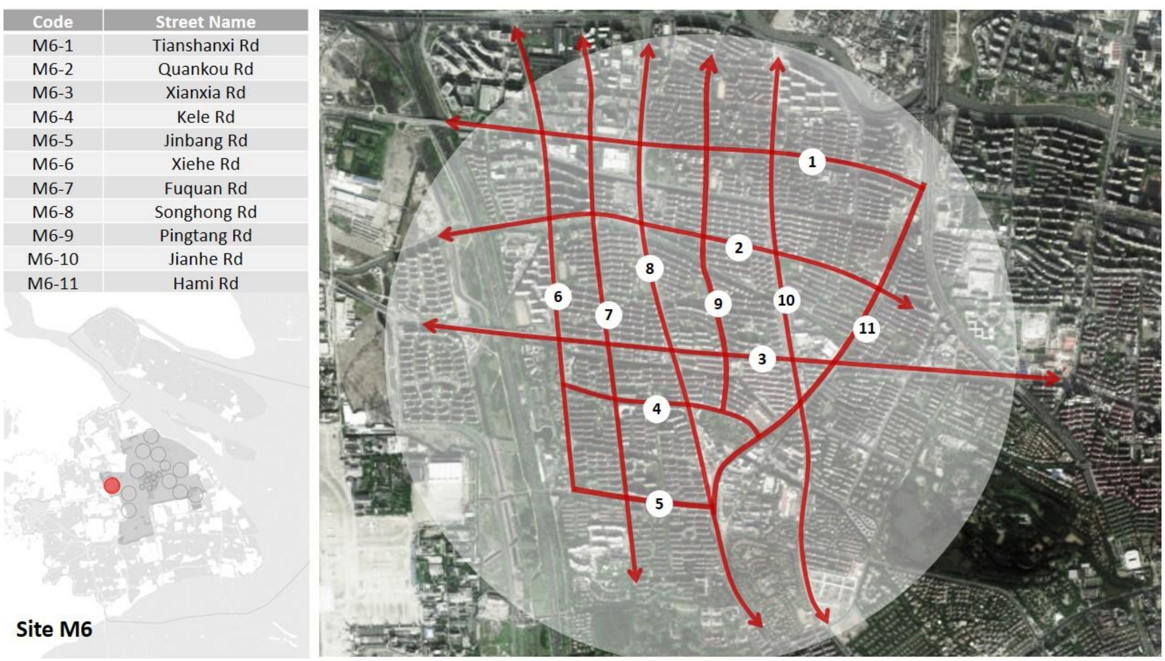
Street	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M5-4	2.8	2.8	2.8	2.8	2.8	2.0	2.8	2.0	2.8	2.8	2.8	2.8	1.0	1.0	1.8	**24.3**
Meilinbei Rd	EnSI=1.60					SoSI=1.55					EcSI=1.70					
236 streets	*1.4*	*1.4*	*1.6*	*1.3*	*1.5*	*1.5*	*2.0*	*1.9*	*1.5*	*1.6*	*1.5*	*1.8*	*1.4*	*1.4*	*1.3*	***23.0***
Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					

6.2.6 Site: M6

6.2.6.1 Site Brief

Site M6 is in Gubei new area of Hongqiao region which is in Shanghai downtown. It is an international community and next to the Hongqiao economic and technological development zone. The first residential quarter was built in 1986, and this area has been a mature community after decades' development.

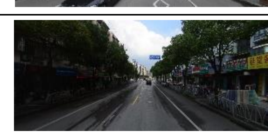
Totally 11 streets were investigated within this area. Figure 6. 11 and Table 6. 16 show the layout and names of these streets. According to the street survey, the streets in this area were clean and tidy. The street section layout was reasonable and efficient. There were street trees and other plants on nearly all sidewalks. In general, the streetscape looked pleasant and under relatively proper maintenance.



The satellite map was from Baidu Map (Baidu, 2017)

Figure 6. 11: Layout and Key Map of Investigated Streets in Site M6

Table 6. 16: Investigated Streets in Site M6

Code	Street Name	Photo	Code	Street Name	Photo
M6-1	Tianshanxi Rd		***M6-2***	Quankou Rd	
M6-3	Xianxia Rd		***M6-4***	Kele Rd	

Code	Street Name	Photo	Code	Street Name	Photo
M6-5	Jinbang Rd		***M6-6***	Xiehe Rd	
M6-7	Fuquan Rd		***M6-8***	Songhong Rd	
M6-9	Pingtang Rd		***M6-10***	Jianhe Rd	
M6-11	Hami Rd				

Some of the photos are from Baidu Streetscape (Baidu, 2017)

6.2.6.2 Street Evaluation

Eleven streets in the Site M6 were investigated and assessed. Figure 6. 12 & Table 6. 17 show the statistics of assessment results, and the primary findings are summarised below:

- The overall performance of M6's streets was slightly below the average level of total 236 surveyed street in the 1st Field Survey. The average SSI of M6's streets was 22.1, which was 0.9 lower than the average of 236 streets (23.0);
- In the sustainability assessment, M6-9 (Pingtang Rd) achieved the highest SSI of 26.0, while M6-6 (Xiehe Rd) achieved the lowest SSI of 13.5. The Standard Deviation of M6's streets was only 3.79, which showed the performance of eleven surveyed streets in the Site M6 did not change much.
- Concerning the three aspects of sustainability:
    - The average EnSI of the eleven surveyed streets in the Site M5 was 1.25, which was a bit lower than the average of 236 streets (1.43). There were street trees in all sidewalk, and there were also pocket garden and green belts in some street, like Xiehe Rd, Pingtang Rd, Hami Rd and Jianhe Rd. However, the green coverage and shading rate of the whole streets in this area was relatively low since all these areas were just built within around 20 years and the tree canopy of the street trees was small.
    - The average SoSI of the eleven surveyed streets in the Site M6 was 1.62, which was at the average level of 236 streets. The performance of M6's streets was not bad in the assessment of social sustainability. According to the site investigation, the marks

on the ground to remind people of safety and car speed were clear and efficient. In some streets of large traffic volume, like Tianshanxi Rd, Kele Rd, and Songhong Rd, there were safety fences between counter flow or travel lanes and cycling lanes. However, according to observation, the street activities were not diverse enough.

- The average EcSI of the eleven surveyed streets in the Site M6 was 1.54. It was observed that the commercial atmosphere along the M6's streets was relatively rich. A variety of shops were along the sidewalks, such as convenient stores, small restaurants, hardware stores, and food stores. Moreover, the land use of streets was compact. Hence, the scores of C12 (Efficient) and C13 (Business Creation) were relatively high, which are 1.8 and 1.6 respectively.

Table 6. 17: Evaluation Statistics of M6 Streets

Street Code	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M6-1	1.3	1.5	1.8	0.8	1.5	1.0	2.0	2.0	1.5	1.8	1.0	2.0	2.0	1.8	1.8	**23.5**
M6-2	1.0	1.5	1.8	0.8	1.5	1.8	1.8	2.5	1.5	1.8	1.8	1.8	1.8	1.5	1.5	**24.0**
M6-3	1.0	0.8	1.8	0.8	1.5	1.3	1.8	1.8	2.3	1.8	1.8	1.8	2.5	2.3	1.5	**24.3**
M6-4	1.0	0.8	1.8	0.8	1.5	1.0	1.8	1.8	2.3	1.8	1.5	1.8	2.5	2.3	1.5	**23.8**
M6-5	1.0	0.8	0.8	0.8	0.8	1.0	1.0	1.8	1.5	1.8	1.5	1.8	1.5	1.5	1.5	**18.8**
M6-6(min)	1.0	0.0	0.0	0.8	0.8	1.8	1.8	1.0	0.8	0.8	1.0	1.8	0.8	0.8	0.8	**13.5**
M6-7	1.0	1.5	1.8	1.5	1.5	2.3	1.8	1.8	1.5	1.8	1.5	1.5	1.5	1.5	1.5	**23.8**
M6-8	1.0	0.8	1.0	0.8	0.8	1.0	2.0	1.3	1.5	0.8	1.0	2.0	1.5	1.5	0.8	**17.5**
M6-9(max)	1.8	1.5	1.8	1.5	1.5	2.5	1.8	2.5	1.5	1.8	1.8	1.8	1.5	1.5	1.5	**26.0**
M6-10	1.8	1.5	1.8	0.8	1.5	1.5	1.8	1.8	1.5	1.5	2.0	1.8	1.5	1.5	1.5	**23.5**
M6-11	2.5	1.8	2.5	2.5	1.8	1.8	1.8	1.8	0.8	1.8	1.5	1.8	0.8	0.8	0.8	**24.3**
M6 Average	***1.3***	***1.1***	***1.5***	***1.0***	***1.3***	***1.5***	***1.7***	***1.8***	***1.5***	***1.5***	***1.5***	***1.8***	***1.6***	***1.5***	***1.3***	**22.1**
	EnSI=1.25					**SoSI=1.62**					**EcSI=1.54**					
											Standard Deviation					**3.79**
236 streets Total Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					*23.0*

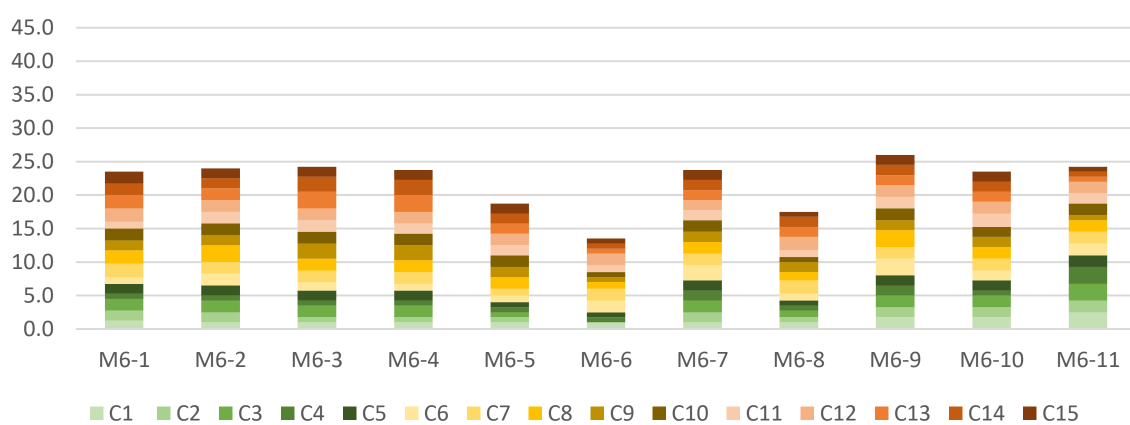


Figure 6. 12: Statistics Analysis of M6 Streets

6.2.6.3 Best Case: Pingtang Rd (M6-9)

Table 6. 18 presents the assessment results and the statistical comparison of Street M6-9 (Pingtang Rd). This is a typical neighbourhood street. The details of the rating results and evaluation illustration can be seen in Appendix P.

Though the SSI of M6-9 (Pingtang Rd) was the highest in the Site M6, the score of 26.0 was 3.0 higher than the average of 236 investigated streets (23.0). Also, the EnSI, SoSI, and EcSI were just above the average of 236 surveyed streets. It was observed that there were street trees, flower beds and tactile pavement for the blind on both sidewalks. Also, there were some street activities observed during the survey, like jogging, dog walking, and shopping. However, it was found in the site investigation that there was no appropriate facility, like the seats or exercise equipment, to create a dynamic public space. Also, it looked neat and clean but ordinary and lack of identification.

To sum up, M6-9 (Pingtang Rd) was a typical Shanghai street, and its performances were just above medium in all three aspects of sustainability. Therefore, it was not selected as the sample case for the 2nd Field Survey.

Table 6. 18: Statistics of M6-9 (Pingtang Rd) Sustainability Evaluation

Street	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M3-1 *Daxue Rd*	1.8	1.5	1.8	1.5	1.5	2.5	1.8	2.5	1.5	1.8	1.8	1.8	1.5	1.5	1.5	**26.0**
	EnSI=1.60					SoSI=2.00					EcSI=1.60					
236 *streets Average*	*1.4*	*1.4*	*1.6*	*1.3*	*1.5*	*1.5*	*2.0*	*1.9*	*1.5*	*1.6*	*1.5*	*1.8*	*1.4*	*1.4*	*1.3*	***23.0***
	EnSI=1.43					*SoSI=1.69*					*EcSI=1.49*					

6.2.7 Site: M7

6.2.7.1 Site Brief

Site M7 is in Caohejin development zone where is in the east suburb of Shanghai. Shanghai Caohejing Emerging Technology Development Zone is one of the first batches of 14 state-level economic and technological development zones approved by the state council. The development of this area was approved as a national high-tech industrial development zone in 1991. Caohejin development zone has been constructed since the 1990s. This area is mainly composed of office buildings, commercial centres, and some high-rise houses.

Totally 13 streets were investigated in the Site M7. Figure 6. 13 and Table 6. 19 illustrate the layout and names of these streets. Except for daily commuting, few activities were observed in the M7's streets. Different from streets in other study sites, not many shops were along the streets, but a variety of fences of the office park and car parking. It was found in the investigation that all elements in the streets, such as street trees, marks on the ground, cycling parking, sidewalks pavement, were clean and under proper maintenance.

The satellite map was from Baidu Map (Baidu, 2017)

Figure 6. 13: Layout and Key Map of Investigated Streets in Site M7

Table 6. 19: Investigated streets in Site M7

Code	Street Name	Photo	Code	Street Name	Photo
M7-1	Lianhua Rd		***M7-2***	Hongmei Rd	
M7-3	Guijing Rd		***M7-4***	Hongcao Rd	
M7-5	Cangwu Rd		***M7-6***	Guilin Rd	
M7-7	Wuzhong Rd		***M7-8***	Qinjiang Rd	
M7-9	Yishan Rd		***M7-10***	Tianlin Rd	
M7-11	Caobao Rd		***M7-12***	Guiguo Rd	

Code	Street Name	Photo	Code	Street Name	Photo
M7-13	Qinzhoubei Rd				

Some of the photos are from Baidu Streetscape (Baidu, 2017)

6.2.7.2 Street Evaluation

Thirteen streets in the Site M7 were investigated and assessed. Figure 6. 14 and Table 6. 20 show the statistics of assessment results, and the primary findings are summarised below:

- The overall performance of M7's streets was below the average of 236 surveyed street in the 1st Field Survey. The average SSI of 13 surveyed streets in the Site M7 was 19.9, which was 3.1 less than the average of 236 streets (23.0);
- In the assessment, the street M7-9 (Yishan Rd) achieved the highest score of SSI (25.5), while M7-2 (HongMei Rd) achieved the lowest score of 13.8. The Standard Deviation of M6's streets was only 3.47, which reflected the performance of all streets in M7 did not change much.
- Regarding the three aspects of sustainability:
  - The average EnSI of the thirteen surveyed streets in the Site M7 was 1.27, which was 0.15 lower than the average of 236 streets (1.43). According to the site observation, the street greening in this area was average. There were street trees in all sidewalk and some pocket gardens and green belts in some streets, like Lianhua Rd, Guijing Rd, Cangwu Rd, and Guilin Rd. However, it was found that the green coverage and shading rate of the whole streets in this area was relatively low since some of the streets were too wide and the tree canopy of the street trees was relatively small.
  - The average SoSI of the thirteen surveyed streets in the Site M7 was 1.53, which was 0.16 lower than the average of 236 streets (1.69). The score of C9 (Diversity) was the lowest (1.0). Only a few street activities were observed in the streets even. Besides, the score of C6 (Equality) and C10 (Culture Inheritance) were only 1.3 and 1.4 respectively. No barrier-free facilities were found in the streets. Also, the fences of office parks and factories hurt the overall streetscape and social sustainability.
  - The average EcSI of the thirteen surveyed streets in the Site M7 was 1.20 which was 0.29 lower than the average of 236 surveyed streets. The scores of C13 (Business Creation), C14 (Job Creation), and C15 (Added-Value) were only 0.8, 0.8 and 1.0 respectively.

Table 6. 20: Evaluation Statistics of M7 Streets

Street Code	Environmental sustainability					Social sustainability					Economic sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M7-1	1.8	2.5	2.8	2.3	1.8	1.5	1.8	1.8	1.5	1.8	1.5	1.8	0.0	0.0	1.0	**23.5**
M7-2(min)	1.3	0.0	1.3	0.0	0.0	0.0	1.3	1.5	0.8	0.8	1.5	3.0	0.8	0.8	1.0	**13.8**
M7-3	1.8	1.5	1.8	1.5	1.5	1.0	1.8	1.8	0.8	1.8	2.0	1.8	0.0	0.0	0.8	**19.5**
M7-4	1.0	0.8	1.0	0.8	0.8	1.0	1.8	2.5	1.5	1.8	1.8	1.8	0.8	0.8	0.8	**18.5**
M7-5	1.8	1.5	1.8	1.5	0.8	1.8	2.5	1.5	1.5	1.8	1.8	1.8	1.8	1.5	1.5	**24.5**
M7-6	1.0	0.8	1.0	0.8	1.5	0.8	1.0	1.3	0.8	1.0	0.8	2.0	0.8	0.8	0.8	**14.8**
M7-7	1.0	0.8	1.0	0.8	0.8	1.8	2.0	2.0	1.5	0.8	0.8	2.0	1.5	1.5	0.8	**18.8**
M7-8	1.0	1.5	1.8	1.5	1.5	1.5	2.5	1.8	0.8	1.8	1.5	1.8	0.8	0.8	0.8	**21.0**
M7-9(max)	1.0	0.8	1.8	0.8	1.5	2.5	2.8	3.0	1.5	2.3	0.8	2.3	1.5	1.5	1.8	**25.5**
M7-10	1.0	2.3	2.5	1.5	1.5	1.5	2.5	1.8	0.8	1.8	1.5	1.8	0.8	0.8	0.8	**22.5**
M7-11	1.0	0.8	1.0	0.8	1.5	1.8	2.8	1.8	0.8	1.0	0.8	2.0	0.8	0.8	1.0	**18.3**
M7-12	1.0	1.8	1.0	1.5	1.8	0.8	1.8	1.8	0.8	0.8	1.8	1.8	0.8	1.0	1.0	**19.0**
M7-13	1.0	1.8	1.8	0.8	1.0	1.5	2.5	1.8	0.8	0.8	1.8	1.8	0.8	1.0	1.0	**19.8**
M6 Average	*1.2*	*1.3*	*1.6*	*1.1*	*1.2*	*1.3*	*2.1*	*1.8*	*1.0*	*1.4*	*1.4*	*1.9*	*0.8*	*0.8*	*1.0*	**19.9**
	EnSI=1.27					**SoSI=1.52**					**EcSI=1.20**					
															Standard Deviation	**3.47**
236 streets Total Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					*23.0*

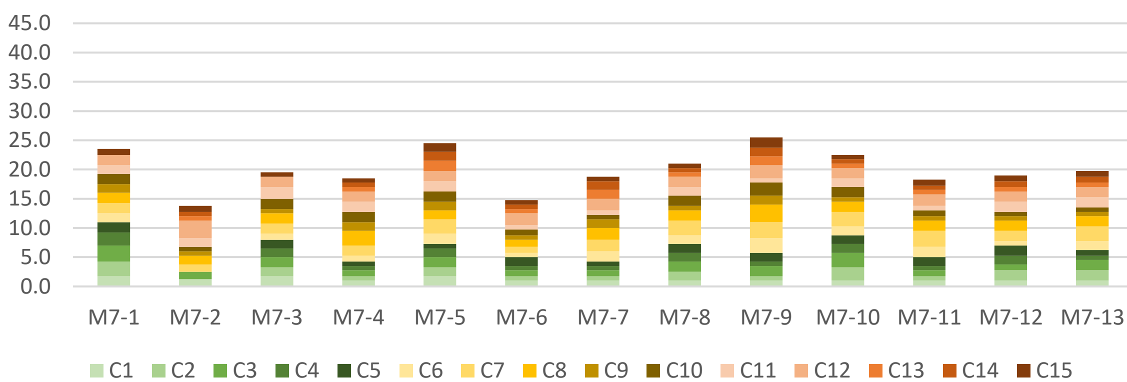


Figure 6. 14: Statistics Analysis of M7 Streets

6.2.7.3 Best Case: Yishan Rd (M7-9)

Table 6. 20 presents the assessment results and the statistical comparison of Street M7-9 (Yishan Rd). Yishan Rd is a traffic street linking two districts of Shanghai. The details of the rating results and evaluation illustration can be seen in Appendix Q.

The SSI of M7-9 (Yishan Rd) was the highest (25.5) in the assessment of the Site M7, but this score was just higher than the average (23.0) of 236 streets. Its EnSI, SoSI, and EcSI were 2.45, 2.05, and 1.15 respectively. The street was renovated recently, and the renovation jobs included the upgrade of storm-water system and pavement, retrofit of street furniture and lighting system, the increase of motor lanes, and the reduction of the sidewalks and street green. All these changes, on the one side, helped to ease the traffic congestion, reinforced the street safety, improved the street accessibility and humanistic care, as well as beautified the streetscape to some extent, however on the other side reduced the environmental adaptation and the walkers' comfort.

To sum up, M7-9 (Yishan Rd) was a typical newly renovated street in Shanghai. The renovation solved some problems but also left some issues. So, it just got an average score in the sustainability assessment and was not selected as the sample case for the 2nd Field Survey.

Table 6. 21: Statistics of M7-9 (Yishan Rd) Sustainability Evaluation

Street	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M10-3 *Meihua Rd*	2.8	2.8	1.8	2.5	2.5	1.8	2.8	2.8	1.5	1.5	1.0	2.3	0.8	0.8	1.0	**28.3**
	EnSI=2.45					SoSI=2.05					EcSI=1.15					
236 streets *Average*	*1.4*	*1.4*	*1.6*	*1.3*	*1.5*	*1.5*	*2.0*	*1.9*	*1.5*	*1.6*	*1.5*	*1.8*	*1.4*	*1.4*	*1.3*	***23.0***
	EnSI=1.43					*SoSI=1.69*					*EcSI=1.49*					

6.2.8 Site: M8

6.2.8.1 Site Brief

Site M8 is in Xinzhuang area, the southeast of Shanghai. Xinzhuang area is at the edge of Shanghai central city, adjacent to Shanghai Hongqiao airport. The location is relatively remote. But there are still many big residential quarters and mature community with medium living density. The construction of this area mainly relied on Shanghai Metro Line 1 that was built in 1990.

Totally 15 streets were investigated in the Site M8. Figure 6. 15 and Table 6. 22 show the layout and names of these streets. According to the site observation, M8's streets were clean and tidy. Most of the street green was in excellent condition and maintenance. The street section was reasonable and efficient, for example, sharing travel lanes, time-limited on-street parking area, and cycling parking area. It was found that this area was an energetic atmosphere of community with pleasant streetscape and diverse street activities.

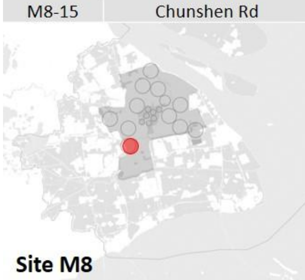
Table 6. 22: Investigated streets in Site M8

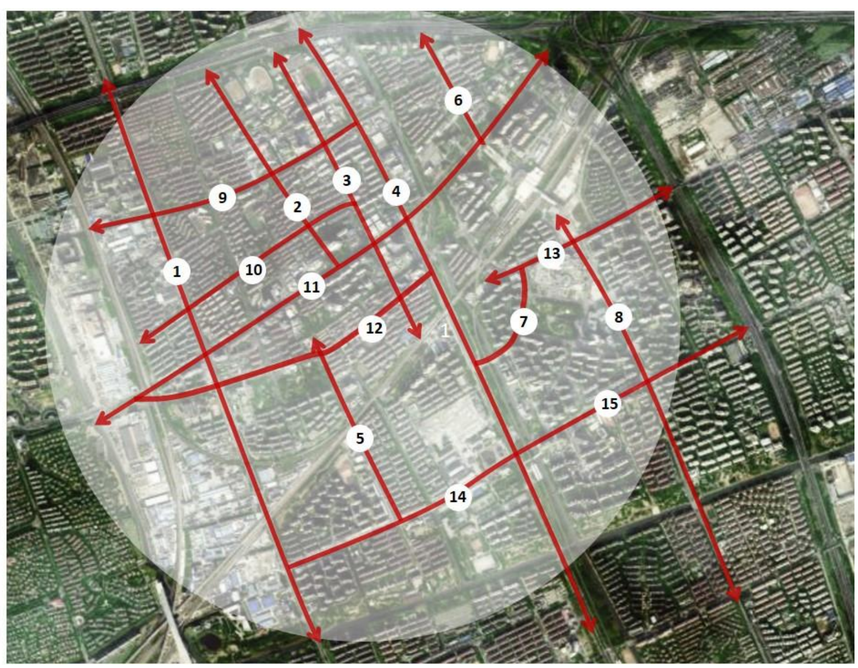
Code	Street Name	Photo	Code	Street Name	Photo
M8-1	Zhongchu Rd		***M8-2***	Xinling Rd	
M8-3	Xindong Rd		***M8-4***	Qixin Rd	

Code	Street Name	Photo	Code	Street Name	Photo
M8-5	Xinxinan Rd		***M8-6***	Shuiqingrd	
M8-7	Mincheng Rd		***M8-8***	Dushi Rd	
M8-9	Xinbei Rd		***M8-10***	Xinli Rd	
M8-11	Xinsong Rd		***M8-12***	Xinbang Rd	
M8-13	Xinzhu Rd		***M8-14***	Qinchun Rd	
M8-15	Chunshen Rd				

Some of the photos are from Baidu Streetscape (Baidu, 2017)

Code	Street Name
M8-1	Zhongchun Rd
M8-2	Xinling Rd
M8-3	Xindong Rd
M8-4	Qixin Rd
M8-5	Xinxinan Rd
M8-6	Shuiqing Rd
M8-7	Mincheng Rd
M8-8	Dushi Rd
M8-9	Xinbei Rd
M8-10	Xinli Rd
M8-11	Xinsong Rd
M8-12	Xinbang Rd
M8-13	Xinzhu Rd
M8-14	Qinchun Rd
M8-15	Chunshen Rd





The satellite map was from Baidu Map (Baidu, 2017)

Figure 6. 15: Layout and Key Map of Investigated Streets in Site M8

6.2.8.2 Street Evaluation

Fifteen streets in the Site M8 were investigated and assessed. Figure 6. 16 and Table 6. 23 show the statistics of assessment results, and the primary findings are summarised below:

- The overall performance of M8's streets was nearly equal to the average level of total 236 surveyed streets. The average SSI of M8 streets was 24.1, which was 1.1 higher than the average of 236 streets (23.0);
- M8-6 (*Shuiqing Rd*) got 28.0 which was the highest score of SSI in M8's streets, while the SSI of M8-9 (*Xinbei Rd*) was the lowest (19.0). The Standard Deviation of M8's streets was only 2.83, which showed the performance of all streets in M8 was quite similar.
- Concerning the three aspects of sustainability:
  - The average EnSI of the fifteen surveyed streets in the Site M8 was 1.49, which was a bit higher than the average score of 236 streets (1.43). It was observed that there were street trees in all M8's streets. The street trees provided desired shadings for people on sidewalks and cycling lanes. Many trees were deciduous plants, which provided not only necessary shading in summer but also solar radiation on the street in winter.
  - The average SoSI of the fifteen surveyed streets in the Site M8 was 1.82, which was 0.13 higher than the average score of 236 surveyed streets (1.69). The score of C8 (Accessibility) was the highest (2.4). According to the street survey, the bus stations were convenient and efficient, and there are many sharing-bike stations.
  - The average EcSI of the fifteen surveyed streets was 1.50. It was found that there were various stores along the streets. These stores linked the railway station with residential quarters. Moreover, few traffic congestions were observed.

Table 6. 23: Evaluation Statistics of M8 Streets

Street Code	Environmental sustainability					Social sustainability					Economic sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M8-1	2.0	1.8	2.0	1.5	0.8	1.0	1.3	3.0	1.5	1.8	1.8	2.3	0.8	0.8	1.0	**23.0**
M8-2	1.0	0.8	1.8	0.8	1.5	1.8	1.8	2.5	1.5	1.0	1.8	1.8	1.5	1.5	0.8	**21.5**
M8-3	1.8	1.5	1.8	1.5	2.3	2.5	2.5	2.5	1.5	1.8	1.8	1.8	1.5	1.5	1.5	**27.5**
M8-4	1.8	1.5	2.5	1.5	1.5	1.8	1.8	2.8	0.8	1.5	0.8	2.0	0.8	0.8	0.8	**22.3**
M8-5	1.8	2.3	2.5	1.5	1.5	1.8	1.8	1.8	1.5	1.8	1.5	1.8	1.5	1.5	1.5	**25.8**
M8-6(max)	1.8	1.5	1.8	1.5	1.5	1.5	2.0	2.8	1.5	1.8	1.8	2.0	2.5	2.5	1.8	**28.0**
M8-7	1.8	2.3	2.5	1.5	2.5	2.5	2.5	2.5	1.5	1.5	1.8	1.8	0.8	0.8	1.8	**27.8**
M8-8	1.8	1.5	1.8	1.5	1.5	1.0	1.8	2.0	1.5	1.5	1.0	2.0	1.8	1.8	1.8	**24.0**
M8-9(min)	1.0	1.5	1.5	0.8	1.5	1.8	1.8	1.8	0.8	1.0	1.8	1.8	0.8	0.8	0.8	**19.0**
M8-10	1.0	0.8	0.8	0.8	1.5	1.8	2.5	2.5	2.3	1.8	1.8	1.8	2.5	2.3	1.5	**25.3**
M8-11	1.0	0.8	1.5	0.8	1.5	1.8	2.0	2.8	2.3	1.8	1.8	2.0	1.8	1.5	1.8	**24.8**
M8-12	0.8	1.5	1.5	0.8	1.5	1.0	1.8	1.5	1.5	1.3	1.8	1.5	1.5	1.5	0.8	**20.0**

Street Code	Environmental sustainability					Social sustainability					Economic sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M8-13	2.0	1.5	1.5	1.5	1.5	1.8	2.8	2.3	2.3	1.5	1.5	2.3	1.5	1.5	1.8	**27.0**
M8-14	1.8	0.8	1.5	0.8	1.5	2.3	2.0	2.8	0.8	1.8	1.5	2.0	0.8	0.8	1.5	**22.3**
M8-15	1.8	1.5	1.8	1.5	1.5	0.8	2.0	2.8	1.5	1.5	1.5	2.0	0.8	0.8	1.5	**23.0**
M8 Average	*1.5*	*1.4*	*1.8*	*1.2*	*1.6*	*1.7*	*2.0*	*2.4*	*1.5*	*1.5*	*1.6*	*1.9*	*1.4*	*1.3*	*1.4*	**24.1**
	EnSI=1.49					**SoSI=1.82**					**EcSI=1.50**					
											Standard Deviation					**2.83**
236 streets Total Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					*23.0*

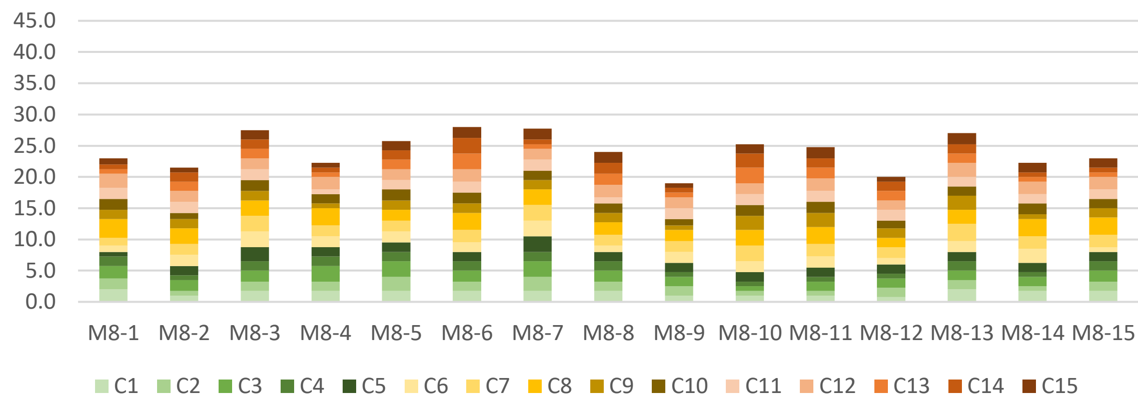


Figure 6. 16: Statistics Analysis of M8 Streets

6.2.8.3 Best Case: Shuiqing Rd (M8-6)

Table 6. 24 presents the assessment results and the statistical comparison of Street M8-6 (Shuiqing Rd). It is a multi-funcion street that integrated with neighbourhood service and traffic linkage. The details of the rating results and evaluation illustration can be seen in Appendix R.

The SSI of M8-6 (Shuiqing Rd) was 28.0 which was the highest one in the street assessment of the Site M8. According to the assessment results, the performance of Shuiqing Rd was relatively balanced in three sustainable pillars. Among them, the EcSI of Shuiqing Rd was the highest because of the vibrant commercial atmosphere on both sides of the street and relatively high traffic mobility. However, there were still some problems that lead to the overall score of sustainability was not very high. Specifically speaking, the layout of street green was lack of the consideration of ecological balance and enhancement of street adaptability. The layout of the bus station adopted the bay pattern to improve bus efficiency and safety of get-on/off. However, it was observed that the bay area was often occupied by private cars.

To sum up, the SSI of M8-6 (Shuiqing Rd) was above-average, and there were gaps to be a genuinely sustainable street. Therefore, it was not selected as the sample case for the 2nd Field Survey.

Table 6. 24: Statistics of M8-6 (Shuiqing Rd) Sustainability Evaluation

Street	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M3-1 ***Daxue Rd***	1.8	1.5	1.8	1.5	1.5	1.5	2.0	2.8	1.5	1.8	1.8	2.0	2.5	2.5	1.8	**28.0**
	EnSI=1.60					SoSI=1.90					EcSI=2.10					
236 ***streets Average***	*1.4*	*1.4*	*1.6*	*1.3*	*1.5*	*1.5*	*2.0*	*1.9*	*1.5*	*1.6*	*1.5*	*1.8*	*1.4*	*1.4*	*1.3*	*23.0*
	EnSI=1.43					*SoSI=1.69*					*EcSI=1.49*					

6.2.9 Site: M9

6.2.9.1 Site Brief

Site M9, Biyun community, is in Jinqiao area of Pudong district, the southeast of Shanghai. Biyun International Community, as one of the biggest communities in Jinqiao area, was built in the 1990s. It is a pleasant and liveable community.

Totally 17 streets were investigated within this area. Figure 6. 17 and Table 6. 25 show the layout and names of these streets. According to the street survey, the streets in M9 were clean and tidy. Most of the street green was in good condition and under proper maintenance. The design of the street section was reasonable and efficient. The streets in the Biyun community were particularly pleasant. They had high green coverage. Except for the green belt in the middle of the streets, there were also plant belts and big street trees on sidewalks.

Code	Street Name
M9-1	Zhangyang Rd
M9-2	Yushan Rd
M9-3	Yanggaozhong Rd
M9-4	Lantian Rd
M9-5	Biyun Rd
M9-6	Mingyue Rd
M9-7	Jinxiudong Rd
M9-8	Deping Rd
M9-9	Baihua Rd
M9-10	Yunshan Rd
M9-11	Jinkou Rd
M9-12	Lanan Rd
M9-13	Huangyang Rd
M9-14	Hongfeng Rd
M9-15	Heisong Rd
M9-16	Jujiaqiao Rd
M9-17	Zaozhuang Rd

The satellite map was from Baidu Map (Baidu, 2017)

Figure 6. 17: Layout and Key Map of Investigated Streets in Site M9

Table 6. 25: Investigated Streets in Site M9

Code	Street Name	Photo	Code	Street Name	Photo
M9-1	Zhangyang Rd		***M9-2***	Yushan Rd	
M9-3	Yanggaozhong Rd		***M9-4***	*Lantian Rd*	
M9-5	*Biyun Rd*		***M9-6***	*Mingyue Rd*	
M9-7	*Jinxiudong Rd*		***M9-8***	*Deping Rd*	
M9-9	*Baihua Rd*		***M9-10***	*Yunshan Rd*	
M9-11	*Jinkou Rd*		***M9-12***	*Lanan Rd*	
M9-13	*Huangyang Rd*		***M9-14***	*Hongfeng Rd*	
M9-15	*Heisong Rd*		***M9-16***	*Jujiaqiao Rd*	
M9-17	*Zaozhuang Rd*				

Some of the photos are from Baidu Streetscape (Baidu, 2017)

6.2.9.2 Street Evaluation

Seventeen streets in the Site M1 were investigated and assessed. Figure 6. 18 and Table 6. 26 show the statistics of assessment results, and the primary findings are summarised below:

- According to the assessment results, the overall performance of M9's streets was slightly higher to the average level of 236 surveyed street in the 1st Field Survey. The average SSI of M8 streets was 23.7, which was 0.7 above the average of 236 streets;
- M9-1 (*Zhangyang Rd*) achieved 32.0 which was the highest score in the assessment of the Site M9, while the SSI of M9-3 *(Yanggaozhong Rd*) got the lowest score (15.5). The

Standard Deviation of M6's streets was 4.83, which reflected the performance of surveyed streets in the Site M9 was relatively stable.

- Regarding the three aspects of sustainability:
  - The average EnSI of the seventeen surveyed streets in the Site M9 was 1.70, which was 0.27 higher than the average of 236 streets. It was found in the survey that the greening condition of most survey streets was pleasant.
  - The average SoSI of the seventeen surveyed streets in the Site M9 was 1.69, which was equal to the average score of 236 streets. C7 (Safety) got a relatively high score (2.0). According to the street investigation, all traffic signs and marks were clear and efficient, and there were various types of safety fences in the middle of streets or between travel lanes and cycling lanes.
  - The average EcSI of the seventeen surveyed streets in the Site M9 was 1.36, and the score was 0.13 lower than the average of 236 streets. It was found in the survey that the commercial atmosphere in the Site M9 was weak. There were often various types of fences between the street land and next to residential quarters.

Table 6. 26: Evaluation Statistics of M8 Streets

Street Code	**Environmental sustainability**					**Social sustainability**					**Economic sustainability**					**SSI**
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M9-1(max)	2.0	1.8	2.5	2.5	2.5	2.5	2.8	3.0	1.5	2.3	1.5	2.3	1.8	1.5	1.8	32.0
M9-2	1.8	1.5	1.5	1.5	1.5	1.5	1.8	1.8	1.5	1.8	1.8	1.8	1.8	1.8	1.5	24.5
M9-3(min)	2.0	1.0	1.0	0.8	0.8	1.0	1.3	1.5	0.8	0.8	0.8	1.5	0.8	0.8	1.0	15.5
M9-4	1.8	2.8	2.8	2.5	1.8	1.0	1.8	1.8	1.8	2.3	2.5	1.8	0.8	0.8	2.0	27.8
M9-5	2.5	2.5	2.8	2.3	2.5	2.5	2.8	2.0	1.5	2.5	1.8	2.0	0.8	0.8	2.0	31.0
M9-6	1.8	1.5	1.8	1.5	1.5	1.8	2.0	1.8	1.5	1.5	1.5	1.8	0.8	0.8	0.8	22.0
M9-7	2.0	1.8	2.0	1.5	2.0	1.8	2.0	1.3	0.8	1.5	0.8	2.0	0.8	0.8	1.3	22.0
M9-8	1.0	1.5	1.5	0.8	1.5	1.0	1.0	2.5	2.3	1.8	1.8	1.8	1.8	1.8	1.5	23.3
M9-9	1.8	1.5	1.8	1.5	1.5	2.5	1.8	1.8	0.8	0.8	1.5	1.8	0.8	0.8	0.8	21.0
M9-10	2.5	2.5	2.8	2.3	2.5	2.5	2.8	2.8	1.5	2.3	1.5	2.0	0.8	0.8	1.8	31.0
M9-11	1.0	1.5	1.5	0.8	1.5	0.8	1.8	1.8	1.5	1.0	1.8	1.8	0.8	0.8	0.8	18.8
M9-12	1.8	1.5	1.8	1.5	1.5	1.8	1.8	1.8	1.5	1.8	1.8	1.8	0.8	0.8	1.5	23.0
M9-13	1.0	1.5	1.8	0.8	1.5	1.8	1.0	1.0	0.8	1.8	1.8	1.0	0.8	0.8	1.5	18.5
M9-14	2.0	1.5	1.8	1.5	1.5	1.8	2.8	2.0	1.8	1.8	1.8	2.0	2.0	2.0	2.0	28.0
M9-15	1.0	1.0	1.8	1.5	1.8	1.8	2.0	2.0	0.8	0.8	1.5	2.0	0.8	0.8	1.0	20.3
M9-16	1.8	1.8	1.8	1.5	1.8	1.8	2.0	1.0	0.8	0.8	0.8	1.8	0.8	0.8	1.0	19.8
M9-17	1.0	1.5	1.8	1.5	1.5	2.5	2.8	1.8	1.5	1.0	1.5	2.0	1.8	1.8	1.5	25.3
M9 Average	*1.7*	*1.7*	*1.9*	*1.5*	*1.7*	*1.8*	*2.0*	*1.8*	*1.3*	*1.5*	*1.5*	*1.8*	*1.1*	*1.0*	*1.4*	**23.7**
	EnSI=1.70					**SoSI=1.69**					**EcSI=1.36**					
															Standard Deviation	**4.83**
236 streets Total Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					*23.0*

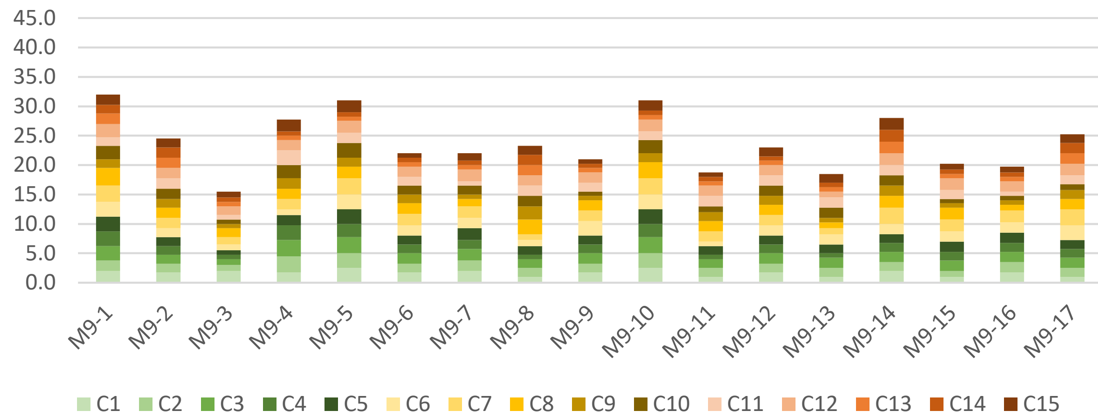


Figure 6. 18: Statistics Analysis of M9 Streets

6.2.9.3 Best Case: Zhangyang Rd (M9-1)

Table 6. 27 presents the assessment results and the statistical comparison of M9-1 (Zhangyang Rd). This is a major road of Shanghai and a typical traffic street. The details of the rating results and evaluation illustration can be seen in Appendix S.

The SSI of M9-1 (Zhangyang Rd) was 32.0, which was 9.0 higher than the average of 236 streets. According to the assessment results, Zhangyang Rd showed better performance in social and environmental aspects. The EnSI and SoSI of Zhangyang Rd were 2.25 and 2.40 respectively. It was observed that there were big trees in sidewalks and wide green belts in the street. Also, the street provided tactile pavement for the blind on both sides, and the width of the sidewalk and height difference in intersections were designed for the convenience of all kinds of people. There was one time-sharing bus-only lane on both sides. Between rush hours (7am-10am & 4pm-7pm), it could be used only by public buses. However, except for this period, other cars could share this lane. This solution not only provided priority to public transportation but also improved the efficiency and intensive land usage within street space. However, it was found in the survey that Zhangyang Rd was not vibrant enough and the street activities were not diverse enough. Firstly, the central green belt was wide and beautiful. However, it could not be used by the public. Secondly, there was no pleasant street furniture to stimulate public activities. The last but not the least, the street scale was too big and lack of human touch.

To sum up, M9-1 (Zhangyang Rd), with the highest SSI of 32.0 in Site M9, showed the excellent performance in greening layout, traffic accessibility, road safety, and public transport priority.

However, it was unable to stimulate vibrant social life within street space. Therefore, it was not selected as the sample case for the 2nd Field Survey.

Table 6. 27: Statistics of M9-1 (Zhangyang Rd) Sustainability Evaluation

Street	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M2-5	2.0	1.8	2.5	2.5	2.5	2.5	2.8	3.0	1.5	2.3	1.5	2.3	1.8	1.5	1.8	**32.0**
Baode Rd	EnSI=2.25					SoSI=2.40					EcSI=1.75					
236 ***streets***	*1.4*	*1.4*	*1.6*	*1.3*	*1.5*	*1.5*	*2.0*	*1.9*	*1.5*	*1.6*	*1.5*	*1.8*	*1.4*	*1.4*	*1.3*	***23.0***
Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					

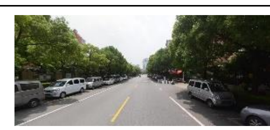
6.2.10 Site: M10

6.2.10.1 Site Brief

Site M10 is located in Huamu area, the south of Shanghai. Huamu Area is the administrative culture centre of Pudong district. Many public buildings, like China's Pudong Cadre Institute, Shanghai International Expo Center, Oriental Art Center, Century Park and Shanghai Science and Technology Museum, are located here. Hence, it is a newly developed area with a high standard of construction and several high-end communities.

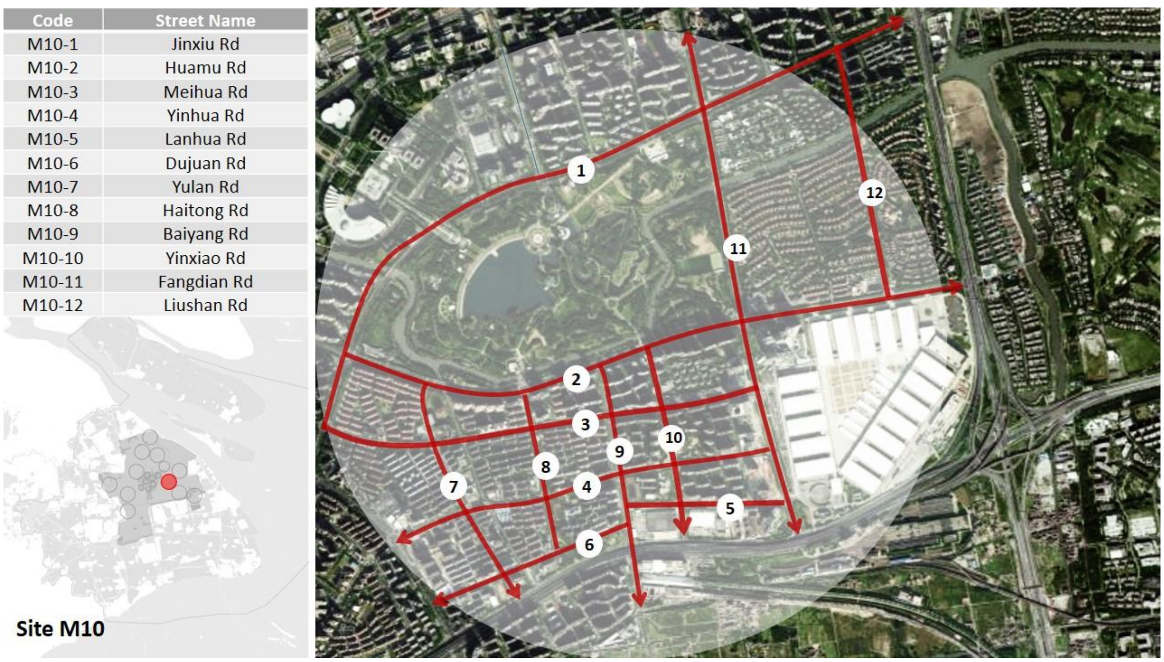
Totally 12 streets were investigated in the Site M10. Figure 6. 19 and Table 6. 28 illustrate the layout and names of these streets. According to the survey, most streets were spacious. For example, M10-1(Jinxiu Rd) was 60 meters' width with a total of 8 motor lanes, and M10-2 (Huamu Rd) was 50 meters in width with a total of 6 motor lanes. Also, most streets looked clean and tidy. There were mature street trees, green belts, tidy pavements on the sidewalks.

Table 6. 28: Investigated streets in Site M10

Code	Street Name	Photo	Code	Street Name	Photo
M10-1	Jinxiu Rd		***M10-2***	Huamu Rd	
M10-3	Meihua Rd		***M10-4***	*Yinhuard*	
M10-5	*Lanhua Rd*		***M10-6***	*Dujuan Rd*	

Code	Street Name	Photo	Code	Street Name	Photo
M10-7	*Yulan Rd*		***M10-8***	*Haitong Rd*	
M10-9	*Baiyang Rd*		***M10-10***	*Yinxiao Rd*	
M10-11	*Fangdian Rd*		***M10-12***	*Liushan Rd*	

Some of the photos are from Baidu Streetscape (Baidu, 2017)



The satellite map was from Baidu Map (Baidu, 2017)

Figure 6. 19: Layout and Key Map of Investigated Streets in Site M10

6.2.10.2 Street Evaluation

Twelve streets in the Site M10 were investigated and assessed. Figure 6. 20 and Table 6. 29 show the statistics of assessment results, and the primary findings are summarised below:

- The overall performance of M10's streets was slightly above the average level of 236 streets. The average SSI of M8's streets was 24.3, which was 1.3 above the average of 236 streets;

- M10-3 (Meihua Rd) achieved the highest score in the Site M10, and its SSI was 29.0. M10-5 (Lanhua Rd) achieved the lowest of 21.5. The Standard Deviation of M10's streets was only 2.71. It could be found that there was neither excellent sample nor extreme bad case, and most of M10's streets were in average condition.
- Regarding the three aspects of sustainability:
  - The average EnSI of the twelve surveyed streets in the Site M10 was 1.58. According to the survey, there were street trees in all M10's streets. Also, most of them were in good condition. However, the plants' shadings were unable to cover the whole street because many streets were too wide.
  - The average SoSI of the twelve surveyed streets in the Site M10 was 1.80, which was 1.1 higher than the average score of 236 streets. The score of C7 (Safety) was the highest of 2.1 since all traffic signs and marks were clear and efficient, and there were various types of safety fences in the middle of streets, between motor lanes and cycling lanes, or between cycling lanes and sidewalks.
  - The average EcSI of the twelve surveyed streets in the Site M10 was 1.49. It was found in the survey that many stores were located along the streets near the hotel, exhibition centre, and parks, but not close to residential quarters.

Table 6. 29: Evaluation Statistics of M10 Streets

Street Code	Environmental sustainability					Social sustainability					Economic sustainability					Final
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M10-1	2.0	2.3	2.8	2.3	2.5	2.5	2.0	2.0	1.5	1.8	1.0	2.3	0.8	0.8	1.8	**28.0**
M10-2	1.3	1.8	2.0	1.8	1.8	2.5	2.0	2.3	0.8	1.5	0.8	2.3	0.8	0.8	2.0	**24.0**
M10-3(max)	1.8	1.5	2.5	1.5	1.5	2.5	2.8	1.8	2.3	1.8	2.0	1.8	2.0	1.8	1.8	**29.0**
M10-4	1.8	1.5	1.8	1.5	1.5	1.0	1.8	1.8	1.5	1.8	1.8	1.8	0.8	0.8	1.5	**22.3**
M10-5(min)	1.8	0.8	1.8	0.8	0.8	1.0	1.8	1.8	1.5	1.8	1.8	1.8	1.5	1.5	1.5	**21.5**
M10-6	1.0	1.5	1.5	0.8	0.8	1.0	2.0	1.8	2.3	1.8	2.0	1.8	2.8	2.8	1.8	**25.3**
M10-7	1.8	1.5	1.8	1.5	1.5	0.8	1.8	1.8	1.5	0.8	1.5	1.8	0.8	0.8	0.8	**20.0**
M10-8	1.8	1.8	1.8	1.5	1.5	2.5	2.8	2.0	1.5	1.5	1.5	2.0	0.8	0.8	1.5	**25.0**
M10-9	1.8	1.5	1.5	1.5	1.5	1.8	2.0	1.8	1.5	1.8	1.5	2.0	0.8	0.8	1.5	**23.0**
M10-10	1.0	1.5	1.5	0.8	0.8	1.0	1.8	1.8	1.5	1.8	2.0	1.8	2.0	2.0	1.8	**22.8**
M10-11	2.0	1.8	2.0	1.8	1.8	2.5	2.8	2.8	1.5	1.8	1.5	2.0	0.8	0.8	1.8	**27.3**
M10-12	1.8	1.5	1.8	1.5	1.5	2.5	1.8	1.8	1.5	1.8	1.8	1.8	0.8	0.8	1.8	**24.0**
M10 Average	*1.6*	*1.6*	*1.9*	*1.4*	*1.4*	*1.8*	*2.1*	*1.9*	*1.6*	*1.6*	*1.6*	*1.9*	*1.2*	*1.2*	*1.6*	**24.3**
	1.58					**1.80**					**1.49**					
															Standard Deviation	**2.71**
236 streets Total Average	*1.43*					*1.69*					*1.49*					*23.1*

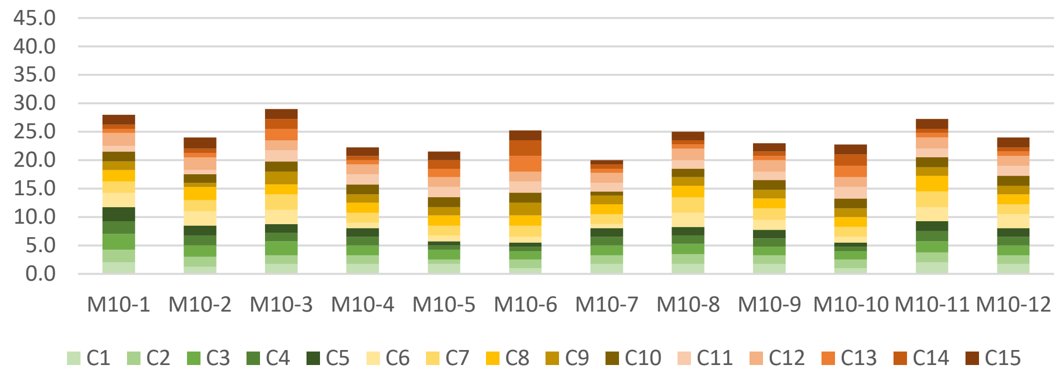


Figure 6. 20: Statistics Analysis of M10 Streets

6.2.10.3 Best Case: Meihua Rd (M10-3)

Table 6. 30 presents the assessment results and the statistical comparison of Street M10-3 (Meihua Rd). It is a neighbourhood street in a mature community. The details of the rating results and evaluation illustration can be seen in Appendix T.

The SSI of M10-3 (Meihua Rd) was 29.0 which was the highest score in the Site M10. It was a typical street of a mature community that was neat, quiet, and pleasant. According to the assessment results, the performance of Meihua Rd was relatively balanced among three sustainable aspects. The EnSI, SoSI, and EcSI of Meihua Rd were 1.75, 2.20, and 1.85 respectively. Street trees provided desired shadings for sidewalks and parking lanes. It was found in the survey that street plants, overall layout, and proper maintenance made the street clean and peaceful. However, the traffic function was still dominated in this street, and the consideration of ecological balance or green life promotion were limited. It was a safe, reliable, and dynamic street, but there were still some safety loopholes, like the conflicts between parking and cycling. The overall streetscape was neat, but it was not delicate and unable to reflect high aesthetic.

To sum up, M10-3 (Meihua Rd) was a lovely community street. It was well-designed and with proper maintenance, but there were still gaps to be a demonstrative case of sustainable streets. Hence, it was not selected as the sample case for the 2nd Field Survey.

Table 6. 30: Statistics of M10-3 (Meihua Rd) Sustainability Evaluation

Street	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M10-3 *Meihua Rd*	1.8	1.5	2.5	1.5	1.5	2.5	2.8	1.8	2.3	1.8	2.0	1.8	2.0	1.8	1.8	**29.0**
	EnSI=1.75					SoSI=2.20					EnSI=1.85					
236 *streets Average*	*1.4*	*1.4*	*1.6*	*1.3*	*1.5*	*1.5*	*2.0*	*1.9*	*1.5*	*1.6*	*1.5*	*1.8*	*1.4*	*1.4*	*1.3*	***23.0***

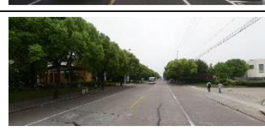
6.2.11 Site: M11

6.2.11.1 Site Brief

Site M11 is in Zhangjiang area, the southeast of Shanghai. Zhangjiang Hi-Tech Park is known as China's Silicon Valley. Located in Pudong district, this Hi-Tech Park was founded in 1992. After nearly two decades of development, it has constructed a framework of biopharmaceutical innovation chain, integrated circuit industry chain and software industry chain. Hence, this area is mainly made up of the hi-tech parks, offices, research institutions, commercial centres, and residential quarters. Residents are mainly young talents working in Zhangjiang Hi-Tech area.

Totally 13 streets were investigated in the Site M11. Figure 6. 21 and Table 6. 31 show the layout and names of these streets. According to the survey, the streets were wide and clean, and most of the street green looked nice. The sidewalks were walkable and spacious. Many streets provided on-street parking or temporary loading areas. Moreover, there was a tram in this area to link the railway station and several main offices buildings.

Table 6. 31: Investigated Streets in Site M11

Code	Street Name	Photo	Code	Street Name	Photo
M11-1	Songtao Rd		***M11-2***	Keyuan Rd	
M11-3	Niudun Rd		***M11-4***	*Xinxiang Rd*	
M11-5	*Juli Rd*		***M11-6***	*Jinke Rd*	
M11-7	*Halei Rd*		***M11-8***	*Gaosi Rd*	
M11-9	*Guoshoujing Rd*		***M11-10***	*Zuchongzhi Rd*	
M11-11	*Chenhui Rd*		***M11-12***	*Gaokezhong Rd*	
M11-13	*Bibo Rd*				

The satellite map was from Baidu Map (Baidu, 2017)

Figure 6. 21: Layout and Key Map of Investigated Streets in Site M11

6.2.11.2 Street Evaluation

Thirteen streets in the Site M11 were investigated and assessed. Figure 6. 22 and Table 6. 32 show the statistics of assessment results, and the primary findings are summarised below:

- The overall performance of M11's streets was above the average level of total 236 surveyed streets. The average SSI of M11's streets was 24.3, 1.3 above 236's average;
- M11-10 (*Zuchongzhi Rd*) achieved the highest score of SSI (32.5), while M11-3 (*Niudun Rd*) achieved the lowest score of SSI (17.5). The Standard Deviation of M11's streets was 4.47, which showed the performance of M11's streets varied but did not change too much.
- Concerning the three aspects of sustainability:
    - The average EnSI of the thirteen surveyed streets in the Site M11 was 1.70 that was 0.27 higher than the average score of 236 streets. According to the survey, the street green rate of M11 was high. Besides street trees, there were also various green belts and pocket gardens along the streets. In some surveyed streets, there were also green buffer belts along the street. Hence, the overall performance of M11's streets was pretty good in the assessment of environmental sustainability.
    - The average SoSI of the thirteen surveyed streets in the Site M11 was 1.89, and the score was 0.2 higher than the average of 236 streets. The score of C7 (Safety), C6 (Equality) and C8 (Accessibility) were the highest three, which are 2.3, 2.1, and 1.9

respectively. There was no potential safety hazard observed in the surveyed streets of this area. It was found in the survey that all traffic signs and marks were clear and efficient. The sidewalks were separated from the travel lanes by green belts or safety fences. Besides, the operation of trams enhanced the accessibility of this area.

- The average EcSI of the thirteen surveyed streets of Site M11 was 1.35. There were fence walls along most of the streets in M11. According to the survey, tons of people were walking in the streets between the subway stations to offices during rush hours. Their consumption demands were strong, such as for breakfast, newspaper, or drinks. However, there was no convenient store along the streets. It was found in the survey that there were some temporary breakfast stalls in the morning and afternoon. Compared with such a massive flow of people and consumption demand, the commercial facilities along the street were very limited.

Table 6. 32: Evaluation Statistics of M11 Streets

Street Code	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M11-1	1.0	1.5	2.0	1.5	1.5	2.3	1.8	2.5	1.5	1.5	1.5	1.8	0.8	0.8	1.5	**23.3**
M11-2	1.8	1.5	2.8	1.5	1.5	2.3	2.5	1.8	1.5	2.3	1.5	1.8	0.8	0.8	1.5	**25.5**
M11-3(min)	1.8	0.8	2.0	1.5	0.8	0.8	1.8	1.0	0.8	0.8	1.8	1.8	0.8	0.8	0.8	**17.5**
M11-4	1.8	0.8	0.8	0.8	1.5	1.8	1.8	1.8	0.8	1.0	0.8	1.8	0.8	0.8	1.5	**18.0**
M11-5	1.8	2.5	2.5	2.5	2.5	2.5	2.8	1.8	1.5	2.3	1.8	1.8	0.8	0.8	1.8	**29.3**
M11-6	2.0	0.8	1.8	1.5	1.8	2.5	2.8	2.3	2.3	2.5	0.8	2.3	2.0	2.0	2.0	**29.0**
M11-7	1.8	1.5	1.8	1.5	1.5	2.5	2.8	1.8	0.8	1.5	1.8	1.8	0.8	0.8	1.0	**23.3**
M11-8	1.8	1.5	1.8	1.5	1.5	1.8	2.0	1.8	0.8	1.5	1.8	1.8	0.8	0.8	1.0	**21.8**
M11-9	1.0	1.5	1.8	1.5	1.5	1.5	1.8	1.8	1.5	1.8	1.5	1.8	0.8	0.8	1.5	**21.8**
M11-10(max)	1.8	1.5	1.5	1.5	2.3	2.5	2.8	2.8	2.5	2.5	1.8	1.8	2.8	2.8	2.0	**32.5**
M11-11	1.8	1.5	2.5	1.5	1.5	1.8	2.0	1.8	1.5	1.5	1.8	1.8	0.8	0.8	1.5	**23.8**
M11-12	2.0	1.8	2.8	2.5	1.8	2.5	2.8	2.0	1.5	1.5	0.8	2.0	0.8	0.8	1.8	**27.0**
M11 Average	*1.7*	*1.5*	*2.0*	*1.7*	*1.6*	*2.1*	*2.3*	*1.9*	*1.4*	*1.7*	*1.5*	*1.8*	*1.0*	*1.0*	*1.5*	**24.7**
	EnSI=1.70					**SoSI=1.89**					**EcSI=1.35**					
											Standard Deviation					**4.47**
236 streets Total Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					*23.0*

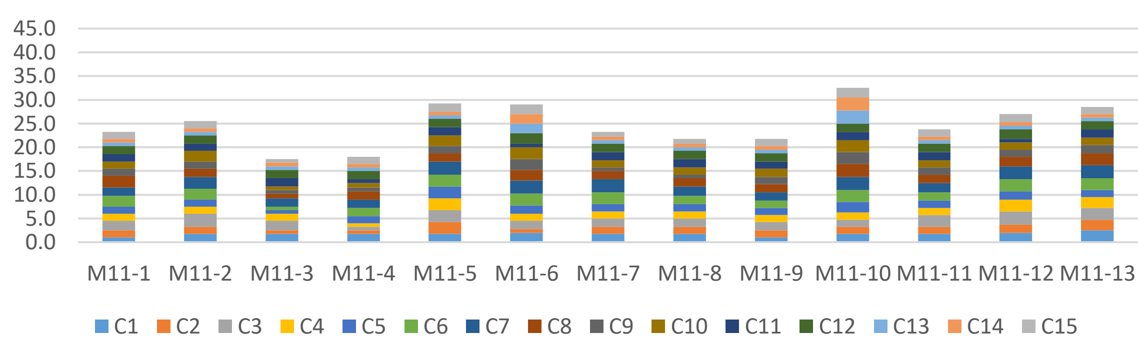


Figure 6. 22: Statistics Analysis of M11 Streets

6.2.11.3 Best Case: Zuchongzhi Rd (M11-10)

Table 6. 33 presents the assessment results and the statistical comparison of M11-10 (Zuchongzhi Rd). This is a secondary road of Shanghai and a typical traffic street. The details of the rating results and evaluation illustration can be seen in Appendix U.

According to the assessment results, the SSI of M11-10 (Zuchongzhi Rd) was 32.5 which was relatively high among 236 streets. Zuchongzhi Rd was relatively balanced and showed better performance in social and economic aspects. It was found in the survey that the street provided blind-pavements on sidewalks and the width of sidewalks and height difference in intersections were considered the convenience of all kinds of people. There were various ways to guarantee street safety, including guide signs, speed control cameras, green belts, and safety fences. Besides, there were various activates observed in Zuchongzhi Rd, like shopping, meeting friends, jogging, and dog walking.

Furthermore, many temporary snack and fruit stores were along the street during rush. Moreover, a 40-meter-wide green belt was on the south side of this street, and it was an open continuous belt-shaped park. This green space not only provided pleasant open space for the public but also enhanced the street's performance with regarding environmental sustainability. However, as the main street in Zhangjiang Hi-tech Park, there were massive people flows and traffic volume in this street, especially during rush hour, which caused a series of issues without reasonable management. Firstly, many scooters and bikes were parked randomly in front of the subway station and often blocked the sidewalks. Secondly, traffic noise and horns of scooters were very annoying pollution in this street. Lastly, there were 6 motor lanes in the street. However, it was still often congested during rush hour and empty in other time.

In summary, M11-10 (Zuchongzhi Rd) was a green, safe, and vibrant street. However, some improvements were still necessary for holistic sustainability, such as the enhancement of environmental adaptation, reinforcement of street safety, and flexible usage of street land. Therefore, it was not selected as the sample case for the 2nd Field Survey.

Table 6. 33: Statistics of M11-10 (Zuzhongzhi Rd) Sustainability Evaluation

Street	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M2-5 *Baode Rd*	1.8	1.5	1.5	1.5	2.3	2.5	2.8	2.8	2.5	2.5	1.8	1.8	2.8	2.8	2.0	**32.5**
	EnSI=1.72					SoSI=2.62					EcSI=2.24					
236 *streets* Average	*1.4*	*1.4*	*1.6*	*1.3*	*1.5*	*1.5*	*2.0*	*1.9*	*1.5*	*1.6*	*1.5*	*1.8*	*1.4*	*1.4*	*1.3*	***23.0***
	EnSI=1.43					*SoSI=1.69*					*EcSI=1.49*					

6.2.12 Site: M12

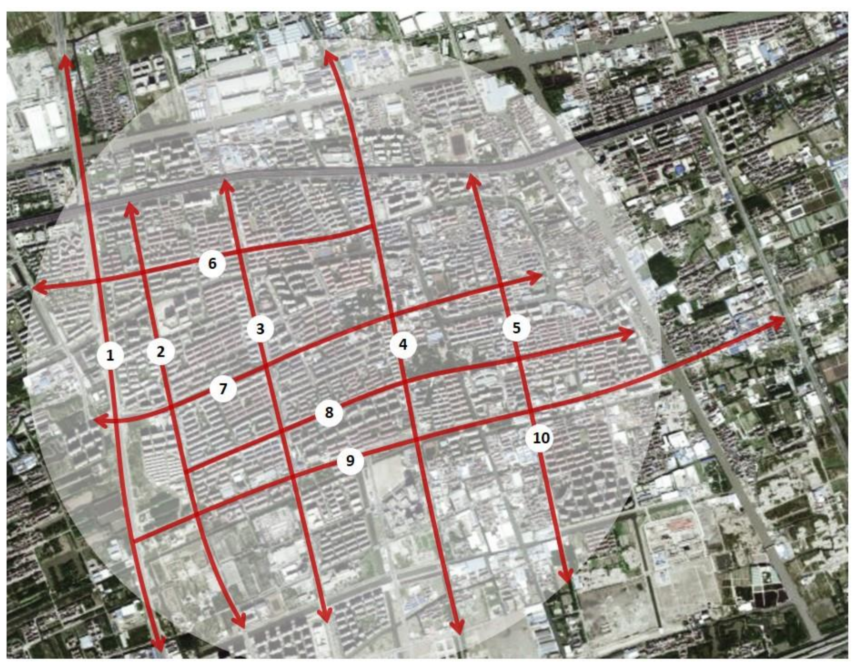
6.2.12.1 Site Brief

Site M12 is in Chuansha area, the eastern suburb of Shanghai. This area was initially the alluvial plain of the ocean and river, which has been gradually formed by the accumulation of sandbanks. Although it has a history of more than 200 years, as the periphery of Shanghai city, this area had been used as agricultural land until the 1980s.Totally ten streets were investigated in the Site M12.

Figure 6. 23 and

Table 6. 34 show the layout and names of these streets. It was found in the survey that the streets in the Site M12 looked a bit disordered and the street management needed to be improved. Moreover, the sidewalks of many streets were occupied by parking of private cars and bicycles, which largely influenced the safety and accessibility of pedestrians. There were many stores along the streets. However, the business of those stores often expanded to the sidewalks and sometimes even occupied the whole sidewalks.

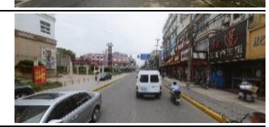
Code	Street Name
M12-1	Huadong Rd
M12-2	Huaxiaer Rd
M12-3	Miaojing Rd
M12-4	Chuan Sha Rd
M12-5	Beishi Rd
M12-6	Xinde Rd
M12-7	Xinchuan Rd
M12-8	Nanqiao Rd
M12-9	Chuanhuannan Rd
M12-10	Chuanhuang Rd



The satellite map was from Baidu Map (Baidu, 2017)

Figure 6. 23: Layout and Key Map of Investigated Streets in Site M12

Table 6. 34: Investigated Streets in Site M11

Code	Street Name	Photo	Code	Street Name	Photo
M12-1	*Huadong Rd*		***M12-2***	*Huaxiaer Rd*	
M12-3	*Miaojing Rd*		***M12-4***	*Chuansha Rd*	
M12-5	*Beishi Rd*		***M12-6***	*Xinde Rd*	
M12-7	*Xinchuan Rd*		***M12-8***	*Nanqiao Rd*	
M12-9	*Chuanhuannan Rd*		***M12-10***	*Chuanhuang Rd*	

Some of the photos are from Baidu Streetscape (Baidu, 2017)

6.2.12.2 Street Evaluation

Ten streets in the Site M12 were investigated and assessed. Table 6. 35 and Figure 6. 24 show the statistics of assessment results, and the primary findings are summarised below:

- The overall performance of M12's streets was remarkably lower than the average of 236 streets. The average SSI of M12's streets was 20.2, which was 2.8 lower than the average of 236 streets;
- Both the street M12-4 (Chuansha Rd) and M12-8 (Nanqiao Rd) achieved the highest score in the assessment, and the SSI score was 25.5. M12-10 (Chuanhuang Rd) got the lowest score of 13.3. The Standard Deviation of M12's streets was 4.66, which showed that the performance of M12's streets varied but did not change too much.
- Concerning the three aspects of sustainability:

- The average EnSI of the ten surveyed streets in the Site M12 was only 0.91. The score of C4 (Ecological Balance), C1 (Adaptability), and C2 (Mitigation UHI) were 0.6, 0.9, and 0.9 respectively. According to the survey, the Street Green Rate was pretty low. There was even no tree in some streets, and many street plants were in poor condition.
- The average SoSI of the surveyed streets in M12 was 1.39. The score of C6 (Equality) was only 0.7. It was found that the majority of M12's streets were lack of tactile pavement for the blind and barrier-free facility. The sidewalks were narrow and often occupied by car parking, which influenced the accessibility and safety of the streets.
- The average EcSI of the ten streets in the Site M12 was 1.75, which was 0.26 higher than the average of 236 streets. Both C13 (Business Creation) and C14 (Job Creation) achieved 2.0 in the assessment. In M12, nearly all streets were sided by various stores, such as convenience stores, restaurants, foot massage, agent centre, kids' education centre, retailers, and services spots of some electrical equipment's.

Table 6. 35: Evaluation Statistics of M12 Streets

Street Code	**Environmental Sustainability**					**Social Sustainability**					**Economic Sustainability**					**SSI**
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M12-1	2.0	0.8	0.8	0.8	0.8	0.8	2.0	2.0	0.8	0.8	0.8	2.3	0.8	0.8	0.8	**16.5**
M12-2	1.0	1.5	1.5	0.8	1.5	0.8	1.8	1.8	1.5	1.8	1.8	1.8	1.8	1.8	1.5	**22.3**
M12-3	1.0	0.8	0.8	0.8	1.5	1.0	1.0	2.5	2.3	1.0	1.5	2.0	1.8	1.8	1.5	**21.0**
M12-4(max)	1.8	1.5	1.5	0.8	2.3	1.0	2.0	2.5	1.5	1.8	2.3	1.8	1.8	1.8	1.5	**25.5**
M12-5	0.0	0.8	0.0	0.0	0.8	0.0	0.8	1.5	1.5	2.0	1.8	1.0	2.5	2.5	1.5	**16.5**
M12-6	1.0	1.5	1.5	0.8	1.5	1.8	2.0	2.5	1.5	1.8	1.8	1.8	2.5	2.5	1.5	**25.8**
M12-7	0.0	0.0	0.0	0.0	0.8	0.0	0.8	1.0	1.5	1.0	1.8	1.8	2.5	2.5	1.5	**15.0**
M12-8	1.0	1.5	1.8	1.5	1.5	1.0	1.8	1.8	1.5	1.8	1.8	1.8	2.8	2.5	1.8	**25.5**
M12-9	1.3	0.8	1.8	0.8	0.8	0.8	1.8	2.0	1.5	1.0	1.8	2.0	1.8	1.8	1.5	**21.0**
M12-10(min)	0.0	0.0	0.0	0.0	0.8	0.0	1.0	1.5	1.5	1.0	1.5	1.8	1.8	1.8	0.8	**13.3**
M12 Average	*0.9*	*0.9*	*1.0*	*0.6*	*1.2*	*0.7*	*1.5*	*1.9*	*1.5*	*1.4*	*1.7*	*1.8*	*2.0*	*2.0*	*1.4*	**20.2**
	EnSI=0.91					**SoSI=1.39**					**EcSI=1.75**					
													Standard Deviation			**4.66**
236 streets Total Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					*23.1*

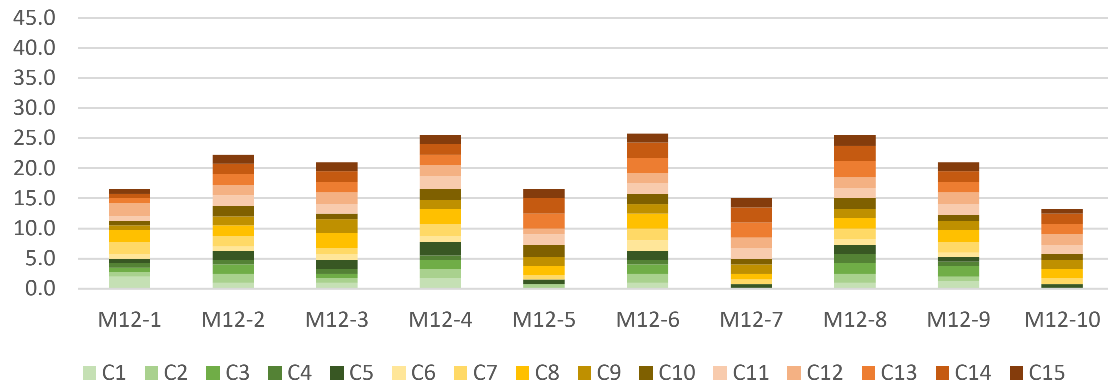


Figure 6. 24: Statistics Analysis of M12 Streets

6.2.12.3 Best Case: Xinde Rd (M12-6)

Table 6. 36 presents the assessment results and the statistical comparison of M12-6 (Xinde Rd). It is a commercial street for the community. The details of the rating results and evaluation illustration can be seen in Appendix V.

In the assessment, the SSI of M12-6 (Xinde Rd) achieved 25.8 which was the highest score in the Site M12. However, this score was just above the average of 236 streets. According to the survey, Xinde Rd was a typical community commercial street. As a sharing street, there was no clear definition of motor lanes and cycling lanes. Many parking lots were marked along the street. The sidewalks were 5 meter's wide to meet the demand of commercial activates. In general, it was a vivid and pleasant community street. However, some sustainability barriers were also found in the survey. For example, cars were often parked on sidewalks. There was no shading for the bus station, which was inconvenient on rainy days.

In summary, M12-6 (Xinde Rd), as a community commercial street, was pleasant. However, there were still gaps to be a genuinely sustainable street. Therefore, it was not selected as the sample case for the 2nd Field Survey.

Table 6. 36: Statistics of M12-6 (Xinde Rd) Sustainability Evaluation

Street	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M12-6 *Xinde Rd*	1.0	1.5	1.5	0.8	1.5	1.8	2.0	2.5	1.5	1.8	1.8	1.8	2.5	2.5	1.5	**25.8**
	EnSI=1.25					SoSI=1.90					EcSI=2.00					
236 *streets Average*	*1.4*	*1.4*	*1.6*	*1.3*	*1.5*	*1.5*	*2.0*	*1.9*	*1.5*	*1.6*	*1.5*	*1.8*	*1.4*	*1.4*	*1.3*	***23.0***
	EnSI=1.43					*SoSI=1.69*					*EcSI=1.49*					

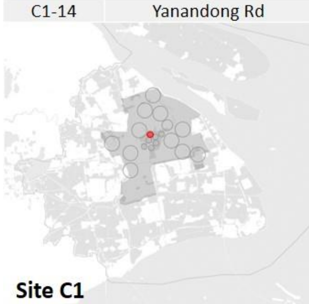
6.2.13 Site: C1

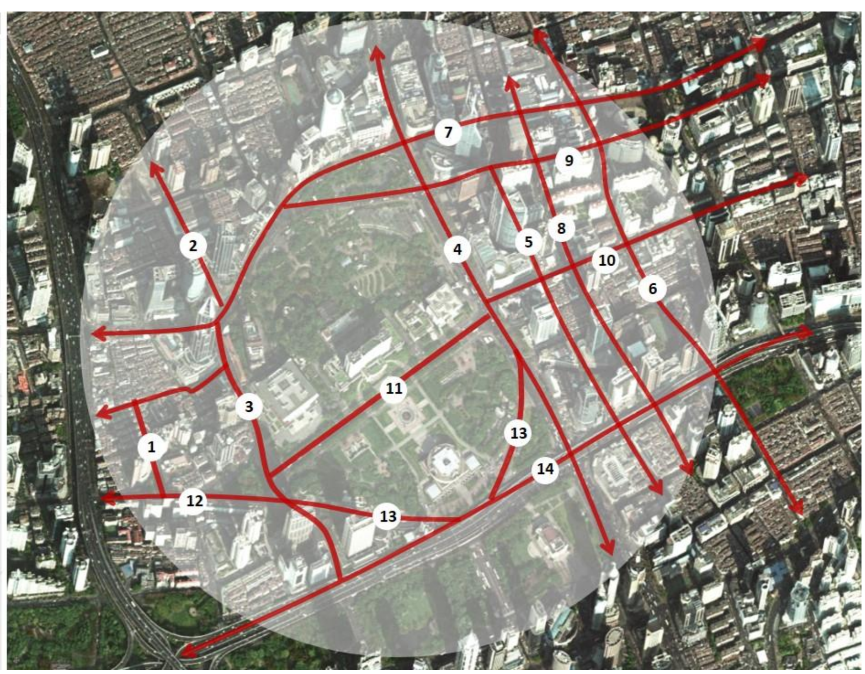
6.2.13.1 Site Brief

Site C1 is in People Square, the centre of Shanghai. As one of the most important landmarks in Shanghai, it is the political, economic, cultural, tourist centre and transportation hub of Shanghai. This area was initially a place for horse racing in the upper world. With the development of Shanghai, it becomes an open square and public park which surrounded by the museum, concert, tourism centre, and commercial buildings. The north side of the square is the seat of the Shanghai municipal people's government. There are Shanghai grand theatre, the Shanghai urban planning exhibition hall, and the Shanghai Museum around the square. Hence, this is not only a tourist destination but also an important landmark integrated with financial administration, culture, transportation, and commerce.

Totally 12 streets were investigated in the Site C1. Figure 6. 25 and Table 6.37 illustrate the layout and names of these streets. In general, the performance of these streets varies a lot. According to the assessment, some streets, like Xizangzhong Rd, Huangpibei Rd, Nanjingxi Rd, Renmin Ave, looked pleasant and elegant. Their streetscape was well-designed and showed the local culture. However, some streets, such as Xinchang Rd, Guanxibei Rd, Fujianzhong Rd, showed inferior performance. The streets were very narrow without proper management. The pedestrians and bicycles parking had to be on motor lanes, which caused severe safety hazards.

Code	Street Name
C1-1	Chongqingbei Rd
C1-2	Xinchang Rd
C1-3	Huangpibei Rd
C1-4	Xizangzhong Rd
C1-5	Guangxibei Rd
C1-6	Fujianzhong Rd
C1-7	Nanjingxi Rd
C1-8	Zhejiangzhong Rd
C1-9	Jiujiang Rd
C1-10	Fuzhou Rd
C1-11	Renminda Rd
C1-12	Weihai Rd
C1-13	Wusheng Rd
C1-14	Yanandong Rd





The satellite map was from Baidu Map (Baidu, 2017)

Figure 6. 25: Layout and Key Map of Investigated Streets in Site C1

Table 6. 37: Investigated Streets in Site C1

Code	Street Name	Photo	Code	Street Name	Photo
C1-1	*Chongqingbei Rd*		***C1-2***	*Xinchang Rd*	
C1-3	*Huangpibei Rd*		***C1-4***	*Xizangzhong Rd*	
C1-5	*Guangxibeird*		***C1-6***	*Fujianzhong Rd*	
C1-7	*Nanjingxi Rd*		***C1-8***	*Zhejiangzhong Rd*	
C1-9	*Jiujiang Rd*		***C1-10***	*Fuzhou Rd*	
C1-11	*Renmin Ave*		***C1-12***	*Weiha Rd*	
C1-13	*Wusheng Rd*		***C1-14***	*Yanandong Rd*	

Some of the photos are from Baidu Streetscape (Baidu, 2017)

6.2.13.2 Street Evaluation

Fourteen streets in the Site C1 were investigated and assessed. Figure 6. 26 and Table 6. 38 show the statistics of assessment results, and the primary findings are summarised below:

- The average SSI of C1's streets was 25.6, which was 2.6 above the average of 236 streets;
- In the assessment, the SSI of C1-4 (*Xizangzhong Rd*) achieved the highest score of 35.0, while C1-2 (*Xinchang Rd*) achieved the lowest score of 14.0. The Standard Deviation of C1's streets was 6.32, which showed the performance of C1's streets was pretty different. Some were very good while some were quite poor.
- Regarding the three aspects of sustainability:

- The average EnSI of the fourteen surveyed streets in the Site C1 was 1.28, which was 0.15 lower than the average of 236 streets. The street green rate of this area was relatively low because of the location and tight street land.
- The average SoSI of the surveyed streets in the Site C1 was 1.96. The assessment results of C7 (Safety), C9 (Diversity) and C10 (Culture Inheritance) were 2.1, 2.0, 2.0 respectively, which was relatively high. There were various ways to arrive these streets, and the streetscape was consistent with surrounding and local history.
- The average EcSI of the streets in C1 was 1.88. It was found that there were various stores along the streets. Also, the commercial types were very diverse.

Table 6. 38: Evaluation Statistics of C1 Streets

Street Code	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
C1-1	1.0	0.8	1.0	1.0	1.8	2.0	2.0	1.8	2.0	2.0	1.8	1.8	2.5	2.5	1.8	**25.5**
C1-2(min)	0.0	0.0	0.0	0.0	0.8	1.0	1.3	1.0	1.0	1.8	2.5	1.0	2.0	1.8	0.0	**14.0**
C1-3	1.0	2.0	2.0	1.3	2.0	2.0	2.8	2.0	1.8	3.0	2.5	2.0	1.8	1.8	2.8	**30.5**
C1-4(max)	1.3	2.0	1.8	1.0	1.8	2.8	2.8	2.8	2.8	2.5	2.8	2.0	3.0	3.0	3.0	**35.0**
C1-5	0.0	0.0	1.0	0.3	1.0	0.3	1.0	1.8	1.8	1.8	1.8	1.0	1.8	1.8	1.8	**16.8**
C1-6	0.8	0.8	1.0	1.0	1.0	1.8	1.0	1.0	1.8	1.8	1.8	1.8	1.8	1.8	1.0	**19.8**
C1-7	2.0	1.3	1.3	1.0	1.3	2.8	3.0	3.0	2.8	1.8	2.8	2.3	3.0	3.0	3.0	**34.0**
C1-8	0.8	0.8	0.8	0.8	0.8	0.0	1.0	0.8	2.5	1.8	2.5	1.8	2.8	2.5	1.5	**20.8**
C1-9	1.8	2.0	2.0	2.0	1.8	2.8	2.8	2.0	1.8	2.3	1.8	2.0	1.0	1.0	1.0	**27.8**
C1-10	1.8	1.5	1.8	1.5	1.5	1.8	2.5	1.8	2.5	1.8	1.8	2.0	2.8	2.8	2.5	**30.0**
C1-11	2.8	2.0	2.5	2.8	2.8	2.8	2.8	2.0	1.5	2.8	1.3	2.0	1.0	1.0	1.3	**31.0**
C1-12	1.5	1.5	1.8	0.8	1.5	1.8	1.8	2.0	2.3	2.0	2.5	1.3	1.8	1.8	1.5	**25.5**
C1-13	1.8	2.0	2.0	1.8	1.8	1.8	2.8	2.0	1.8	1.8	1.8	2.0	0.8	0.8	1.0	**25.5**
C1-14	0.5	0.5	1.3	0.5	1.0	1.8	2.8	2.0	1.8	1.8	2.0	3.0	1.0	1.0	1.3	**22.0**
C1 Average	*1.2*	*1.2*	*1.4*	*1.1*	*1.5*	*1.8*	*2.1*	*1.8*	*2.0*	*2.0*	*2.1*	*1.8*	*1.9*	*1.9*	*1.7*	**25.6**
	EnSI=1.28					**SoSI=1.96**					**EcSI=1.88**					
											Standard Deviation					**6.32**
236 streets Total Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					*23.0*

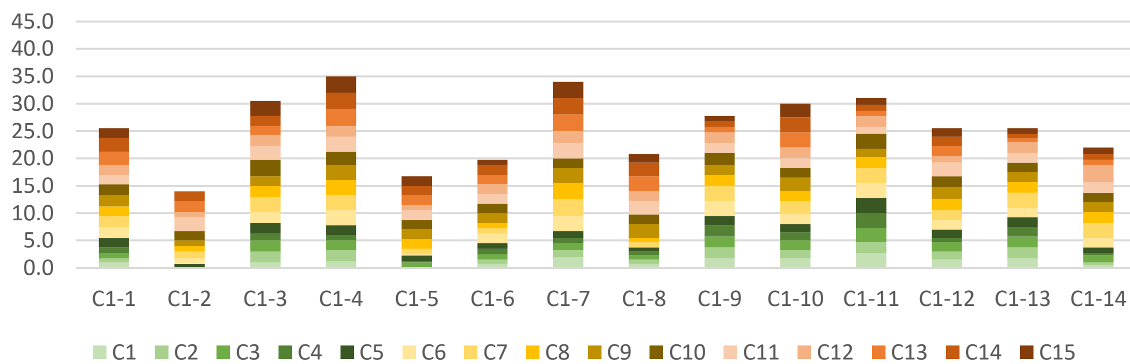


Figure 6. 26: Statistics Analysis of C1 Streets

6.2.13.3 Best Case: Xizangzhong Rd (C1-4)

Table 6. 39 presents the assessment results and the statistical comparison of C1-4 (Xizangzhong Rd). It is a traffic steet. The details of the rating results and evaluation illustration can be seen in Appendix W.

The SSI of C1-4 (Xizangzhong Rd) was 35.0 which was very high among 236 assessed streets. It was the main street in the city centre, which was not only a traffic road in Shanghai centre area but also served as the commercial hub, cultural display, social place as well as the demonstration of political intentions. The assessment results of C6 (Equality), C7 (Safety), C8 (Accessibility), C9

(Diversity), C11 (Intensive Land utilisation), C13 (Business Creation), C14 (Job Creation), and C15 (Added-value) were high, and the scores were between 2.8 and 3.0. However, the Street Green Rate was relatively low. Also, there was no green method to enhance performance in environmental sustainability.

To sum up, C1-4 (Xizangzhong Rd) was a street that is in the city centre. However, from the perspective of holistic sustainability, the performance of Xizangzhong Rd was not balanced among three sustainable aspects. Therefore, it was not selected as the sample case for the 2nd Field Survey.

Table 6. 39: Statistics of C1-4 (Xizangzhong Rd) Sustainability Evaluation

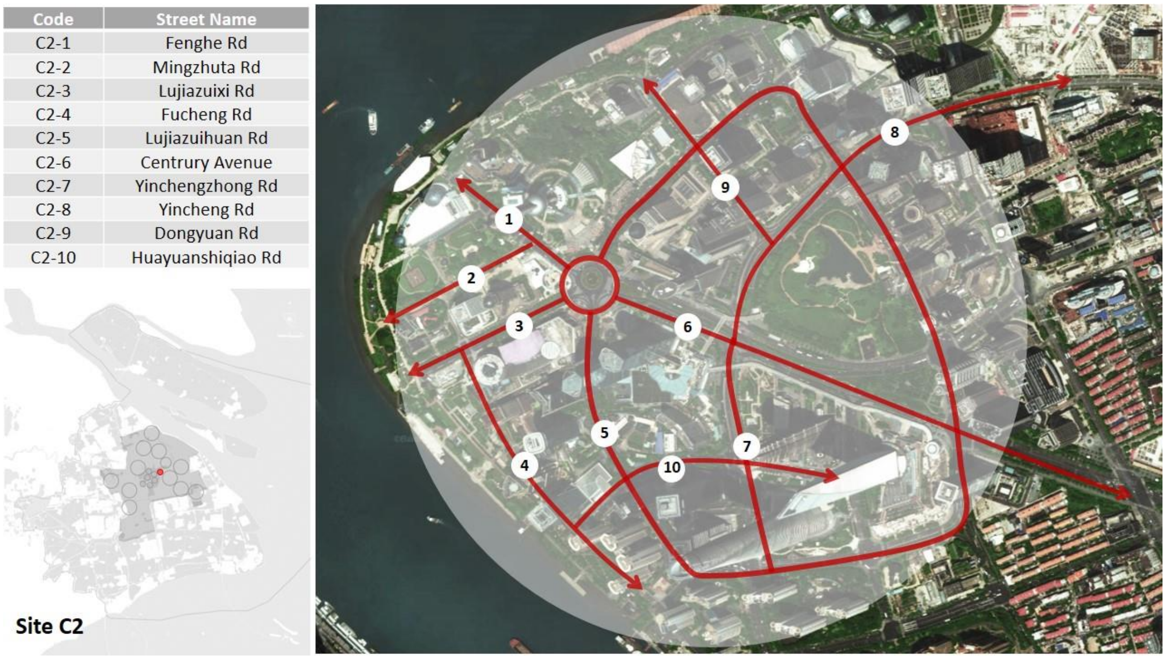
Street	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
C1-4 *Xizangzhong Rd*	1.3	2.0	1.8	1.0	1.8	2.8	2.8	2.8	2.8	2.5	2.8	2.0	3.0	3.0	3.0	**35.0**
	EnSI=1.55					SoSI=2.70					EcSI=2.75					
236 streets Average	*1.4*	*1.4*	*1.6*	*1.3*	*1.5*	*1.5*	*2.0*	*1.9*	*1.5*	*1.6*	*1.5*	*1.8*	*1.4*	*1.4*	*1.3*	***23.0***
	EnSI=1.43					*SoSI=1.69*					*EcSI=1.49*					

6.2.14 Site: C2

6.2.141 Site Brief

Site C2 is in Lujiazui Area. Lujiazui CBD is in Pudong District, and it is next to Shanghai Huangpu River. Lujiazui CBD is one of the most influential financial centres in China. The intensity of development and construction in this area is very high.

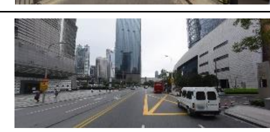
Totally ten streets were investigated in the Site C2. Figure 6. 27 and Table 6.40 illustrate the layouts and names of these streets. In general, the streets of the Site C2 looked tidy, spacious, and well-organised. It was found in the survey that both sidewalk and motor lanes were spacious. The street plants were in good condition. The overall streetscape was modern and coherent with the CBD atmosphere. However, according to the survey, there was no cycling lane in some streets. The streets were too wide, and there were too many high rises in this area, which made it very windy and uncomfortable to walk in these streets.



The satellite map was from Baidu Map (Baidu, 2017)

Figure 6. 27: Layout and Key Map of Investigated Streets in Site C2

Table 6. 40: Investigated streets in Site C2

Code	Street Name	Photo	Code	Street Name	Photo
C2-1	*Fenghe Rd*		***C2-2***	*Mingzhuta Rd*	
C2-3	*Lujiazuixi Rd*		***C2-4***	*Fucheng Rd*	
C2-5	*Lujiazuihuan Rd*		***C2-6***	*Century Avenue*	
C2-7	*Yinchengzhong Rd*		***C2-8***	*Yincheng Rd*	
C2-9	*Dongyuan Rd*		***C2-10***	*Huayuanshiqiao Rd*	

Some of the photos are from Baidu Streetscape (Baidu, 2017)

6.2.14.2 Street Evaluation

Ten streets in the Site M1 were investigated and assessed. Figure 6. 28 and Table 6. 41 illustrate the statistics of assessment results, and the primary findings are summarised below:

- The overall performance of C2's streets was much better than the average of 236 streets. The average SSI of C1's streets was 27.2, which was 4.2 above the average of 236 streets;
- In the assessment, C2-6 (Century Avenue) achieved the highest score of (35.0) for the SSI, while C2-10 (Huayuanshiqiao Rd) achieved the lowest of 19.8. The Standard Deviation of C2's streets was only 3.87, which meant the performance of C2's streets was stable.
- Regarding the three aspects of sustainability:
  - The average EnSI of the ten surveyed streets in the Site C2 was 1.56, which was 0.13 higher than the average of 236 streets. It was found in the survey that the Street Green Rate of this area was relatively high. There were green fences between travel lanes and cycling lanes in some streets and open garden along with some streets.
  - The average SoSI of the surveyed streets of C2 was 2.11, which was 0.42 higher than the average of 236 streets. There were tactile pavements for the blind and barrier-free facilities in nearly all streets. Also, the safety facilities, such as street signals, safety signs, street cameras, and lighting system, were well-equipped in the streets. Besides, there were various ways to arrive these streets, like railway, public buses, taxi, private cars, bicycles, and by foot. Hence, the assessment results of C6 (Equality), C7 (Safety), and C8 (Accessibility) were 2.3, 2.4, and 2.4 respectively.
  - The average EcSI of the streets of C2 was 1.79. The assessment scores of C13 (Business Creation), C14 (Job Creation) and C15 (Added-Value) were 1.8, 1.8, 1.9 respectively. According to the survey, there were various stores, malls, and commercial complex along the streets. Also, the traffic mobility in this area was relatively efficient. There was on-time traffic situation broadcasting in the streets to show the congestion situation, available parking numbers, and public bus arrival time.

Table 6. 41: Evaluation Statistics of C2 Streets

Street Code	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
C2-1	1.3	1.0	1.8	1.5	1.5	2.8	2.8	2.0	2.3	2.5	1.0	2.0	2.8	2.8	2.5	**30.3**
C2-2	1.8	1.8	1.8	1.8	1.8	2.3	2.0	2.5	0.8	1.5	2.5	1.8	0.8	0.8	0.8	**24.3**
C2-3	2.0	1.0	2.0	1.8	1.8	2.8	2.8	2.8	1.8	1.8	2.0	2.3	1.8	1.8	2.8	**30.8**
C2-4	1.0	2.0	2.0	2.0	1.3	1.8	2.5	2.5	2.5	1.8	1.8	1.8	2.5	2.5	1.8	**29.5**
C2-5	2.0	1.8	2.0	1.8	1.5	2.0	1.3	2.3	1.8	1.8	2.0	2.3	2.0	2.0	1.3	**27.5**
C2-6(max)	2.0	2.0	2.0	2.0	1.3	2.8	2.8	3.0	2.0	2.5	1.3	2.3	2.3	2.3	2.3	**32.5**

Street Code	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
C2-7	2.0	1.8	2.0	1.8	2.5	2.8	2.8	2.5	1.5	1.5	1.0	2.0	1.0	1.0	2.0	**28.0**
C2-8	1.5	1.8	1.5	1.5	0.8	2.5	2.5	2.5	1.5	1.5	1.0	1.8	0.8	0.8	1.8	**23.5**
C2-9	1.8	1.5	1.8	1.5	0.8	2.0	2.8	2.0	1.5	1.8	1.3	2.0	2.0	2.0	1.8	**26.3**
<u>C2-10(min)</u>	<u>1.3</u>	<u>0.0</u>	<u>0.8</u>	<u>0.0</u>	<u>0.8</u>	<u>1.3</u>	<u>2.0</u>	<u>2.0</u>	<u>1.0</u>	<u>1.5</u>	<u>1.3</u>	<u>2.0</u>	<u>2.0</u>	<u>2.0</u>	<u>2.0</u>	**<u>19.8</u>**
C2 Average	*1.7*	*1.5*	*1.8*	*1.6*	*1.4*	*2.3*	*2.4*	*2.4*	*1.7*	*1.8*	*1.5*	*2.0*	*1.8*	*1.8*	*1.9*	**27.2**
	EnSI=1.56					**SoSI=2.11**					**EcSI=1.79**					
											Standard Deviation					**3.87**
236 streets Total Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					*23.0*

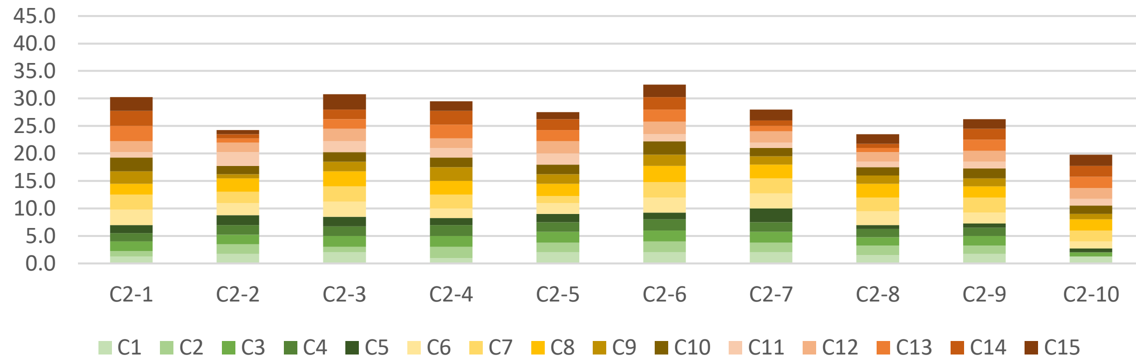


Figure 6. 28: Statistics Analysis of C2 Streets

6.2.14.3 Best Case: Century Avenue (C2-6)

Table 6. 42 presents the assessment results and the statistical comparison of C2-6 (Century Avenue). Centrury Avenue is a typical multi-function street integrated with traffic linkage, commercial service, and landscape gateway of Shanghai. The details of the rating results and evaluation illustration can be seen in Appendix X.

In this assessment, C2-6 (Century Avenue) achieved the highest score of 32.5 for the SSI in the Site C2. As one of the most famous landscape avenues in Shanghai, Century Avenue was built in 2000. It was about 5.5 kilometres long and 100 meters wide, and known as “the Champs-Elysees in the east”. To highlight the landscape feature of Century Avenue, some parts of its sidewalks were 44.5 meters wide with four rows of trees. In this assessment, its SoSI, EcSI, and EnSI were 2.60, 2.05 and 1.85 respectively. Though the sidewalks were very spacious and decorated beautifully, not many public activities were observed during the survey. Also, it was found that ten travel lanes were usually too much for the actual traffic volume.

In summary, C2-6 (Century Avenue) got a relatively high score in sustainability evaluation. However, the design and management of Century Avenue had unique features and political significance. Therefore, the further evaluation and study of this road are not universal. It was not selected as a sample case for the further study.

Table 6. 42: Statistics of C2-6 (Century Avenue) Sustainability Evaluation

Street	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M2-5 ***Baode Rd***	2.0	2.0	2.0	2.0	1.3	2.8	2.8	3.0	2.0	2.5	1.3	2.3	2.3	2.3	2.3	**32.5**
	EnSI=1.85					SoSI=2.60					EcSI=2.05					
236 ***streets Average***	*1.4*	*1.4*	*1.6*	*1.3*	*1.5*	*1.5*	*2.0*	*1.9*	*1.5*	*1.6*	*1.5*	*1.8*	*1.4*	*1.4*	*1.3*	***23.0***
	EnSI=1.43					*SoSI=1.69*					*EcSI=1.49*					

6.2.15 Site: C3

6.2.15.1 Site Brief

Site C3 is in Xintiandi area, the centre of Shanghai. It is a famous tourist attraction which is to display Shanghai historical and cultural features. The whole area is retrofitted from Shikumen buildings which are the unique architectural style of Shanghai. There are various commercial complexes, hotels, museums, and restaurants in this area. The overall landscape of this area is the combination of Chinese and Western, history and modern. So, this area is not only a famous tourist destination but also a critical leisure place for local people.

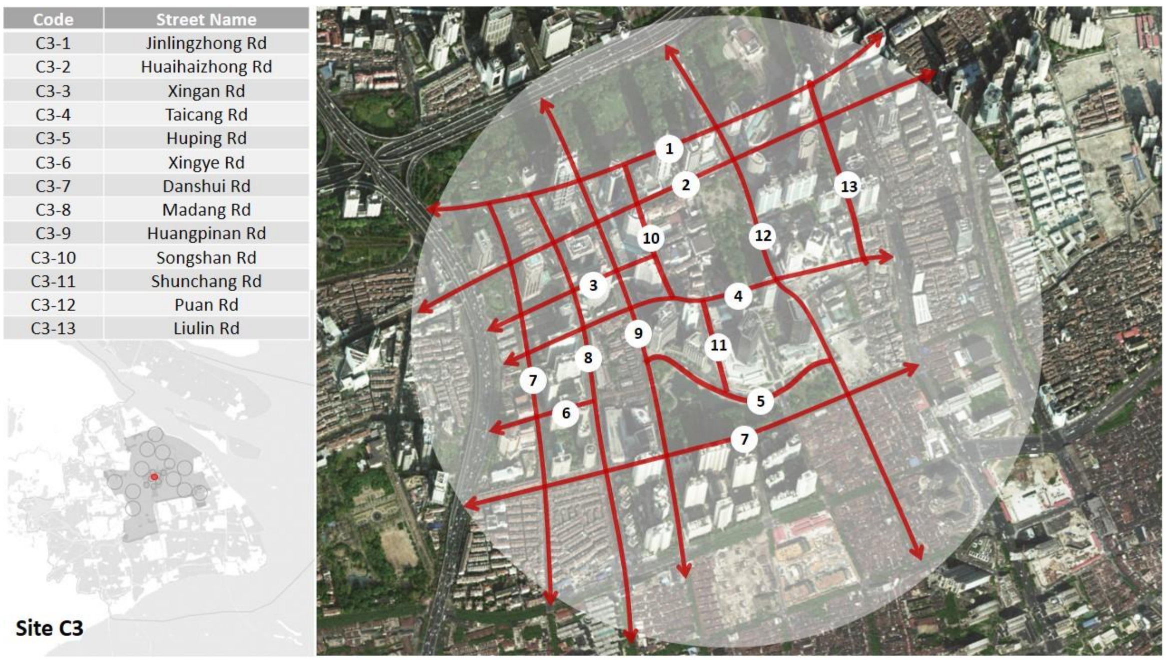
Totally 13 streets were investigated in the Site C3. Figure 6. 29 and Table 6. 43 illustrate the layout and names of these streets. According to the assessment, the performance of these streets was quite good. The streets looked neat and orderly. The pavements of sidewalks and travel lanes were clean and smooth. All traffic signals and signs were clear and efficient. Besides, the overall green rate in C2's streets was relatively high, and the street trees were able to cover most sidewalks and cycling lanes, which provided pleasant walking and cycling spaces.

Table 6. 43: Investigated Streets in Site C3

Code	Street Name	Photo	Code	Street Name	Photo
C3-1	*Jinlingzhong Rd*		***C3-2***	*Huaihaizhong Rd*	
C3-3	*Xingan Rd*		***C3-4***	*Taicang Rd*	
C3-5	*Huping Rd*		***C3-6***	*Xingye Rd*	

Code	Street Name	Photo	Code	Street Name	Photo
C3-7	*Danshui Rd*		***C3-8***	*Madang Rd*	
C3-9	*Huangpinan Rd*		***C3-10***	*Songshan Rd*	
C3-11	*Shunchang Rd*		***C3-12***	*Puan Rd*	
C3-13	*Liulin Rd*				

Some of the photos are from Baidu Streetscape (Baidu, 2017)



The satellite map was from Baidu Map (Baidu, 2017)

Figure 6. 29: Layout and Key Map of Investigated Streets in Site C3

6.2.15.2 Street Evaluation

Thirteen streets in the Site C3 were investigated and assessed. Figure 6. 30 and Table 6. 44 show the statistics of assessment results, and the primary findings are summarised below:

- The overall performance of C3's streets was remarkably higher than the average level of 236 street. The average SSI of C3's streets was 28.7, which was 5.6 above the average of 236 streets;

- The SSI of C3-8(*Madang Rd*) achieved the highest score of 36.0, while that of C3-13 (*Liulin Rd*) got the lowest score of 18.0. The Standard Deviation of C3's streets was 4.76, which showed the performance of C3's streets did not change much.
- Concerning the three aspects of sustainability:
  - The average EnSI of the thirteen surveyed streets in the Site C3 was 1.69, which was 0.26 higher than the average of 236 streets. Both C3 (Pollution Reduction) and C5 (Green Life Promotion) got the score of 1.8 in the assessment, but the C4 (Ecological Balance) was only 1.5.
  - The average SoSI of the surveyed streets in the Site C3 was 2.06, which was 0.37 higher than the average score of 236 streets. The scores of C7 (Safety), C8 (Accessibility), and C10 (Culture Inheritance) were all 2.2. It was found in the survey that the streets' facilities were durable and the streets provided reliable tactile pavement for the blind, barrier-free facilities, and efficient safety equipment, including traffic signals, street signs, street camera, and safety island. The streetscape was consistent with local history and showed relatively high aesthetic quality.
  - The average EcSI of the surveyed streets in the Site C3 was 1.99, which was 0.5 higher than the average of 236 streets. The assessment scores of C13 (Business Creation) and C14 (Job Creation) were 2.1. The commercial function in this area was evident. There were various shops along the streets, and the pavements were also used for the pavement café, F&B, and road showplace.

Table 6. 44: Evaluation Statistics of C3 Streets

Street Code	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
C3-1	1.3	1.3	1.8	1.8	1.8	2.8	2.8	2.8	1.8	1.8	2.0	2.0	2.8	2.8	2.0	31.0
C3-2	2.0	1.8	2.0	0.8	0.8	2.8	2.8	2.8	2.8	3.0	1.8	2.3	3.0	3.0	3.0	34.3
C3-3	1.8	1.5	1.8	0.8	1.5	1.8	1.8	1.8	1.5	1.5	2.0	1.8	1.8	1.8	0.8	23.5
C3-4	1.0	0.8	1.0	0.8	1.5	1.8	2.0	2.8	2.8	2.8	2.0	2.0	3.0	3.0	2.8	29.8
C3-5	2.8	2.3	1.8	2.0	2.0	2.8	2.8	1.8	1.8	2.3	1.8	1.8	1.0	1.0	1.8	29.3
C3-6	1.8	2.3	2.8	1.5	2.3	2.5	1.8	2.0	2.0	3.0	1.8	1.8	3.0	3.0	3.0	34.3
C3-7	1.8	2.3	2.5	1.5	2.3	2.5	2.5	1.8	1.5	1.5	1.8	1.8	0.8	0.8	1.0	26.0
C3-8(max)	1.8	1.5	1.8	1.8	1.5	2.8	2.8	3.0	3.0	3.0	2.0	2.3	3.0	3.0	3.0	36.0
C3-9	1.8	1.5	1.8	1.5	2.3	1.0	2.8	2.8	1.8	2.8	1.8	2.0	2.0	2.0	2.0	29.5
C3-10	1.8	1.5	1.8	1.5	1.5	1.0	1.0	1.8	2.3	2.0	2.5	2.0	2.5	2.5	1.8	27.3
C3-11	1.8	1.8	1.8	1.5	2.3	2.0	2.5	2.5	1.5	1.8	2.0	1.8	1.8	1.8	1.8	28.3
C3-12	1.5	2.3	2.5	2.3	2.3	0.8	1.8	1.8	1.5	2.0	2.3	1.8	1.5	1.5	0.8	26.3
C3-13(min)	1.0	1.5	1.0	1.5	1.5	0.0	1.0	1.8	0.8	0.8	1.5	1.8	1.5	1.5	1.0	18.0
C3 Average	*1.7*	*1.7*	*1.8*	*1.5*	*1.8*	*1.9*	*2.2*	*2.2*	*1.9*	*2.2*	*1.9*	*1.9*	*2.1*	*2.1*	*1.9*	**28.7**
	EnSI=1.69					**SoSI=2.06**					**EcSI=1.99**					
											Standard Deviation					**4.76**
236 streets Total Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					*23.0*

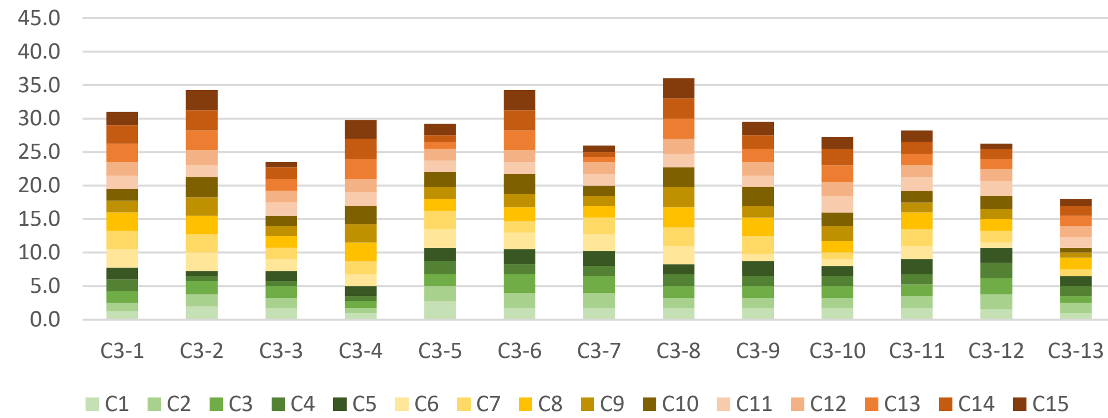


Figure 6. 30: Statistics Analysis of C3 Streets

6.2.15.3 Best Case: Madang Rd (C3-8)

Table 6. 45 presents the assessment results and the statistical comparison of C3-8 (Madang Rd). Madang Rd is a commercial street with historical landscape. The details of the rating results and evaluation illustration can be seen in Appendix Y.

The SSI of C3-8 (Madang Rd) was 36.0, and this was the highest score in 236 streets. Its SoSI, EcSI, and EnSI were 2.90, 2.65, and 1.65 respectively. As a very famous urban street in the Xintiandi area, it got a very high score in social sustainability. According to the street survey, Madang Rd was safe, reliable, and pleasant street. The street space and the frontage space of sided commercial shops were considered and designed as a whole. Thus, the scale, space, and facilities could both satisfy the primary traffic function and promote the occurrence of commercial and social activities.

In general, C3-8 (Madang Rd), achieving the highest score in this assessment, showed an excellent example of a safe, pleasant, and vibrant street. Therefore, it was selected as the sample case for the 2nd Field Survey.

Table 6. 45: Statistics of C3-8(Madang Rd) Sustainability Evaluation

Street	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
C3-8 ***Madang Rd***	1.8	1.5	1.8	1.8	1.5	2.8	2.8	3.0	3.0	3.0	2.0	2.3	3.0	3.0	3.0	**36.0**
	EnSI=1.65					SoSI=2.90					EcSI=2.65					
236 streets ***Average***	*1.4*	*1.4*	*1.6*	*1.3*	*1.5*	*1.5*	*2.0*	*1.9*	*1.5*	*1.6*	*1.5*	*1.8*	*1.4*	*1.4*	*1.3*	***23.0***
	EnSI=1.43					*SoSI=1.69*					*EcSI=1.49*					

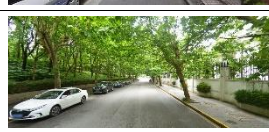
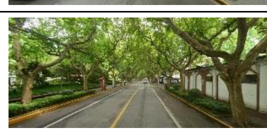
6.2.16 Site: C4

6.2.16.1 Site Brief

Site C4 is in Fahuazhen Area, the east centre of Shanghai. Legend has it that the town of Fahua was the first town in Shanghai. There was a river called Fahua, and some temples and many stores were along the river, which made up a prosperity scene. However, later the river of Fahua was changed into a street, and this area was transformed into a downtown community. Between 1970 and 1980, this area was regenerated, and the streets were reconstructed accordingly. Those old stores and buildings were knocked down and many new residential quarters were built with a relatively high density.

Totally nine streets were investigated in the Site C4. Figure 6. 31 and Table 6. 46 illustrate the layouts and names of the surveyed streets. According to the survey, the performance of the ten surveyed streets in the Site C4 varied a lot. Some streets, like Panyu Rd and Xinhua Rd, looked very pleasant and elegant, while some other streets, like Xianghuaqiao Rd and Anshun Rd, showed many safety hazards and other problems.

Table 6. 46: Investigated Streets in Site C4

Code	Street Name	Photo	Code	Street Name	Photo
C4-1	*Zhongdeqiao Rd*		***C4-2***	*Dingxi Rd*	
C4-3	*Xianghuaqiao Rd*		***C4-4***	*Panyu Rd*	
C4-5	*Xingfu Rd*		***C4-6***	*Fahuazhen Rd*	
C4-7	*Xinhua Rd*		***C4-8***	*Anshun Rd*	
C4-9	*Huaihaixi Rd*				

Some of the photos are from Baidu Streetscape (Baidu, 2017)

Code	Street Name
C4-1	Zhongdeqiao Rd
C4-2	Dingxi Rd
C4-3	Xianghuaqiao Rd
C4-4	Panyu Rd
C4-5	Xingfu Rd
C4-6	Fahuazhen Rd
C4-7	Xinhua Rd
C4-8	Anshun Rd
C4-9	Huaihaixi Rd

The satellite map was from Baidu Map (Baidu, 2017)

Figure 6. 31: Layout and Key Map of Investigated Streets in Site C4

6.2.16.2 Street Evaluation

Nine streets in the Site C4 were investigated and assessed. Figure 6. 32 and Table 6. 47 show the statistics of assessment results, and the primary findings are summarised below:

- The average SSI of C4’s streets was 24.7, which was 1.7 above the average of 236 streets;
- C4-7(Xinhua Rd) achieved the highest score of 32.8 for the SSI, while the C4-3 (Xianghuaqiao Rd) achieved the lowest score of 10.5. The Standard Deviation of C4’s streets was 7.07, which showed the performance of C1’s streets was pretty different. Some were good while some were quite poor.
- Concerning the three aspects of sustainability:
    - The average EnSI of the nine surveyed streets in the Site C4 was 1.64. According to the survey, the Street Green Rate of the Site C4 was relatively high, especially to Xinfu Rd and Xinhua Rd. Despite big street trees to create a pleasant street canopy, there were also open green gardens along the street and nice small flower beds on fences of residential quarters, thereby forming a very environmental-friendly public space.
    - The average SoSI of these streets in C4 was 1.79. Both C8 (Accessibility) and C10 (Culture Inheritance) got 1.9. It was found in the survey that there were various arrival ways and clear sign and guidance system to provide high accessibility of the

streets. Moreover, the streetscape and street furniture also showed high aesthetic quality.

- The average EcSI of these streets in C4 was 1.51. Among the five criteria, C12 (Efficiency) got the highest score of 1.8, while C15 (Added-value) got the lowest score of 1.2.

Table 6. 47: Evaluation Statistics of C4 Streets

Street Code	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
C4-1	1.8	1.5	1.8	1.5	1.5	1.8	2.5	2.5	2.3	1.8	1.3	1.8	1.8	1.8	1.0	**26.3**
C4-2	1.0	1.5	1.8	1.5	1.5	0.8	1.0	1.8	2.3	2.0	2.0	2.0	2.8	2.8	1.8	**26.3**
C4-3(min)	0.0	0.0	0.0	0.0	0.8	0.0	1.0	0.8	1.5	0.8	1.0	1.0	1.5	1.5	0.8	**10.5**
C4-4	1.8	2.8	2.5	1.5	2.3	1.8	2.8	2.8	2.5	2.3	1.8	2.0	2.0	2.0	2.0	**32.5**
C4-5	2.5	2.8	2.8	2.5	1.8	1.8	2.0	1.8	1.5	2.5	1.8	1.8	0.0	0.0	1.0	**26.3**
C4-6	1.0	1.5	1.8	1.5	1.5	1.8	1.0	1.8	2.3	1.8	2.3	1.8	2.3	2.3	0.8	**25.0**
C4-7(max)	2.5	2.8	2.8	2.8	2.5	2.5	2.8	1.8	1.5	2.8	1.5	2.0	1.5	1.5	1.8	**32.8**
C4-8	1.3	0.8	0.8	0.8	1.5	1.8	1.8	2.0	0.8	1.5	1.0	2.0	0.0	0.0	1.0	**16.8**
C4-9	1.8	2.3	2.5	1.5	1.5	1.8	1.8	1.8	1.5	2.3	1.8	2.0	1.5	1.5	1.0	**26.3**
C4 Average	*1.5*	*1.8*	*1.8*	*1.5*	*1.6*	*1.5*	*1.8*	*1.9*	*1.8*	*1.9*	*1.6*	*1.8*	*1.5*	*1.5*	*1.2*	**24.7**
	EnSI=1.64					**SoSI=1.79**					**EcSI=1.51**					
															Standard Deviation	**7.07**
236 streets Total Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					*23.0*

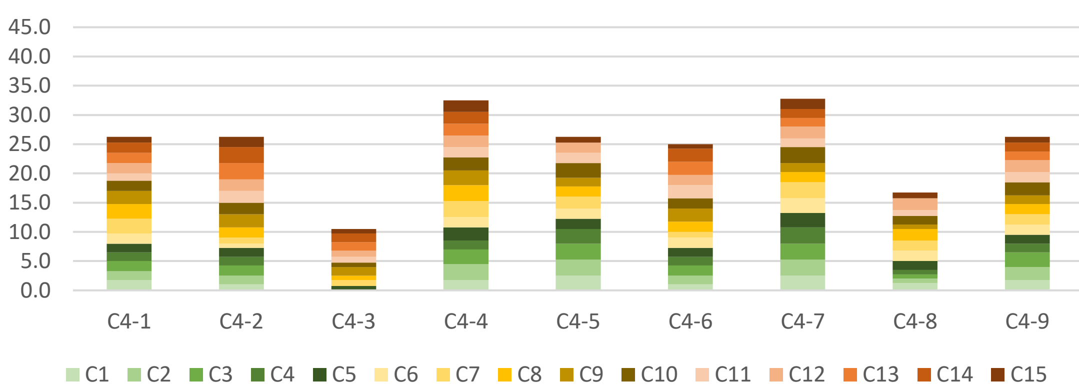


Figure 6. 32: Statistics Analysis of C4 Streets

6.2.16.3 Best Case: Xinhua Rd (C4-7)

Table 6. 48 presents the assessment results and the statistical comparison of C4-7 (Xinhua Rd). Xinhua Rd is a beautiful landscape street with pleasant trees and pocket gardens along it. The details of the rating results and evaluation illustration can be seen in Appendix Z.

The SSI of C4-7 (Xinhua Rd) achieved the highest score of 32.8 in the Site C4. The EnSI, SoSI, and EcSI were 2.65, 2.25, and 1.65 respectively. Based on the street survey, Xinhua Rd was a lovely, pleasant, and peaceful street. The big and tall plane-trees on the sidewalks created very comfortable street canyons. In summer these deciduous plants offered the very desirable shading for the whole street, while the sunlight was able to get through the branches to warm the streets during winter. Moreover, the reasonable layout of the landscape and nice street furniture further encouraged people to have more public activities. The plants, sided building façade, and street furniture inherited and reflected the historical characteristics of French Concession. However, there was not much stores and business on either side of this street, which was why Xinhua Rd got a relatively low score on the economic aspect of sustainability assessment.

To sum up, C4-7 (Xinhua Rd) was a green, attractive, and historic street. However, there were still gaps to be a genuinely sustainable street, so Xinhua Rd was not selected for the 2nd Field Survey.

Table 6. 48: Statistics of C4-7 (Xinhua Rd) Sustainability Evaluation

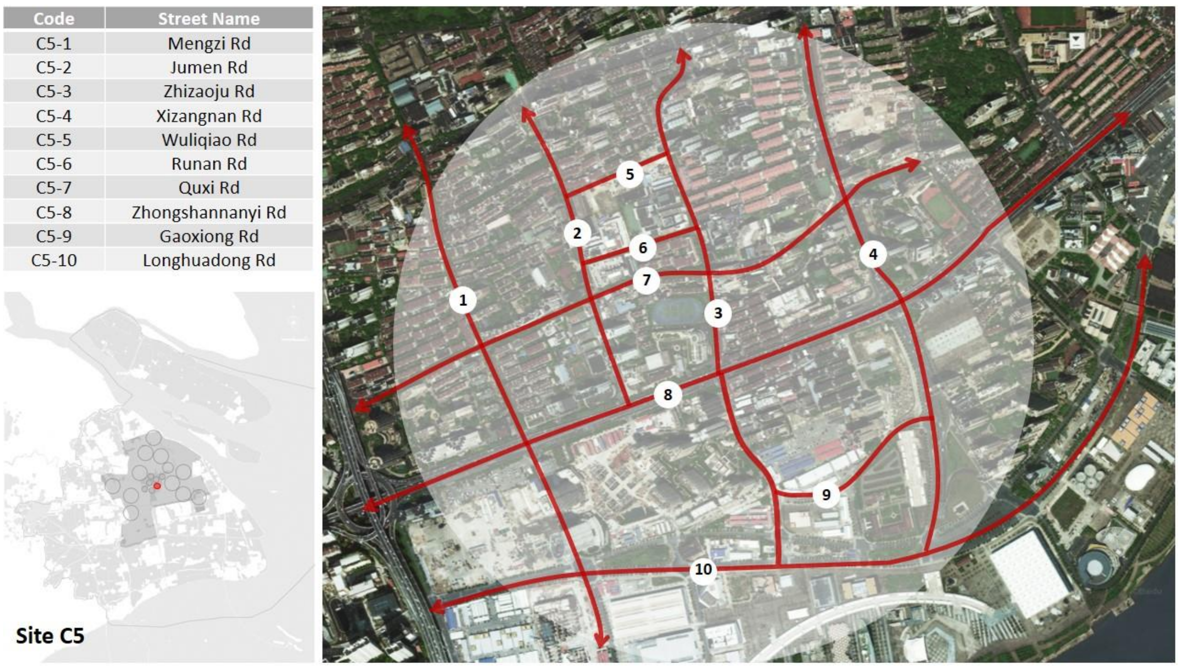
Street	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
C4-7	2.5	2.8	2.8	2.8	2.5	2.5	2.8	1.8	1.5	2.8	1.5	2.0	1.5	1.5	1.8	**32.8**
Xinhua Rd	EnSI=2.65					SoSI=2.25					EcSI=1.65					
236 *streets*	*1.4*	*1.4*	*1.6*	*1.3*	*1.5*	*1.5*	*2.0*	*1.9*	*1.5*	*1.6*	*1.5*	*1.8*	*1.4*	*1.4*	*1.3*	*23.0*
Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					

6.2.17 Site: C5

6.2.17.1 Site Brief

Site C5 is located in Old Nanshi Area, the south centre of Shanghai. Nanshi district was once a municipal district in Shanghai. In 2000, Shanghai government announced the abolition of the Nanshi district and merged the west bank of the southern city of Huangpu river into Huangpu district. After this, this site is often called Old Nanshi Area and has experienced a significant improvement of the basic construction and land redevelopment. But it is still a relatively mature community with high living density.

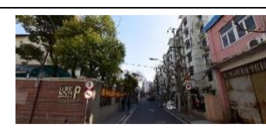
Totally ten streets were investigated in the Site C5. Figure 6. 33 and Table 6. 49 illustrate the layouts and names of these streets. According to the assessment results, the performance of these streets varied a lot, and each street showed different features. Specifically speaking, the streets of C5-1 (Mengzi Rd), C5-2 (Jumen Rd), C5-3 (Zhizaoju Rd), C5-4 (Xiangnan Rd), and C5-7 (Quxi Rd) demonstrated the characteristics of the old town in the city centre. They were narrow streets with desirable scale and big street trees. Also, there were various small shops along the streets and different activities of passers, tourists, and residents happened here, which contributed to dynamic urban streets. Furthermore, the streets of C5-5 (Wuliqiao Rd) and C5-6 (Runan Rd) showed old streets without proper maintenance and renovation. The streets were very narrow, and sidewalks were often occupied by garbage disposal or laundry dries of the residents. The streetscape looked cluster and cramped. Moreover, C5-9 (Gaoxiong Rd) and C5-10 (Longhuadong Rd) displayed the typical streets of the urban new construction area. There were wide motor lanes and narrow sidewalks with small and newly-built street trees. According to the survey observation, there were no life and no activity in such streets but dust and noise.



The satellite map was from Baidu Map (Baidu, 2017)

Figure 6. 33: Layout and Key Map of Investigated Streets in Site C5

Table 6. 49: Investigated Streets in Site C5

Code	Street Name	Photo	Code	Street Name	Photo
C5-1	*Mengzi Rd*		***C5-2***	*Jumen Rd*	
C5-3	*Zhizaoju Rd*		***C5-4***	*Xizangnan Rd*	
C5-5	*Wuliqiao Rd*		***C5-6***	*Runan Rd*	
C5-7	*Quxi Rd*		***C5-8***	*Zhongshannanyi Rd*	

Code	Street Name	Photo	Code	Street Name	Photo
C5-9	*Gaoxiong Rd*		***C5-10***	*Longhuadong Rd*	

Some of the photos are from Baidu Streetscape (Baidu, 2017)

6.2.17.2 Street Evaluation

Ten streets in the Site C5 were investigated and assessed. Figure 6. 34 and Table 6. 52 show the statistics of assessment results, and the primary findings are summarised below:

- The overall performance of C5's streets was quite lower than the average of 236 streets. The average SSI of C5's streets was 20.1, which was 2.9 below the average of 236 streets;
- C5-1 (Mengzi Rd) achieved the highest the SSI of 27.8 in the Site C5, while C5-9 (Gaoxiong Rd) achieved the lowest score of 11.3. The Standard Deviation of C5's streets was 6.10, which showed the performance of C5's streets was pretty different.
- Concerning the three aspects of sustainability:
  - The average EnSI of the ten surveyed streets in the Site C5 was 1.22, which was 0.21 lower than the average of 236 streets. The street land in the old town was insufficient. The sidewalks were often narrow and compact. Hence there was nearly no space for more street plants. The streets of C5-1 (Mengzi Rd), C5-2 (Jumen Rd), C5-4 (Xizangnan Rd), C5-5 (Wuliqiao Rd), and C5-6 (Runan Rd) were the typical examples.
  - The average SoSI of the surveyed streets in the Site C5 was 1.45, which was 0.24 lower than the average of 236 streets. Among the five corresponding criteria, C7 (safety) got the highest score of 1.90. It was found in the survey that there were a serious of efficient safety equipment, including traffic signals, street camera, isolation belt, and safe islands. However, the score of C6 (Equality) got the lowest score of 1.2. According to the survey, there was neither tactile pavement for the blind nor barrier-free facility on some streets. Also, the sidewalks of some streets were too narrow for people with luggage.
  - The average EcSI of the streets in the Site C5 was 1.36, which was 0.13 lower than the average of 236 streets. In the assessment, the average of C12 (Efficiency) was 1.8. It was found in the survey that the traffic was in good condition, and the average traffic mobility of these streets was good. However, the score of C15 (Added-value) was only 0.7 since various walls sided along most of the streets and this area was

under developing status. Therefore, the streets were unable to create a commercial vitality.

Table 6. 50: Evaluation Statistics of C5 Streets

Street Code	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
C5-1(max)	1.8	1.5	1.8	1.5	1.5	1.8	2.8	1.8	2.3	1.8	1.8	1.8	2.5	2.5	1.0	**27.8**
C5-2	0.8	0.8	1.8	0.8	2.3	1.3	2.5	1.8	1.5	1.8	1.8	1.8	1.8	1.8	0.8	**22.8**
C5-3	1.8	1.5	1.8	0.8	1.5	1.8	1.8	1.8	2.3	1.8	1.8	1.8	1.8	1.8	1.0	**24.5**
C5-4	1.3	1.5	1.8	0.8	0.8	2.5	2.8	2.0	1.5	1.8	1.8	2.3	2.5	2.5	1.0	**26.5**
C5-5	0.0	0.8	0.8	0.8	0.8	0.0	0.8	0.8	1.5	0.3	1.5	0.8	1.8	1.5	0.8	**12.5**
C5-6	0.0	1.5	1.5	0.8	1.5	0.0	1.0	1.5	0.8	1.0	1.8	1.5	0.8	0.8	0.8	**15.0**
C5-7	0.8	2.5	1.8	1.5	2.3	0.3	1.8	1.8	2.3	1.8	1.8	1.8	2.5	2.5	0.8	**25.8**
C5-8	1.3	1.3	1.3	0.8	0.8	1.5	2.0	2.0	0.8	1.0	1.3	2.0	0.8	0.8	1.0	**18.3**
C5-9(min)	1.0	0.8	0.8	0.8	0.8	1.0	1.8	1.0	0.0	0.8	0.8	2.0	0.0	0.0	0.0	**11.3**
C5-10	2.0	1.8	1.3	0.8	1.5	1.8	2.0	2.0	0.0	0.8	0.8	2.0	0.0	0.0	0.3	**16.8**
C5 Average	*1.1*	*1.4*	*1.4*	*0.9*	*1.4*	*1.2*	*1.9*	*1.6*	*1.3*	*1.3*	*1.5*	*1.8*	*1.4*	*1.4*	*0.7*	**20.1**
	EnSI=1.22					**SoSI=1.45**					**EcSI=1.36**					
											Standard Deviation					**6.10**
236 streets Total Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					*23.0*

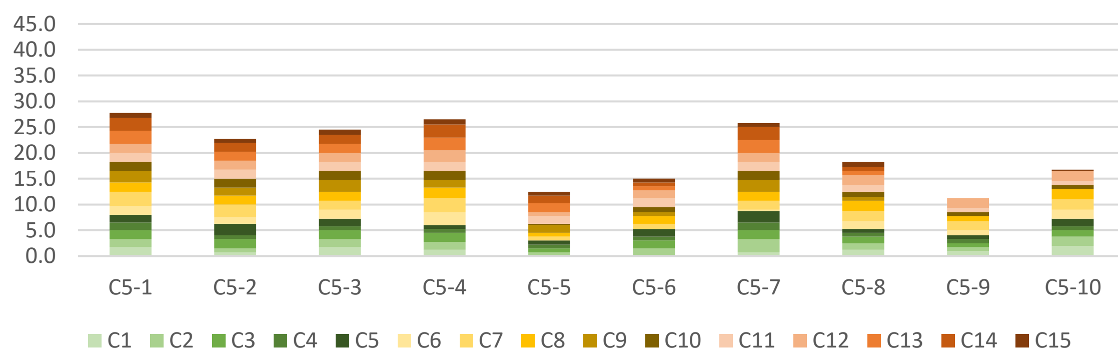


Figure 6. 34: Statistics Analysis of C5 Streets

6.2.17.3 Best Case: Mengzi Rd (C5-1)

Table 6. 51 presents the assessment results and the statistical comparison of C5-1 (Mengzi Rd). It is a neighbourhood street. The details of the rating results and evaluation illustration can be seen in Appendix AA.

The SSI of C5-1 (Mengzi Rd) was 27.8, getting the highest one in the Site C5. According to the assessment results, the performance of Shuiqing Rd was relatively balanced in all three sustainable aspects. The EnSI, SoSI and EcSI were 1.60, 2.05, and 1.90 respectively. It was found in the survey that most of the street elements helped to create a safe street, like guide signs, street cameras, and safety fences. Also, there were many convenient shops and community stores along the street. However, Mengzi Rd had no special performance in environmental sustainability. The hard surface covered the whole street, and the Street Green Rate was relatively low.

To sum up, though C5-1 (Mengzi Rd) achieved the highest score in the sustainability assessment in the Site C5, the overall performance was just above-average and not sufficient as a typical case of a sustainability street. Therefore, it was not selected as the sample case for the 2nd Field Survey.

Table 6. 51: Statistics of C5-1 (Mengzi Rd) Sustainability Evaluation

Street	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
C5-1	1.8	1.5	1.8	1.5	1.5	1.8	2.8	1.8	2.3	1.8	1.8	1.8	2.5	2.5	1.0	**27.8**
Mengzi Rd	EnSI=1.60					SoSI=2.05					EcSI=1.90					
236 *streets*	*1.4*	*1.4*	*1.6*	*1.3*	*1.5*	*1.5*	*2.0*	*1.9*	*1.5*	*1.6*	*1.5*	*1.8*	*1.4*	*1.4*	*1.3*	***23.0***
Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					

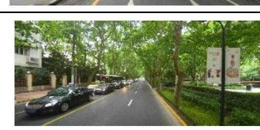
6.2.18 Site: C6

6.2.18.1 Site Brief

Site C6 is in Xujiahui Area, the southeast centre of Shanghai. Xujiahui area is one of the four vice city centres in Shanghai and one of the top ten commercial hubs of Shanghai. Xujiahui commercial centre was built in 1992 and completed in 2000. The history of Xujiahui can be back to the Ming dynasty (the 1630s). A famous scientist and politics, called Xu Guangqi, was born in Shanghai, and buried in Xujiahui, so today people can still to Guangqi park of this area to memory this famous ancient.

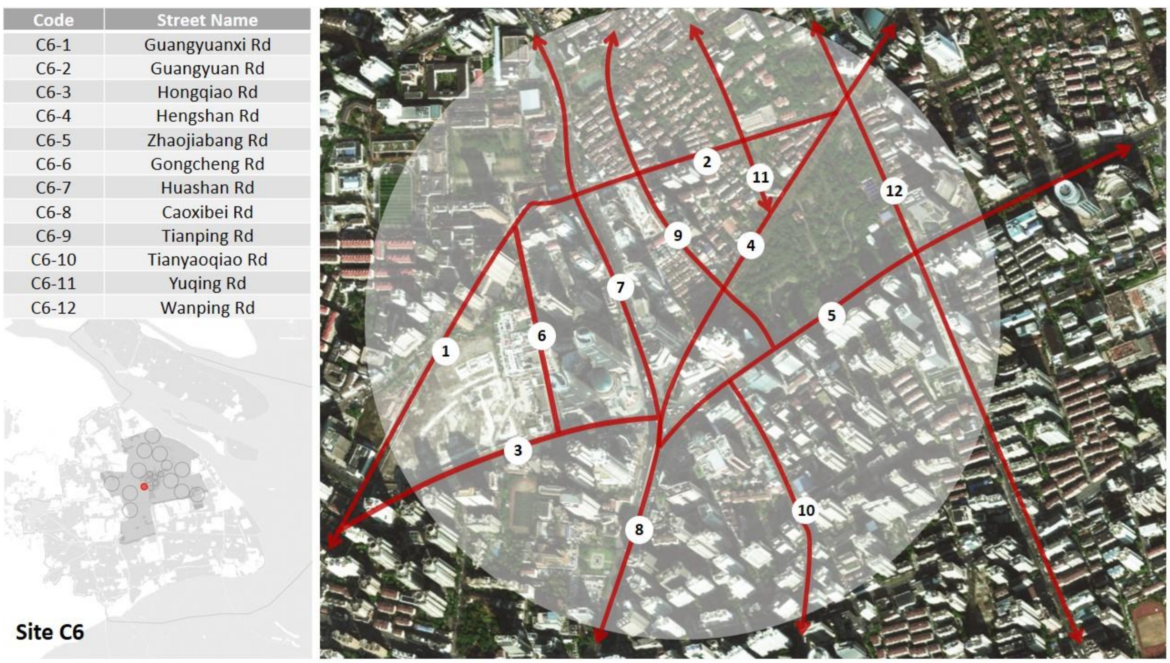
Totally twelve streets were investigated in the Site C6. Figure 6. 35 and Table 6. 52 illustrate the layouts and names of these streets. In general, the streets in the Site C6 were neat and well-managed. To the streets of C6-2 (Guangyuan Rd), C6-4 (Hengshan Rd), C6-9 (Tianping Rd), and C6-12 (Wanping Rd), the streets were comfortable and pleasant. However, the performance of some streets, like C6-1 (Guangyuanxi Rd), and C6-6 (Gongcheng Rd) were inferior.

Table 6. 52: Investigated Streets in Site C5

Code	Street Name	Photo	Code	Street Name	Photo
C6-1	*Guangyuanxi Rd*		***C6-2***	*Guangyuan Rd*	
C6-3	*Hongqiao Rd*		***C6-4***	*Hengshan Rd*	

Code	Street Name	Photo	Code	Street Name	Photo
C6-5	*Zhaojiabang Rd*		***C6-6***	*Gongcheng Rd*	
C6-7	*Huashan Rd*		***C6-8***	*Caoxibei Rd*	
C6-9	*Tianping Rd*		***C6-10***	*Tianyaoqiao Rd*	
C6-11	*Yuqing Rd*		***C6-12***	*Wanping Rd*	

Some of the photos are from Baidu Streetscape (Baidu, 2017)



The satellite map was from Baidu Map (Baidu, 2017)

Figure 6. 35: Layout and Key Map of Investigated Streets in Site C6

6.2.18.2 Street Evaluation

Twelve streets in the Site C6 were investigated and assessed. Figure 6. 36 and Table 6. 53 show the statistics of assessment results, and the primary findings are summarised below:

- The overall performance of C6's streets was above the average level of 236 surveyed street. The average SSI of C6's streets was 24.6, which was 1.6 higher than 236's average;

- C6-12 (*Wanping Rd*) achieved the highest score in the assessment of Site C6, and the SSI was 33.5. C6-6 (*Gongcheng Rd*) achieved the lowest of 5.5. The Standard Deviation of C6's streets was 8.21, which showed the performance of C6's streets varied a lot.
- Regarding the three aspects of sustainability:
    - The average EnSI of the twelve surveyed streets in the Site C6 was 1.50, which was 0.07 higher than the average of 236 streets. Some of the C6's streets demonstrated excellent examples from the perspective of environmental sustainability. However, some of the streets showed inferior performance on the environmental aspect, which was to be elaborated by the typical cases.
    - The average SoSI of the surveyed streets in the Site C5 was 1.85, which was 0.16 higher than the average of 236 streets. According to the assessment results, the best performance of C5's streets in social sustainability was C7 (Safety). It was found in the survey that there were various types of safety equipment in the streets of C5, such as safety island, traffic signals, guide signs and speed camera.
    - The average EcSI of the surveyed streets in the Site C6 was 1.57. It was found in the survey that there were various shops and commercial complexes along the streets, but the commercial activities and business linkage were separated rather than merged due to excessively wide streets. Hence, the score of C11 (Intensive Land Utilisation), C13 (Business Creation), C14 (Job Creation) and C15 (Added-value) are all at the average level (1.5).

Table 6. 53: Evaluation Statistics of C6 Streets

Street Code	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
C6-1	1.0	0.8	1.0	0.8	0.8	1.8	1.8	1.8	0.8	1.0	1.8	1.0	0.8	0.8	0.8	**16.3**
C6-2	0.8	1.5	1.8	0.8	1.5	0.8	1.8	1.8	1.5	1.8	1.5	1.8	1.5	1.5	1.5	**21.5**
C6-3	1.3	0.0	0.0	0.0	0.8	1.8	2.0	2.0	1.5	1.3	1.0	2.3	1.3	1.3	1.3	**17.5**
C6-4	2.5	2.8	2.8	2.8	2.0	2.8	2.8	1.8	1.8	2.5	1.8	2.0	0.8	0.8	1.8	**31.3**
C6-5	2.0	2.0	1.8	2.0	2.0	1.8	2.0	2.3	2.3	2.5	1.0	2.3	2.0	2.0	2.0	**29.8**
C6-6(min)	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.8	0.8	0.8	1.3	1.0	0.0	0.0	0.0	**5.5**
C6-7	1.3	0.8	1.0	0.8	1.5	2.0	2.8	2.0	1.5	1.5	1.0	2.3	2.0	2.0	1.8	**24.0**
C6-8	1.0	1.0	1.0	1.5	1.8	1.8	2.0	2.0	1.8	2.5	1.0	2.3	2.8	2.8	1.8	**26.8**
C6-9	1.5	2.3	1.8	1.5	2.3	1.5	1.8	2.3	2.3	2.8	2.5	1.8	2.8	2.5	1.8	**31.0**
C6-10	1.8	2.5	1.8	1.5	1.5	1.8	2.0	2.8	2.5	1.8	1.8	2.0	3.0	3.0	2.5	**32.0**
C6-11	1.8	2.5	2.5	1.8	2.5	0.8	2.5	1.5	1.5	2.5	2.0	1.8	0.8	0.8	0.8	**25.8**
C6-12(max)	2.5	3.0	3.0	3.0	2.8	2.8	2.8	2.5	2.0	2.5	1.8	1.8	0.8	0.8	1.8	**33.5**
C6 Average	*1.4*	*1.6*	*1.5*	*1.4*	*1.6*	*1.6*	*2.1*	*1.9*	*1.7*	*1.9*	*1.5*	*1.8*	*1.5*	*1.5*	1.5	**24.6**
	EnSI=1.50					**SoSI=1.85**					**EcSI=1.57**					
Standard Deviation																**8.24**
236 streets Total Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					*23.0*

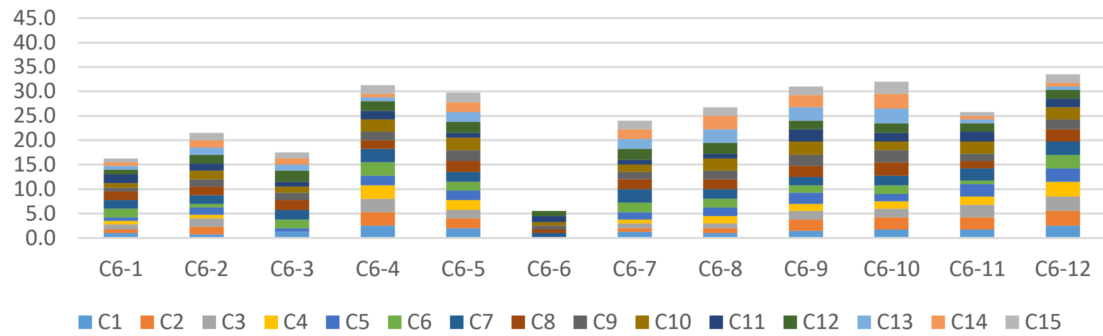


Figure 6. 36: Statistics Analysis of C6 Streets

6.2.18.3 Best Case: Wanping Rd (C6-12)

Table 6. 54 presents the assessment results and the statistical comparison of C6-12 (Wanping Rd). This is a beautiful landscape street with tall trees, pleasant greenery, and elegant pocket gardens. The details of the rating results and evaluation illustration can be seen in Appendix BB.

C6-12 (Wanping Rd) achieved the highest score in the sustainability assessment of the Site C5, and its SSI was 33.5. According to the assessment results, Wanping Rd showed very excellent performance in environmental and social aspects, and slightly below the average regarding economic sustainability. The EnSI, SoSI, and EcSI were 2.85, 2.50, and 1.35 respectively. In general, Wanping Rd was a lovely, pleasant, and peaceful street. It was found in the survey that the big and tall plane-trees on the sidewalks created a comfortable street canyon. Besides the street trees, there were also two wide green fences on both sidewalks, and an open park was along the street. However, compared with other streets, there were not many shops and business along Wanping Rd, so the vitality of Wanping Rd was limited.

To sum up, C6-12 (Wanping Rd) was a green, attractive, and desirable street, which could demonstrate some features of a sustainable urban street. However, there were still some gaps to be a genuinely sustainable street concerning economic sustainability. So Wanping Rd was not selected as the sample case for the 2nd Field Survey.

Table 6. 54: Statistics of C6-12 (Wanping Rd) Sustainability Evaluation

Street	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
C6-12 ***Wanping8Rd***	2.5	3.0	3.0	3.0	2.8	2.8	2.8	2.5	2.0	2.5	1.8	1.8	0.8	0.8	1.8	**33.5**
	EnSI=2.85					SoSI=2.50					EcSI=1.35					
236 streets ***Average***	*1.4*	*1.4*	*1.6*	*1.3*	*1.5*	*1.5*	*2.0*	*1.9*	*1.5*	*1.6*	*1.5*	*1.8*	*1.4*	*1.4*	*1.3*	***23.0***
	EnSI=1.43					*SoSI=1.69*					*EcSI=1.49*					

6.2.19 Site: C7

6.2.19.1 Site Brief

Site C7 is in Shibo Area in Pudong district. The Shanghai 2010 EXPO was held here. Due to some historical reasons and the urban development process, the valuable riverside area of Shanghai was occupied by many factories, cargo berth, and old workers' house. Hence, the Shanghai government and planning department selected this site to locate 2010 EXPO, thereby promoting urban renewal and upgrading of municipal facilities. After Shanghai 2010 EXPO, this area was redeveloped. Some lands have been renewed to be high-end residences, offices, and commercial complexes, while many other lands are still under construction.

Totally nine streets were investigated in the Site C7. Figure 6. 37 and Table 6. 55 illustrate the layouts and names of these streets. In general, these streets could be divided into two groups: the streets in the un-renovated area and the streets in the redevelopment area. The streets in the un-renovated area, like C7-1 (Longheng Rd), C7-2 (Jichangxi Rd), and C7-7 (Xitaibei Rd), were narrow and a bit cluster. Car parking or garbage bins often occupied the sidewalks. People had to walk in motor lanes. The street trees were wild and without proper maintenance. The streets in the redevelopment area, like C7-3 (Longlan Rd), C7-4 (Longyao Rd), C7-5 (Fenggu Rd), C7-6 (Longwu Rd), C7-8 (Yunjin Rd), and C7-9 (Longteng Avenue) were spacious. Some of these streets had ten travel lanes with tiny and newly-planted trees. However, few people were observed walking or cycling in such streets.

Code	Street Name
C7-1	Longheng Rd
C7-2	Jichangxi Rd
C7-3	Longlan Rd
C7-4	Longyao Rd
C7-5	Fenggu Rd
C7-6	Longwu Rd
C7-7	Xitaibei Rd
C7-8	Yunjin Rd
C7-9	Longteng Avenue

The satellite map was from Baidu Map (Baidu, 2017)

Figure 6. 37: Layout and Key Map of Investigated Streets in Site C7

Table 6. 55: Investigated Streets in Site C7

Code	Street Name	Photo	Code	Street Name	Photo
C7-1	*Longheng Rd*		***C7-2***	*Jichangxi Rd*	
C7-3	*Longlan Rd*		***C7-4***	*Longyao Rd*	
C7-5	*Fenggu Rd*		***C7-6***	*Longwu Rd*	
C7-7	*Xitaibei Rd*		***C7-8***	*Yunjin Rd*	
C7-9	*Longteng Avenue*				

Some of the photos are from Baidu Streetscape (Baidu, 2017)

6.2.19.2 Street Evaluation

Ten streets in the Site C7 were investigated and assessed. Figure 6. 38 and Table 6. 56 show the statistics of assessment results, and the primary findings are summarised below:

- The average SSI of the C7's streets was 18.7, which was 4.3 below the average of 236 streets;
- The SSI of C7-8 (*Yunjin Rd*) got the highest score of 28.3, while C7-2 (*Jichangxi Rd*) got the lowest of 3.5. The Standard Deviation of C7's streets was 7.93, which showed the performance of C7's streets was very different.
- Concerning the three aspects of sustainability:
    - The average EnSI of the ten surveyed streets in the Site C7 was 1.32, which was 0.11 lower than the average of 236 streets. It was found in the survey the plant in these streets was messy and wild. Some streets were newly constructed. For example, C7-4 (Longyao Rd) showed inferior performance from the perspective of environmental sustainability. According to the survey, Longyao Rd was a 40-meter-wide street with 8 motor lanes and no green space. On the contrary C7-8 (Yunjin Rd) displayed an excellent example in environmental sustainability, like the usage of rain garden and ecological consideration in street design.

- The average SoSI of the surveyed streets in the Site C7 was 1.39. The best performance of C7's streets from the social sustainability perspective was C7 (safety) because many newly-built streets provided a serious of safety equipment, such a traffic signals, street signs and street camera. However, the social diversity and culture inheritance of C7's streets were poor because few street activities were observed in the streets and streetscape looked just spacious and new.
- The average EcSI of the surveyed streets in the Site C7 was 1.03, which was 0.46 lower than the average of 236 streets. It was found in the survey that there were many fences along the streets. The creation of business and job opportunities of these streets were limited.

Table 6. 56: Evaluation Statistics of C7 Streets

Street Code	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
C7-1	1.0	0.8	1.5	0.8	1.5	2.5	2.5	1.8	1.5	1.0	1.8	1.8	0.8	0.8	0.8	**20.5**
C7-2(min)	0.0	0.8	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	**3.5**
C7-3	1.8	0.8	2.0	1.5	0.8	1.0	2.5	1.8	0.8	1.5	1.8	1.8	0.0	0.0	1.0	**18.8**
C7-4	0.3	0.0	0.0	0.0	0.8	0.8	1.8	1.3	0.8	0.8	0.8	2.0	0.0	0.0	0.0	**9.0**
C7-5	2.0	1.5	1.8	1.5	1.5	1.8	2.8	2.0	1.5	1.8	1.0	2.0	1.5	1.5	0.8	**24.8**
C7-6	2.0	0.8	2.0	1.5	1.5	1.8	2.0	2.0	1.5	1.5	0.8	2.3	1.8	1.8	1.0	**24.0**
C7-7	0.8	1.5	1.5	0.8	0.8	0.0	0.8	0.8	1.5	0.0	2.0	1.0	2.5	2.5	0.8	**17.0**
C7-8(max)	2.8	2.8	1.8	2.5	2.5	1.8	2.8	2.8	1.5	1.5	1.0	2.3	0.8	0.8	1.0	**28.3**
C7-9	2.5	2.3	1.8	2.3	1.5	1.8	2.5	1.8	1.5	1.5	0.8	2.0	0.0	0.0	0.8	**22.8**
C7 Average	*1.0*	*0.8*	*1.5*	*0.8*	*1.5*	*2.5*	*2.5*	*1.8*	*1.5*	*1.0*	*1.8*	*1.8*	*0.8*	*0.8*	*0.8*	**18.7**
	EnSI=1.32					**SoSI=1.39**					**EcSI=1.03**					
															Standard Deviation	**7.93**
236 streets Total Average	*EnSI=1.43*					*SoSI=1.69*					*EcSI=1.49*					*23.0*

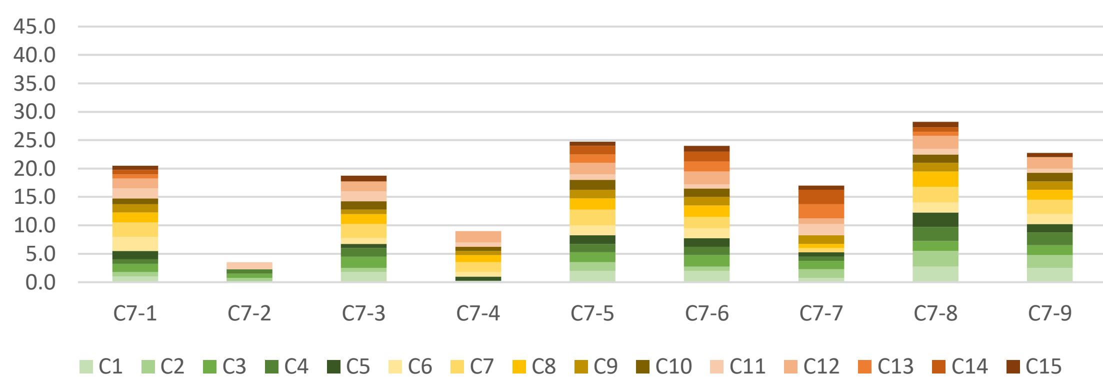


Figure 6. 38: Statistics Analysis of C7 Streets

6.2.19.3 Best Case: Yunjin Rd (C7-8)

Table 6. 3 presents the assessment results and the statistical comparison of C7-8 (Yunjin Rd). This is a secondary road and serve as a traffic street for this area. The details of the rating results and evaluation illustration can be seen in Appendix CC.

The SSI of C7-8 (Yunjin Rd) was 28.3. Though it was the highest score in the assessment of the Site M10, the score of 28.3 was at the above average level in 236 assessed streets. According to the assessment results, the EnSI, the SoSI, and the EcSI were 2.45, 2.05, and 1.15 respectively. The performance of Yunjin Rd was not balanced in three sustainable aspects. Yunjin Rd was a demonstrative case of green streets, so many green solutions were implemented on Yunjin Rd, including rain gardens, green walls, and the increase of green belts. It was not outstanding from the perspective of social and economic sustainability. The street was newly-built, and many lands along the street were still under construction. So, there was no shop and business along the street, and not many activities were observed in the street. The overall streetscape was neat but lifeless.

In summary, C7-8 (Yunjin Rd) showed many green methods and practices. However, as a newly-built street, it was not diverse and vibrant enough. So, it was not selected as the sample case for the 2nd Field Survey.

Table 6. 57: Statistics of C7-8 (Yunjin Rd) Sustainability Evaluation

Street	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M10-3 *Meihua Rd*	2.8	2.8	1.8	2.5	2.5	1.8	2.8	2.8	1.5	1.5	1.0	2.3	0.8	0.8	1.0	**28.3**
	EnSI=1.30					SoSI=1.20					EcSI=0.95					
236 *streets Average*	*1.4*	*1.4*	*1.6*	*1.3*	*1.5*	*1.5*	*2.0*	*1.9*	*1.5*	*1.6*	*1.5*	*1.8*	*1.4*	*1.4*	*1.3*	***23.0***
	EnSI=1.43					*SoSI=1.69*					*EcSI=1.49*					

6.3 Selection of Demonstration Cases

Through the survey and an assessment of 236 streets, three streets that got the highest scores in the sustainability assessment were chosen as sample cases for the 2nd Field Survey. The three selected streets were M3-1 (Daxue Rd), M4-10 (Sujiatun Rd), and C3-8 (Madang Rd) respectively. Table 6. 58 summarises the assessment results of three selected streets.

The reasons for choosing these three streets were:

Firstly, these streets were ranked as the top three in the preliminary assessment, which demonstrated that they were representative and exemplary from the sustainable perspective. The streets of the highest score in the preliminary assessment were selected as samples for further study because it is helpful to explore these demonstrative streets and to summarise their characteristics.

Secondly, the performance and characteristics of these three streets in the three pillars of sustainability were different, which further analysis and research. Madang Rd performed very well in the aspect of social sustainability, and its evaluation index was very high. Daxue Rd was outstanding in economic sustainability, and Sujiatun Rd got the highest score in environmental sustainability. Figure 6. 39 and Figure 6. 40 illustrate the difference. Therefore, the three aspects of sustainability of different cases can be analysed in depth in the next stage.

Finally, the characteristics of these three streets were different, and each case represented a type of Shanghai streets. The research and analysis of them were representative and generalisation. Madang Rd was a multi-function street in the city center which integrated with commercial activities, historic landscape, cultural preservation, tourismand sightseeing as well. Daxue Rd was a commercial street in a newly-developed area. Sujiatun Rd was a typical neighbourhood street in a mature community which served as a social hub for residents. Therefore, the research results of three streets in the next stage were of extensiveness and reference significance.

Table 6. 58: Statistics of Sustainability Assessment Results of Three Selected Streets

Street Name	Environmental Sustainability					Social Sustainability					Economic Sustainability					SSI
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
C3-8	*1.8*	*1.5*	*1.8*	*1.8*	*1.5*	*2.8*	*2.8*	*3.0*	*3.0*	*3.0*	*2.0*	*2.3*	*3.0*	*3.0*	*3.0*	**36.0**
Madang Rd	***EnSI=1.66***					***SoSI=2.90***					***EcSI=2.65***					
M3-1	*1.8*	*2.0*	*2.0*	*1.8*	*2.8*	*1.8*	*2.8*	*1.8*	*2.8*	*2.8*	*2.8*	*2.0*	*3.0*	*2.8*	*3.0*	**35.5**
Daxue Rd	***EnSI=2.05***					***SoSI=2.35***					***EcSI=2.70***					
M4-10	*2.8*	*2.8*	*2.8*	*2.8*	*2.8*	*2.0*	*2.8*	*2.0*	*2.8*	*2.8*	*2.8*	*2.8*	*1.0*	*1.0*	*1.8*	**35.3**
Sujitun Rd	***EnSI=2.75***					***SoSI=2.45***					***EcSI=1.85***					

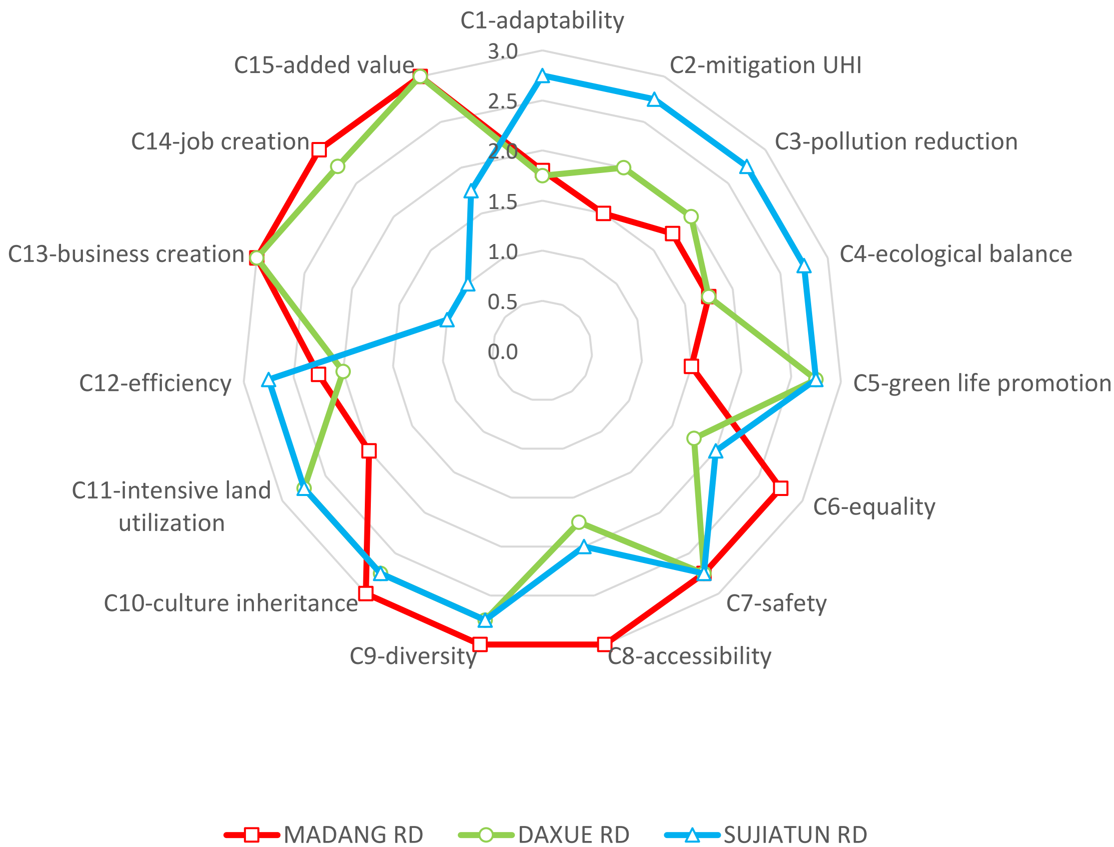


Figure 6. 39: Radar Chart of Sustainability Evaluation Results of Three Selected Demonstration Street in Field Study One

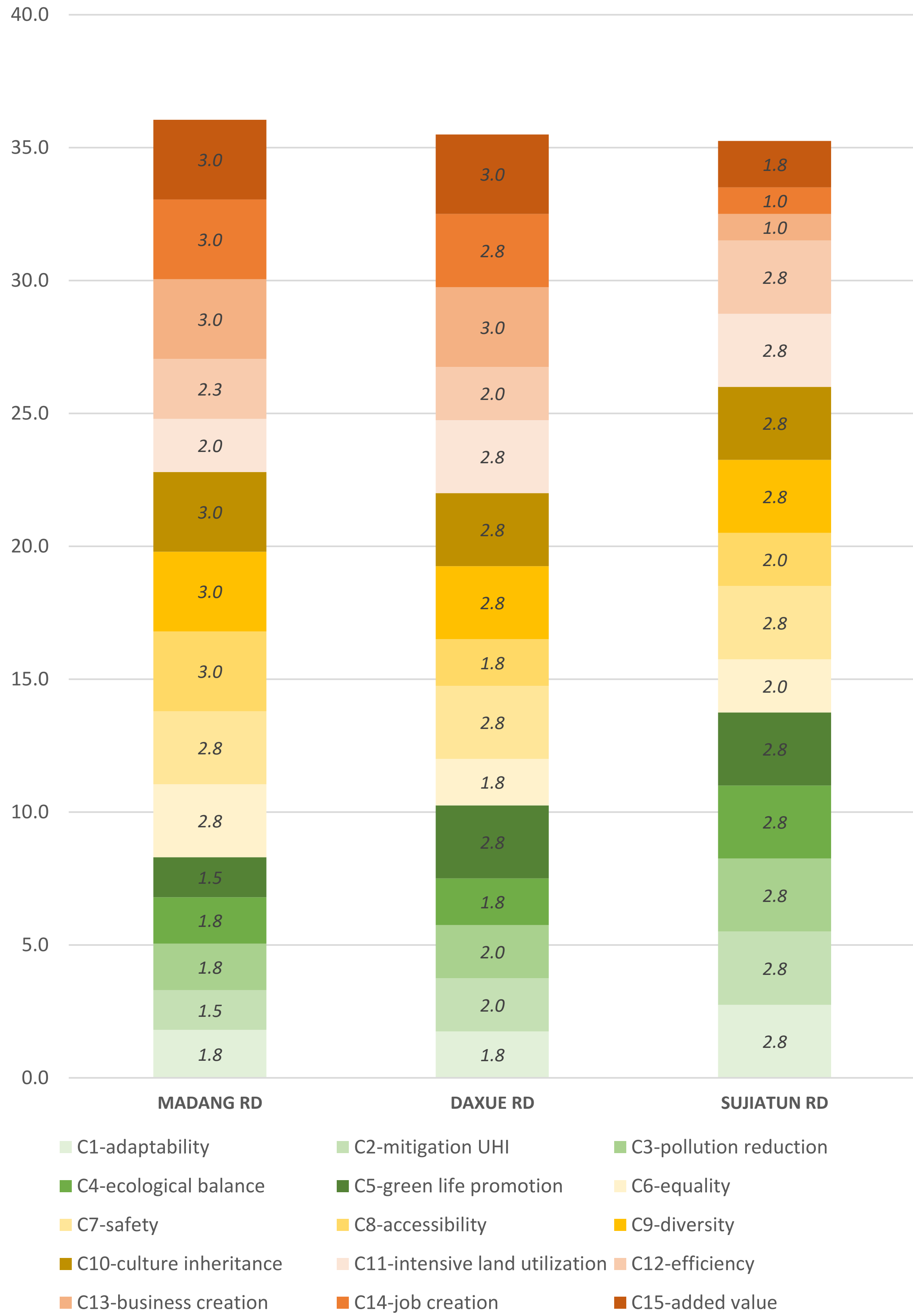


Figure 6. 40: Graph of Sustainability Evaluation Results of three Selected Demonstration Street in Field Study One

6.4 Summary

Chapter Six elaborated on the evaluation results of 236 Shanghai streets and selected three streets with the highest scores, namely Daxue Rd, Sujiatun Rd, and Madang Rd respectively, as the samples for the subsequent study.

Through the cross-comparison of the spatial distribution, overall characteristics, evaluation results, typical cases (streets with the highest and lowest scores) of 236 streets in 19 research sites, the overall performance of Shanghai streets can be summarized as follows:

1) ***The overall performance of Shanghai streets is above the average level, and the three streets with the highest scores in this evaluation, namely M3-1 (Daxue Rd), M4-10 (Sujiatun Rd), and C3-8 (Madang Rd) respectively, could be studied as typical cases to promote sustainable development of Shanghai streets.*** The average SSI of the 236 surveyed streets was 23.04 (*scores ranges from 0 to 45*), and 79.7% of the streets (188 out of 236) scored at the medium level (15 ~ 30) (see Table 6. 59). The performance and characteristics of the top three streets were various, but they represented three different types of Shanghai streets. Madang Rd is a typical commercial street in the central area of Shanghai, integrating historical conservation, leisure, and tourism, and it got the highest score regarding Social Sustainability Index. Daxue Rd is a comprehensive commercial and life service street located in the international community of the new development areas. In order to promote street vitality, it has made many innovations in planning, design, construction, management, and operation. It performs great regarding to economic sustainability in this evaluation. Sujiatun Rd is a community street with very pleasant green belt and the small gardens to form an avenue favoured by residents. Its environmental Sustainability Index was the highest. Therefore, because of their differences and typicality, a further evaluation and in-depth analysis of these three streets was of great significance for promoting the sustainable development of Shanghai streets.

Table 6. 59: Statistics of Evaluation Results of 236 Shanghai streets

Performance Level	SSI (Sustainable Street Index) 0~45	Number of Streets	% of 236
Good	>=30	24	10.2%
Medium	>=15;<30	188	79.7%
Poor	<15	24	10.2%
Total		236	100%

2) ***The future development of Shanghai streets should focus on promoting environmental sustainability and activating the street economy in a targeted way.*** According to the data statistics of sustainability evaluation, the SoSIs were higher than EnSIs and EcSIs. The average SoSI of the 236 streets achieved 1.69 which was the highest among three indexes (See Appendix DD). The top two of the 15 indicators were safety (1.95) and accessibility (1.90), both in the category of social sustainability. However, the EnSIs and EcSIs were relatively low, at 1.43 and 1.49. Also, the three lowest scores across the 15 evaluation indicators were the indicators of Ecological Balance (1.25), Value-Added (1.32) And Job Creation (1.37) which reflected the unsatisfactory performance in environmental and economic aspects. It can be seen from the data analysis that the future development of Shanghai streets should focus on promoting environmental sustainability and stimulating economic vitality of streets based on gradually improving social sustainability.

3) The streets of central Shanghai performed better than the surroundings within the main urban areas, and more attentions should be paid to the surrounding areas regarding the future renovations of Shanghai streets. The average SSI of the seven study sites located in central Shanghai (C Area) was higher than the average score of the twelve study sites within the main area of Shanghai (M Area), and the scores were 24.56 vs 22.34 (See Appendix DD). Furthermore, all three sub-indexes of streets in central Shanghai were higher than those of main areas, and the SoSI and EcSI were higher by 12% and 14%. In addition, the three sites with the highest average scores were C3 (28.71), C2 (27.23), and C1 (25.57), all of which located in the center Shanghai, while the sites with relatively low scores were M3 (18.38), M5 (19.61), and M7 (19.94), all of which were in the edge of center. When further analysing the population and functional characteristics of these sites and the statistics of evaluation data, it was found that the population density of these areas was also relatively high, the community characteristics were different, and the evaluation scores varied. Therefore, more attentions should be paid to the surrounding areas regarding the future renovations of Shanghai streets, and the renovation methods should be analyzed according to local conditions.

4) In general, about 10% of Shanghai streets were in urgent need of renovation. The analysis of the assessment data for 236 streets showed that 24 of them, or 10.2%, scored under 15 that are levelled at “Poor Performance” (Table 6. 59). Furthermore, all three aspects of the 24 streets are poor. The average EnSI, ScSI, and EcSI of 24 streets were only

0.50, 0.92, and 0.97 respectively. Five indicators of Environmental Sustainability were lower than 0.6, the indicator of “Equality” was the lowest regarding Social Sustainability, only 0.6, and the score of “Added-Value” of Economic Sustainability achieved the lowest, 0.4. It can be seen from the data statistics that the renovation of these streets should be from a comprehensive perspective and take a problem-oriented approach to find the efficient and effective solutions.

5) ***A list of demonstrative streets according to street types and functions is benefit for future street renovations and relevant researches from the perspective of street typology.*** Table 6.60 shows the street typologies and main features of 19 best cases in 19 study sites. Streets of any type can get high scores in Sustainable Streets Evaluation, and no type of street is inherently superior to others. Furthermore, these good cases embodied the characteristics of their communities with different locations, functions, and landscape. Therefore, these streets can serve as demonstrative examples of community-based publicity, thereby promoting the street renovation and development. One potential question might be whether all streets or streets of all types could get a full score in sustainability evaluation. Combined with investigation and evaluation of 236 Shanghai streets, the streets’ performances of different types are various regarding to three pillars of sustainability. Because of the different types and functions, some of the streets couldn’t get full or high scores on some indicators. For example, landscape streets with natural plants and pleasant landscape might unable to get high scores regarding to EcSI because of the lack of commercial activities. One of the advantages of sustainability evaluation is to analyze the street in a comprehensive way, to find problems, and to provide strategies for further design and improvement. Under this context, for a landscape street, some potential design strategies might be to use some space for mobile café to activate local ecnomics. In summary, not all streets can get full marks for sustainability, but the results can provide useful suggestions for street renovations.

Table 6. 60: Demonstrative streets of 5 street typologies

STREET TYPE	DEMONSTRATIVE STREETS (STUDY SITE NO: NAME)	FEATURES
COMMERCIAL STREETS	Daxue Rd (M3: New Jiangwan city)	*Located in an innovative community of a new development area*
	Xinde Rd (M12: Chuansha area)	*A commercial street for the community*
	Madnag Rd (C3: Xintiandi area)	*a commercial street with historical landscape which is also the destination of tourists and residents in weekends*
LIFE SERVICE STREETS	Sujiatun Rd (M4: Siping Area)	*A typical life service street with pleasant plants and pocket gardens in a mature community*
	Meilinbei Rd （M5: Zhenru area）	*A clean, green, and pleasant street*
	Pingtang Rd (M6: Gubei new area*)*	*A typical Shanghai street with above-medium performances*
	Meihua Rd (M10: Huamu area)	*A life service street in a mature community*
	Mengzi Rd (C5: Old Nanshi Area)	*A safe street*
LANDSCAPE AND LEISURE STREETS	*Xinhua Rd (C4:* Fahuazhen Area*)*	*A beautiful landscape and leisure street in Shanghai with pleasant trees and pocket gardens along the street.*
	Wanping Rd (C6: Xujiahui Area*)*	*A beautiful landscape and leisure street with tall trees, pleasant greenery, and elegant pocket gardens for citizens*
TRAFFIC STREETS	Yishan Rd (M7: Caohejin development zone)	*A typical newly renovated traffic street linking two districts of Shanghai*
	Zhangyang Rd (M9: Biyun community)	*A major road of Shanghai and a typical traffic street.*
	Zuchongzhi Rd (M11: Zhangjiang area)	*A secondary road of Shanghai and a traffic street*
	Xizangzhong Rd (C1: People Square)	*A main street in the city centre*
	Yunjin Rd (C7: Shibo Area)	*A secondary road and serve as a traffic street for this area*
INTEGRATED STREETS	Youyizhi Rd (M1: Wusong Area)	*A life service and community landscape street*
	Baode Rd (M2: Gongkang Area)	*A life, traffic, and leisure street*
	Shuiqing Rd (M8: Xinzhuang area)	*A life service and traffic street*
	Century Avenue (C2: Lujiazui Area)	*A typical integrated street, which undertakes the function of traffic, commercial service, and landscape as a gateway street of Shanghai.*

Chapter 7. Indicator System of Sustainability Evaluation of Shanghai Streets

7.1 Introduction

Chapter 7 states the establishment process and results of the Indicator System for sustainability evaluation of Shanghai streets. A basic structure of the sustainable street evaluation framework was built in Chapter 3.4.4. Based on this structure, this chapter builds the Indicator System of sustainability evaluation for Shanghai streets through the four steps, namely indicator selection, data normalisation, weight allocation, and final aggregation.

First, Chapter 7.2 introduces the process of indicator selection. There are two types of potential indicators, which was introduced in Chapter 4.4.2.1.4. Hence, the verification and selection results of these two types of indicators are described in Chapter 7.2.1 and Chapter 7.2.2 respectively. Chapter 7.2.3 induces the selection results of two types of indicators to form a complete set of Indicator System.

Then, Chapter 7.3 explains the normalisation methods of these selected indicators from Chapter 7.2. These selected indicators were divided into four categories according to the acquisition mode of indicator data. Chapter 7.3.1, 7.3.2, 7.3.3, and 7.3.4 explain the normalisation principle, methods, and standardisation results of these four modes of indicators respectively.

Chapter 7.4 states the formation procedure of the weighting system for the evaluation framework. Based on the structure of the Weighting System built in Chapter 7.4.1 and the statistical results of the Questionnaire shown in Chapter 7.4.2, Chapter 7.4.3 presents the Weighting System on the evaluation structure of sustainable streets.

Chapter 7.5 elaborates the aggregation method of the final evaluation results of sustainable streets. This step not only provides the calculation method for the final evaluation result but also integrates the outcomes of previous steps. Consequently, a complete set of the indicator system of sustainable evaluation was established.

Finally, the robustness of the established Indicator System is analysed in Chapter 7.6. Also, the sources and dimensions of potential uncertainties are identified and analysed accordingly.

7.2 Indicator selection

An Evaluation Structure for Sustainable Streets has been proposed in Table 3. 12 of Chapter 3.4.4, and the structure included the evaluation framework, a set of criteria, and a full list of potential indicators. Also, the classification and research methods of potential indicators were elaborated in Chapter 4.4.2.1.4.

It can be seen in Table 3. 12 that there are two types of indicators regarding the methods of validation and feasibility test. They are:

> ***Type O****: the indicator which needs to be tested by fieldwork, such as on-site observation or measurement, to examine its validation and feasibility;*
>
> ***Type D****: the indicator which needs to be reviewed though deskwork, such as online searching the publication of relevant index and its corresponding standards, to examine its validation and feasibility.*

7.2.1 Indicators of Type O

The indicators of Type O which need to be examined by on-site observation or measurement were organised into a checklist for the 1st Field survey. The validation and feasibility of these indicators were tested and checked during the investigation of 236 Shanghai streets in the 1st Field Survey. The specific survey methods were explained in detail in Chapter 4.4.2.1.

The availability and feasibility of the potential indicators of Type O were checked through the analysis of the field checklist and the integration of survey notes. In overall, the selection procedure could be summarised into three steps. Table 7. 1 illustrates the results of indicator selection.

Step One: ***Preliminary Check the Acquisition Condition of Listed Indicators***

The statistics of the field checklists which were filled for 19 study sites provided an information on whether the indicators' value could be obtained by on-site observation or measurement. The numerical values of some indicators could be gained through the fieldwork, such as item count, site measurement, and observation, while some indicators, could not. The values of these indicators, such as Public Campaigns for Traffic Safety, Bus System Service Quality, and Efficiency in Parking/Loading, could not be obtained through several times' fieldwork but a particular long-term study. Therefore, these kinds of indicators were deleted.

Step Two: ***Classification of Acquisition Mode of Indicator Values***

Based on the induction and summary of field notes, the indicators that passed the filter in Step One were divided into two modes according to the acquisition pattern of indicator values:

Mode M: indicators whose values can be obtained by on-site measurement; and

Mode D: indicators whose values can be rated according to the completion of design requirements.

Step Three: ***Check the Indicators Feasibility***

All indicators needed to be converted into the unified unit for calculation and aggregation. Therefore, all remaining indicators were checked if their values were accessible and their normalisations were feasible accordingly. For the indicators of Mode M, it was necessary to check whether there were corresponding design standards or relevant benchmarks for the value measured in the street so that the evaluation score could be calculated by comparing the gaps between the measurement data and the benchmarks. For the indicators of Mode D, it was to check whether there were corresponding design requirements in the Sustainable Street Design Toolbox (Table 3. 9 in Chapter 3.4.3). Then, the evaluation score could be rated by the completion degree. It is important to note that four indicators were marked as "▲" in the row of "Feasibility check", namely "Air Temp. Difference", "Diversity of street activity", "Temporary business", and "Types of employment" respectively. The initial value of these indicators could be obtained in the street survey. There was no existing relevant standards or similar studies to mark for these values, but the statistics of investigation notes of 76 Shanghai streets could form as grading basis. The specific methods for value normalisation will be elaborated in Chapter 7.3. Therefore, this step not only checked the feasibility and validation of these indicators but also had a preliminary preparation for the indicator normalisation in the next stage.

Table 7. 1: Summary of the Selection Results of the Indicators of Type O

	Evaluation Criterion		**Potential Indicators**		**Indicator Selection**		
	Code	**Title**	**Code**	**Title**	**Preliminary check**	**Acquisition mode**	**Feasibility check**
Environmental Sustainability	*C1*	Adaptability	*C1c*	Adaptable Capacity to Local Climate	✓	D	✓
			C1d	Adaptable Capacity to Extreme Weather Events	✓	D	✓
	C2		*C2b*	Street Green Rate	✓	M	✓

	Evaluation Criterion		Potential Indicators		Indicator Selection		
	Code	Title	Code	Title	Preliminary check	Acquisition mode	Feasibility check
		Mitigation UHI	*C2c*	% Street Tree Shading	✓	M	×
			C2d	Air Temp. Difference	✓	M	▲
	C3	Pollution Reduction	*C3b*	Average Emission of Noise	✓	M	✓
			C3k	Pollution Reduction	✓	D	✓
	C4	Ecological Balance	*C4d*	Site Vegetation	×	-	-
			C4e	Ecological Planting	✓	D	✓
			C4f	Number of Planting Types	✓	M	×
			C4g	Rainwater management	✓	D	✓
	C5	Green Life Promotion	*C5a*	Public Conversation Events for Street Safety	×	-	-
			C5b	Public Campaigns for Traffic Safety	×	-	-
			C5c	Green Lifestyle Promotion	✓	D	✓
			C5d	Green travel support	✓	D	✓
Social Sustainability	*C6*	Equality	*C6a*	Tactile pavement for the blind	✓	D	✓
			C6b	Barrier-Free Facilities	✓	D	✓
			C6c	Transparency of the Party Wall	✓	M	×
	C7	Safety	*C7c*	Designed Traffic Speeds	✓	M	×
			C7d	Coverage Proportion of Street Cameras	✓	M	✓
			C7f	Coverage Safety Equipment	✓	M	✓
	C8	Accessibility	*C8a*	Quality of Service in Public Transport	×	-	-
			C8b	Number of Parking Lots	✓	M	×
			C8c	Volume of Vehicles, Bus Passengers, Bicycle Riders and Users of Public Space	✓	M	×
			C8d	Bus System Service Quality	×	-	-
			C8e	Ridership on Bus	×	-	-
			C8f	Bus Lane Network	✓	D	✓
Social Sustainability	*C8*	Accessibility	*C8g*	Cycling Lane Network	✓	D	✓
			C8h	Coverage of Sharing Bike	✓	M	×
			C8i	Pedestrian Access	✓	D	✓

	Evaluation Criterion		Potential Indicators		Indicator Selection		
	Code	**Title**	**Code**	**Title**	**Preliminary check**	**Acquisition mode**	**Feasibility check**
			C8j	Bicycle Access	✓	D	✓
			C8k	Transit Access	✓	D	✓
			C8l	The Variety of Arrival Ways	✓	D	✓
			C8m	Clear Sign and Guidance System	✓	D	✓
	C9	Diversity	*C9a*	Diversity of Street Activities	✓	M	▲
			C9c	Number of Public Seats	✓	M	×
			C9d	Diversity of Street Functions	✓	D	✓
	C10	Culture Inheritance	*C10a*	Number of Urban arts	✓	M	×
			C10b	Aesthetic Quality of Urban Art	✓	D	✓
			C10c	Aesthetic Quality of Street Furniture	✓	D	✓
			C10d	Style Consistency with Surroundings	✓	D	✓
			C10e	Historical Inheritance & Culture Display	✓	D	✓
Economic Sustainability	*C11*	Intensive Land Utilisation	*C11a*	Intensiveness of Street Space	✓	D	✓
			C11b	Mixed-use of Street Land	✓	D	✓
	C12	Efficiency	*C12a*	Efficiency in Parking/Loading	×	-	-
			C12b	Actual Traffic Speed	×	-	-
			C12c	Parking Smart Program	✓	M	✓
			C12d	Intelligent Transportation System	✓	D	✓
	C13	Business Creation	*C13d*	Density of Shops	✓	M	✓
			C13e	Types of Temporary Business	✓	M	▲
	C14	Job Creation	*C14a*	Employment Creation	✓	D	✓
			C14b	Number of Employment	×	-	-
			C14c	Types of Jobs	✓	M	▲
	C15	Added-Value	*C15a*	Added Value of Commercial Rents	×	-	-
			C15b	Added-Value of Housing prices	×	-	-

7.2.2 Indicators of Type D

Concerning the indicators of Type D, the check method was mainly through online data searching. A search was conducted to check whether the official statistics of those potential indicators were accessible, and then to test the data acquisition mode as well as data's representativeness, thereby assessing the feasibility of these potential indicators.

Overall, the procedure of indicator selection could be summarised into three steps. Table 7. 2 illustrates the selection results of indicators of Type D.

Step One: ***Preliminary Check the Acquisition of Listed Indicators***

The searching included the relevant data on statistical platforms open to the public, including Shanghai Statistics Website, Shanghai Municipal Transportation Website, Shanghai Government Website etc. In addition, emails were sent to the Bureau of Shanghai Statistics to ask about the availability of data for the research purpose. However, most of the potential indicators were still unavailable, and Table 7. 2 summarises the results. There were four main reasons: 1) the potential evaluation indicators were summarised by literature review, such as the indexes of "Restoring Mobility Efficiency after the storm/hurricane" and "Annual energy saving from conversion to LED's", so such official indexes were regularly published in other countries but not in China. 2) The statistics of some indicators, such as the indexes of "Percentage of flood risk area" and "Runoff quality", could be found in published studies. However, these studies only focused on several selected streets for the case study. Hence these indexes were lack of universality and infeasible for general street evaluation. 3) Some indicators, such as the indexes of "noise level" and "air quality", were official statistics and published regularly. However, these statistics were not specific to one street but the whole area. So, these published indexes were also not representative. 4) Concerning some indicators, such as indexes of "Crashes and injuries for motorists, pedestrians, and cyclists" and "Number of street crimes", there were relevant statistics in Transport Agency, but these data were not published to the public. Hence these indicators were not feasible for this research.

Step Two: Classification of Acquisition Mode of Indicator Values

The available indicators were divided into two categories according to the acquisition mode:

Mode N: the indicator that its value and rate can be obtained directly by the published index;

Mode C: the indicator that its value should be calculated by the initial diagnosis from published data/index.

Step Three: Check the Indicators Feasibility

The validation of remaining indicators was checked through the feasibility of data normalisation.

For the indicators of Mode N, they were to examine the representativeness of the published indexes. Given this, “Traffic Performance Index”, the only left indicators of Mode N, was released by grade on the “Shanghai Transportation Website” (SMTIC, 2018), so it was selected because of its reliable data source full statistical coverage.

For the indicators of Mode C, there were two indicators in this group, namely C15a (Added Value of Commercial Rents) and C15b (Added-Value of Housing Price). The calculation formulas of C15a and C15b were as below:

$$\text{C15a (Added Value of Commerical Rents)} = \frac{\text{(Unit Price of Commercial Rent along the Street} - \text{Average Unit Price of Commercial Rent in this District)}}{\text{Average Unit Price of Commercial Rent in this District}}$$

$$\text{C15b (added Value of Housing Price)} = \frac{\text{(Unit Housing Price along the Street} - \text{Average Unit Housing Price in this District)}}{\text{Average Unit Housing Price in this District}}$$

Firstly, the initial diagnosis of these two indicators could be obtained through data searching and relevant calculation. In other words, all the data within the calculation formula could be obtained through official data published by Lianjia Website (Home Link, 2017) which was currently China's biggest real estate transaction and leasing platform. Secondly, concerning the feasibility of data normalisation, no data or rating system could be referenced directly. However, a primary normalisation method and the scoring system could be designed based on the reference of relevant academic researches and data statistics of 236 streets in the 1st Field Survey. It must be acknowledged that various factors influence the price of commercial rents and houses, such as location, urban streets, landscape, metro station, buildings’ quality, population density, and traffic intensity. (Xiao, 2010; Li, 2011; Niu, 2016; Zhou, 2004). However, the influence of urban streets should include the tangible parts, such as metro/bus station, traffic facilities, and streetscape, and the intangible parts, such as location, accessibility, and traffic intensity. More importantly, all these factors mutually interact. Therefore, it is complicated to calculate the exact value of the added-value of commercial rents and housing price from urban streets. However, there are some helpful reference data. In Boston, the prices of real estate near the streets with metro was 6.7% higher than the others (Amstrong, 1994); in San Diego housing prices along the street railway were 2.9-4.7%

higher (Agostini & Palmucci, 2008); in Shenzhen, China, the housing prices along the subway line rose 16.95-23.03% (Zheng, 2004); the construction of subway and street renovation boosted the housing price by 7.6 – 9.4% (Yang, 2010); the condition of urban streets and traffic was the main factor that affects the price of commercial rents, and the influencing weighting was 35.52% according to the calculation of Hedonic Model in Tianjin, China (Xiao, 2010), and urban streets and overall accessibility largely influenced the rental price of commercial space, and the added-value could reach 10%-20% according to the research in Hangzhou, China (Li, 2011). Therefore, these academic results were used as basic reference data, and meanwhile, the statistics outcomes of 236 Shanghai streets were analysed in depth, to design a feasible normalisation method finally. The specific normalisation rules and scoring system are to be explained in Chapter 7.3.4.

Table 7. 2: Summary of the Selection Procedure and Results of Indicators of Type D

	Evaluation Criterion		Potential Indicators		Indicator Selection		
	Code	**Title**	**Code**	**Title**	**Preliminary Check**	**Acquisition Mode**	**Feasibility Check**
Environmental Sustainability	*C1*	Adaptability	*C1a*	Restoring Mobility Efficiency after the storm/hurricane	×	-	-
			C1b	Percentage of flood risk area	×	-	-
			C1c	Adaptable capacity to local climate	×	-	-
			C1d	Adaptable capacity to extreme weather events	×	-	-
	C2	*Mitigation UHI*	*C2a*	Cool pavement	×	-	-
	C3	Pollution Reduction	*C3a*	Average Annual emission of NO_2	×	-	-
			C3b	Average emission of noise	×	-	-
			C3c	Air quality	×	-	
			C3d	The usage of green asphalt	×	-	-
			C3e	Annual energy saving from conversion to LED's	×	-	-
			C3f	Road transport CO_2 emission	×	-	-
			C3g	% of pavement reuse	×	-	-
			C3h	Recycled materials	×	-	-
			C3i	Regional materials	×	-	-

	Evaluation Criterion		Potential Indicators		Indicator Selection		
	Code	Title	Code	Title	Preliminary Check	Acquisition Mode	Feasibility Check
			C3j	Quiet pavement	×	-	-
			C3k	Waste management	×	-	-
			C3l	Life cycle pollution reduction	×	-	-
			C3m	Road transport CO_2 emission	×	-	-
Environmental Sustainability	*C4*	Ecological Balance	*C4a*	Permeable pavement and bioswales	×	-	-
			C4b	Runoff flow control	×	-	-
			C4c	Runoff quality	×	-	-
			C4e	Ecological connectivity	×	-	-
	C5	Green Life Promotion	*C5a*	Public conversation events for street safety	×	-	-
			C5b	Public Campaigns for traffic safety	×	-	-
Social Sustainability	*C7*	Safety	*C7a*	Crashes and injuries for motorists, pedestrians, and cyclists	×	-	-
			C7b	Traffic fatality	×	-	-
			C7d	Coverage proportion of street camera	×	-	-
			C7e	Number of street crimes	×	-	-
			C7f	Coverage safety equipment	×	-	-
	C8	Accessibility	*C8a*	Quality of service in public transport	×	-	-
			C8c	Volume of vehicles, bus passengers, bicycle riders and users of public space	×	-	-
			C8d	Bus system service Quality	×	-	-
			C8e	Ridership on Bus	×	-	-
			C8f	Bus Lane network	×	-	-
	C9	Diversity	*C9b*	Number of Street events per year	×	-	-
Economic Sustainability	*C12*	Efficiency	*C12e*	Traffic Performance Index	√	N	√
	C13	Business Creation	*C13a*	Retail sales	×	-	-
			C13b	Retailer visitor spending	×	-	-
			C13c	Retail sales tax fillings	×	-	-
	C14	Job Creation	*C14a*	Net employment density	×	-	-

Evaluation Criterion		Potential Indicators		Indicator Selection		
Code	Title	Code	Title	Preliminary Check	Acquisition Mode	Feasibility Check
		C14b	Number of employments	×	-	-
		C14c	Types of employment	×	-	-
C15	Added-Value	*C15a*	Added Value of Commercial rents	√	C	√
		C15b	Added-Value of housing prices	√	C	√

7.2.3 Integration and Summary

Chapter 7.2.1 and Chapter 7.2.2 have demonstrated the analysis procedure and selection results of indicators of Type O and Type D respectively, so Chapter 7.2.3 summarises the findings above and presents the final Indicator System.

The integration of two types of indicators and the selection procedure could be summarised into two steps: the first step was to gather all indicators that were defined as "feasible" in both Table 7. 1 of Chapter 7.2.1 and Table 7. 2 of Chapter 7.2.2 into one table. The second step was to check the integrity and representativeness of the Indicator System. All remaining indicators were reviewed again to check if they are duplicated or have any inclusion relation. For instance, the five indicators of C8f "Bus Lane network", C8g "Cycling lane network", C8i "Pedestrian access", C8j "Bicycle access", and C8k "Transit access" were excluded since they could be reflected by one indicator of C8l "The variety of arrival ways". Moreover, C12b "Parking Smart program" was also removed from the system because it could be integrated into the indicator of C12d "Intelligent transportation system". The integrity and soundness of the Indicator System were also checked regarding whether each evaluation criterion had the same number of corresponding indicators. Table 7. 3 shows the integration process and results of selection.

Accordingly, ***two indicators were chosen for each criterion, and a total of thirty indicators were selected.*** Then, the definition, calculation methods, measurement units, and acquisition mode of each indicator were further specified. ***Table 7. 4 presents the essential characteristics of selected indicators.***

Finally, the quality of the selected indicators and the soundness of the Indicator System were analysed. Chapter 2.3.2.4 summarised six principles to select indicators of high-quality, namely Exhaustive, Relativity, Sensitivity, Objectivity, Accessibility, and Readability respectively. Two principles of "Exhaustive" and "Accessibility" could be achieved by the research procedure. The "Exhaustive" of indicators was ensured by listing all potential indicators in the selection pool. The

"Accessibility" was examined in Chapter 7.2.1 and Chapter 7.2.2 as the primary filtering principle. Therefore, the four principles of "Relativity", "Sensitivity', "Objectivity", and "Readability" were used to qualitatively analysed the 30 selected indicators and three grades of "Good", "Medium", and "Poor" were given. Based on the conceptual definition of these four principles, the selected indicators were assessed qualitatively and their strengths and weakness were analysed accordingly. ***Table 7. 5 summarises the results of assessment and analysis of 30 selected indicators.*** It is important to note that there were 7 "poor" in the indicator quality rating, but this does not mean a problem with the indicator system or the quality of these indicators. Firstly, a total of 30 indicators were evaluated from four dimensions, so there were 120 evaluation results totally. Only 7 out of 120 were "poor", which indicated that the whole system was relatively robust. Secondly, 7 "Poor" were mainly due to the subjectivity of the scoring and the indirect representative of the indicators. Also, 7 related indicators had at least two "excellent" in the other three dimensions. Finally, an objective evaluation of indicators' quality, especially marking which dimensions are poor, was conducive to finding better alternative indicators in future researches.

It must be acknowledged that there were still some deficiencies in the selected indicators due to the limitation of data resources and research condition. For example, the assessment of C10-2 (Style Consistency with Surroundings) was to score the street performance by observation according to the designed rating system. So, it was qualitative judgments, which inevitably contained some subjectivity when scoring. Because it was to choose the one rating level that mostly fit the actual condition of the street, the slight differences were not able to be reflected by the assessment results. However, compared with all listed potential indicators, the thirty selected indicators were the best under the research conditions.

Table 7. 3: Summary of the Integration Procedure of Potential Indicators

	Criteria		**Potential Indicators**		**Indicators Selection**	
	Code	**Title**	**Code**	**Title**	**Integrated Check Results**	**Notes**
Environmental Sustainability	*C1*	Adaptability	*C1c*	Adaptable capacity to local climate	√	-
			C1d	Adaptable capacity to extreme weather events	√	-
	C2	*Mitigation UHI*	*C2b*	Street green rate	√	-
			C2d	Air Temp. difference	√	-
	C3	Pollution Reduction	*C3b*	Average emission of noise	√	-
			C3k	Pollution reduction	√	-
	C4		*C4e*	Ecological Planting	√	-

	Criteria		Potential Indicators		Indicators Selection	
	Code	**Title**	**Code**	**Title**	**Integrated Check Results**	**Notes**
		Ecological Balance	*C4g*	Rainwater management	√	-
	C5	Green Life Promotion	*C5c*	Green lifestyle promotion	√	-
			C5d	Green travel support	√	-
Social Sustainability	*C6*	Equality	*C6a*	Tactile pavement for the blind	√	-
			C6b	Barrier-free facilities	√	-
	C7	Safety	*C7d*	Coverage proportion of street cameras	√	-
			C7f	Coverage safety equipment	√	-
	C8	Accessibility	*C8f*	Bus Lane network	×	*Integrated into C8l*
			C8g	Cycling lane network	×	*Integrated into C8l*
			C8i	Pedestrian access	×	*Integrated into C8l*
			C8j	Bicycle access	×	*Integrated into C8l*
			C8k	Transit access	×	*Integrated into C8l*
			C8l	The variety of arrival ways	√	*Including the evaluation of bus, bicycle, walking, car, subway, transfer accessibility*
			C8m	Clear sign and guidance system	√	-
Social Sustainability	*C9*	Diversity	*C9a*	Diversity of street activities	√	-
			C9d	Diversity of street functions	√	-
	C10	Culture Inheritance	*C10b*	Aesthetic Quality of urban art	×	*Integrated into C10c*
			C10c	Aesthetic Quality of street furniture	√	*Including the evaluation of urban art, including sculpture and paintings.*
			C10d	Style consistency with surroundings	√	-
			C10e	Historical inheritance & culture display	×	*Integrated into C10d*
Econo mic	*C11*	Intensive Land Utilisation	*C11a*	Intensiveness of street space	√	
			C11b	Mixed-use of street land	√	

Criteria		Potential Indicators		Indicators Selection	
Code	**Title**	**Code**	**Title**	**Integrated Check Results**	**Notes**
C12	Efficiency	*C12c*	Parking Smart program	×	*Integrated into C12d*
		C12d	Intelligent transportation system	√	*Including the evaluation of intelligent public bus system, parking system, and traffic system*
		C12e	Traffic Performance Index	√	
C13	Business Creation	*C13d*	Density of Shops	√	
		C13e	Types of Temporary business	√	
C14	Job Creation	*C14a*	Employment Creation	√	
		C14c	Types of jobs	√	
C15	Added-Value	*C15a*	Added Value of Commercial rents	√	
		C15b	Added-Value of housing prices	√	

Table 7. 4: Characteristics of 30 Selected Indicator

	Criteria Code	Criteria Title	Indicators Code	Title	Definition	Calculation Methods	Measurement Unit	Acquisition Mode
Environmental Sustainability	*C1*	Adaptability	*C1-1*	Adaptable Capacity to Local Climate	The ability of the street to adapt to local climatic conditions	Total number of ticks (√) in the evaluation checklist	Pcs	D
			C1-2	Adaptable Capacity to Extreme Weather Events	The ability of the street to adapt to extreme weather events, such as windstorm, rainstorm, and extreme hot/cold weathers	Total number of ticks (√) in the evaluation checklist	Pcs	D
	C2	Mitigation UHI	*C2-1*	Street Green Rate	Percentage of the width of green bands in the street	$\text{C2 1 (Street Green Rate)} = \frac{\text{Total width of green bands}}{\text{Total width of the street}}$	%	M
			C2-2	Air Temp. Difference	Difference between on-site measured Air Temperature and regional average Air Temperature.	$\text{C2 2 (Air Temp. Difference)} = \text{Regional Avg. Air Temp.} - \text{Air Temp. in street}$	℃	M
	C3	Pollution Reduction	*C3-1*	Average Emission of Noise	Average noise emitted in the street within 20 minutes during measurement of daytime	Meter reading	Decibel	M
			C3-2	Pollution Reduction	Measures to reduce pollution during streets' construction and operation	Total number of ticks (√) in the evaluation checklist	Pcs	D
	C4	Ecological Balance	*C4-1*	Rainwater management	Management ability for rainfall	Total number of ticks (√) in the evaluation checklist	Pcs	D
			C4-2	Ecological Planting	Ecological planting in the street	Total number of ticks (√) in the evaluation checklist	Pcs	D
	C5	Green Life Promotion	*C5-1*	Green Lifestyle Promotion	The promotion and propaganda of green life and environmental preservation in the street	Total number of ticks (√) in the evaluation checklist	Pcs	D
			C5-2	Green Travel Support	Support and promotion of Green Travel	Total number of ticks (√) in the evaluation checklist	Pcs	D

	Criteria		Indicators					
	Code	**Title**	**Code**	**Title**	**Definition**	**Calculation Methods**	**Measurement Unit**	**Acquisition Mode**
Social Sustainability	*C6*	Equality	*C6-1*	Tactile pavement for the blind	Provision of reliable tactile pavement for the blind in the sidewalks	Rating the street performance accordingly	-	D
			C6-2	Barrier-Free Facilities	Provision of reliable and convenient barrier-free facilities for all kinds of people in the street	Total number of ticks (√) in the evaluation checklist	Pcs	D
	C7	Safety	*C7-1*	Coverage Proportion of Street Cameras	The coverage proportion of CCTV cameras within the street	C7 1 (Coverage Proportion of Street Camera) $= \frac{\text{Length covered by the street camera}}{\text{Total length of the street}}$	%	M
			C7-2	Coverage Safety Equipment	The coverage of relevant equipment and facilities for street safety	Total number of ticks (√) in the evaluation checklist	Pcs	D
	C8	Accessibility	*C8-1*	The Variety of Arrival Ways	Provision of various arrival ways	Total number of ticks (√) in the evaluation checklist	Pcs	D
			C8-2	Clear Sign and Guidance System	Provision of clear signs and guidance system for easy street accessibility	Total number of ticks (√) in the evaluation checklist	Pcs	D
	C9	Diversity	*C9-1*	Diversity of Street Activities	Diversity of activities within the street	Total number of ticks (√) in the evaluation checklist	Pcs	M
			C9-2	Diversity of Street Functions	The various functions that the street serves in urban life	Total number of ticks (√) in the evaluation checklist	Pcs	D
	C10	Culture Inheritance	*C10-1*	Aesthetic Quality of Street Furniture	The overall aesthetic quality of street furniture	Rating the street performance accordingly	-	D
			C10-2	Style Consistency with Surroundings	Style consistency of streetscape with the surrounding landscape and local history	Rating the street performance accordingly	-	D

	Criteria		Indicators					
	Code	Title	Code	Title	Definition	Calculation Methods	Measurement Unit	Acquisition Mode
Economic Sustainability	*C11*	Intensive Land Utilisation	*C11-1*	Intensiveness of Street Space	Economical and efficient use of street land	Total number of ticks (√) in the evaluation checklist	Pcs	D
			C11-2	Mixed-Use of Street Land	Mixed-usage and multi-function of street space	Total number of ticks (√) in the evaluation checklist	Pcs	D
	C12	Efficiency	*C12-1*	Intelligent Transportation System	Usage and coverage of the intelligent transportation system	Total number of ticks (√) in the evaluation checklist	Pcs	D
			C12-2	Traffic Performance Index	Year average Traffic Performance Index	Total number of ticks (√) in the evaluation checklist	-	N
	C13	Business Creation	*C13-1*	Density of Shops	The density of shops along the street	$C13\ 1\ (\text{Density of shops}) = \frac{\text{Number of shops}}{\text{Total length of the street}} * 100$	shops /100m	M
			C13-2	Types of Temporary Business	Total types of temporary business	Total number of ticks (√) in the evaluation checklist	Pcs	M
	C14	Job Creation	*C14-1*	Employment Creation	Ability of the street to create employment positions	Rating the street performance accordingly	-	D
			C14-2	Types of Jobs	The types of job opportunities in the street	Total number of ticks (√) in the evaluation checklist	Pcs	M
	C15	Added-Value	*C15-1*	Added Value of Commercial Rents	Value-added rate of commercial rents along the street	See Note 1	%	C
			C15-2	Added-Value of Housing Prices	Value-added rate of Housing Price along the street	See Note 2	%	C

Note:

1. The formula to calculate C15-1: $\text{Added Value of Commerical Rents} = \frac{(\text{Unit Price of Commercial Rent along the Street} - \text{Average Unit Price of Commercial Rent in this District})}{\text{Average Unit Price of Commercial Rent in this District}}$
2. The formula to calculate C15-2: $\text{Added Value of Housing Price} = \frac{(\text{Unit Housing Price along the Street} - \text{Average Unit Housing Price in this District})}{\text{Average Unit Housing Price in this District}}$
3. The four types of acquisition modes of indicators are:
   Mode M: indicators linked to on-site measurements;
   Mode D: indicators linked to the completion of design requirements:
   Mode N: indicators linked to official published indexes;
   Mode C: indicators linked to the calculation of some officially published indexes.

Table 7. 5: Analysis of 30 Selected Indicators

	Criteria		Selected indicators		Check of Indicators' quality					
	Code	**Title**	**Code**	**Title**	Objectivity	Sensitivity	Relativity	Readability	**Strengths**	**Weakness**
Environmental Sustainability	*C1*	Adaptability	*C1-1*	Adaptable Capacity to Local Climate	▲	●	★	★	- Interpreted simply; - Overall reflecting the evaluated criterion	- Qualitative judgments with some subjectivity
			C1-2	Adaptable Capacity to Extreme Weather Events	▲	●	★	★	- Interpreted simply and high readability; - Overall reflecting the evaluated criterion	- Qualitative judgments; - Insensitivity to slight variations.
	C2	*Mitigation UHI*	*C2-1*	Street Green Rate	★	★	▲	★	- Quantitative assessments with high objectivity and sensitivity.	- Indirectly reflect the criterion.
			C2-2	Air Temp. Difference	★	★	★	★	- Quantitative assessments with high objectivity, relativity, and readability.	- Data measurements are subject to climate restrictions.
	C3	Pollution Reduction	*C3-1*	Average Emission of Noise	★	★	▲	★	- Quantitative assessments with high objectivity and sensitivity.	- Only reflecting one aspect of evaluated criterion
			C3-2	Pollution Reduction	▲	●	★	★	- High readability; - Comprehensively reflecting the evaluated criterion	- Qualitative judgments with some subjectivity; - Insensitivity to slight variations.
	C4	Ecological Balance	*C4-1*	Rainwater management	▲	●	★	★	- Interpreted simply and high readability.	- Qualitative judgments; - Insensitivity to slight variations.
			C4-2	Ecological Planting	▲	▲	★	★	- Interpreted simply and high readability	- Qualitative judgments; - Insensitive to small differences.
	C5	Green Life Promotion	*C5-1*	Green Lifestyle Promotion	▲	▲	★	★	- Directly reflecting the evaluated criterion; - Interpreted simply and high readability	- Qualitative judgments; - Insensitive to slight differences.
			C5-2	Green Travel Support	▲	▲	★	★	- Objectively reflecting the evaluated criterion; - Interpreted simply	- Unable to reflect the extraordinary performance.

	Criteria		Selected indicators		Check of Indicators' quality					
	Code	Title	Code	Title	Objectivity	Sensitivity	Relativity	Readability	Strengths	Weakness
Social Sustainability	*C6*	Equality	*C6-1*	Tactile pavement for the blind	▲	▲	★	★	- Easy accessibility; - Interpreted simply and high readability.	- Qualitative judgments; - Insensitive to slight differences.
			C6-2	Barrier-Free Facilities	▲	▲	★	★	- Overall reflecting the evaluated criterion; - Interpreted simply.	- Unable to reflect the extraordinary performance.
	C7	Safety	*C7-1*	Coverage Proportion of Street Cameras	★	★	●	★	- Quantitative assessments.	- Reflecting the evaluated criterion indirectly;
			C7-2	Coverage Safety Equipment	▲	▲	▲	★	- Interpreted simply.	- Qualitative judgments; - Insensitive to slight differences.
	C8	Accessibility	*C8-1*	The Variety of Arrival Ways	▲	▲	★	★	- Overall reflecting the evaluated criterion; - Interpreted simply.	- Insensitive to slight differences
			C8-2	Clear Sign and Guidance System	▲	★	★	★	- Easy accessibility; - Interpreted simply and high readability.	- Qualitative judgments.
	C9	Diversity	*C9-1*	Diversity of Street Activities	★	▲	★	★	- Overall reflecting the evaluated criterion; - Interpreted simply.	- Unable to reflect the differences in various time slots.
			C9-2	Diversity of Street Functions	▲	●	★	★	- Showing an overall condition; - Interpreted simply and high readability	- Qualitative judgments with some subjectivity; - Insensitive to slight differences.
	C10	Culture Inheritance	*C10-1*	Aesthetic Quality of Street Furniture	▲	▲	★	★	- Overall reflecting the evaluated criterion; - Interpreted simply.	- Qualitative judgments with some subjectivity.
			C10-2	Style Consistency with Surroundings	▲	▲	★	★	- Comprehensively reflecting the evaluated criterion; - High readability.	- Qualitative judgments with some subjectivity; - Insensitive to slight differences.

	Criteria		Selected indicators		Check of Indicators' quality					
	Code	Title	Code	Title	Objectivity	Sensitivity	Relativity	Readability	Strengths	Weakness
Economic Sustainability	*C11*	Intensive Land Utilisation	*C11-1*	Intensiveness of Street Space	▲	●	★	★	- Comprehensively reflecting street performance; - High readability.	- Qualitative judgments with some subjectivity; - Insensitive to slight differences.
			C11-2	Mixed-Use of Street Land	▲	★	★	★	- Easy accessibility; - Overall reflecting the evaluated criterion.	- Insensitive to slight differences and variation of time.
	C12	Efficiency	*C12-1*	Intelligent Transportation System	▲	▲	▲	★	- Overall judgments of intelligent management of streets - High readability.	- Reflecting the evaluated criterion indirectly; - Unable to reflect the service quality.
			C12-2	Traffic Performance Index	★	▲	★	★	- Reflecting the evaluated criterion directly; - High objectivity and readability.	- Insensitive to slight differences.
	C13	Business Creation	*C13-1*	Density of Shops	★	★	▲	★	- Quantitative assessments with high objectivity; - Interpreted simply.	- Unable to reflect the quality and direct economic values;
			C13-2	Types of Temporary Business	★	★	▲	★	- High accessibility; - Reflecting diversity; - Interpreted simply;	- Unable to reflect the quality and overall gross.
	C14	Job Creation	*C14-1*	Employment Creation	▲	▲	★	★	- Overall reflecting the evaluated criterion; - Interpreted simply.	- Qualitative judgments with some subjectivity; - Insensitive to slight differences.
			C14-2	Types of Jobs	★	★	▲	★	- Easy accessibility; - Reflecting diversity; - Interpreted simply;	- Unable to reflect the quality and overall gross.
	C15	Added-Value	*C15-1*	Added Value of Commercial Rents	★	▲	★	★	- Quantitative assessments with high objectivity; - Interpreted simply.	- Unable to precisely calculate the pure added value from the evaluated street.
			C15-2	Added-Value of Housing Prices	★	▲	★	★	- Quantitative assessments with high objectivity; - Interpreted simply.	- Unable to precisely calculate the pure added value from the evaluated street.

Note: 1. The four principles to assess the indicators' quality, namely Objectivity, Sensitivity, Relativity, and Readability, are introduced in Chapter 2.3.2, and the assessment standards follow the definition of these four principles.

2. The symbols in the columns of "Check of Indicators' quality" are: ★ *– Good;* ▲ *– Medium;* ● *– Poor*.

7.3 Normalisation method

Normalisation is used to transform an indicator into a common dimensionless unit for the calculation of composite index. The normalisation methods are the approaches to transformation. There are various normalisation methods: Ranking, Standardisation (or Z-scores), Min-Max, Distance to a reference country, Categorical scales, indicators above or below the mean, cyclical indicators, Balance of Opinions, and percentage of annual differences over consecutive years (Freudenberg, 2003; Jacobs, et al., 2004; OECD & JRC, 2008). ***Concerning the characteristics of selected indicators and evaluation property, the normalisation method of the Categorical Scale was selected for this research.***

Firstly, some methods were not applicable to this study. Specifically speaking, this evaluation task was an exploratory academic study on the sustainability of urban streets, and it mainly adopted the survey techniques of site observation, information recording, and relevant calculation to obtain the initial diagnosis of evaluation. Therefore, some normalisation methods such as "Distance to a Reference Country", "Percentage of Annual Differences over Consecutive Years", and "Balance of Opinions", were not suitable for this work.

Secondly, the characteristics of selected indicators made some normalisation methods unadaptable in this evaluation framework. Because the units of measurement of the selected 30 indicators were various, and the initial diagnoses of indicators were obtained in different ways. Moreover, for some quantitative indicators, there was no corresponding reference data for evaluation standards, and for some other indicators, the evaluation results were linked with the accomplishment of relevant design requirements. Hence, some normalisation methods that were commonly used in sustainability assessments, like Ranking, Standardisation (or Z-scores), Min-Max, and indicators above or below the mean, were inapplicable to the Indicator System of this research.

Finally, the Categorical Scale was adopted as the normalisation method because of its high adaptability and numerical features. By the method of Categorical Scales, no matter the raw data are qualitative or quantitative data, and no matter what kind of the measurement unit various indicators are, they are assigned a score according to the specific scoring rules. In this way, 30 indicators were normalised and operated mathematically for aggregation. Also, the values of the same indicators for different streets were able to be compared horizontally.

Choosing the thresholds in the method of categorical scale is essential. In this framework, ***the three-point system (a score between 0 and 3) was adopted*** because it is the simplest and most straightforward system compared with 5-point, 10-point or 100-point system (which is elaborated in Chapter 4.4.2.1.4). Furthermore, the evaluation value of each criterion was to be compared with users' appraisal from the street questionnaires. Therefore, the four-level grading system was corresponding to the response scales of the survey questionnaire. Specifically speaking, the respondents were asked to give their appraisal by selecting the most suitable one from four choices, namely excellent (3 points), Good (2 points), Medium (1 point), and bad (0 point) respectively, regarding each sustainable criterion. The appraisal scale of user's questionnaires was the same as the scoring scale of the evaluation framework, which made it easier to compare two sets of data. Moreover, the 3-point-system was consistent with that used in a preliminary assessment of 236 Shanghai streets in the 1st Field Survey, which was the benefit of the comparison of the results of one street in two surveys. The last but not the least, the system of one, two, three stars has a tradition in China's sustainability evaluation as the first Indicator System of green building evaluation in China is a three-star rating system and got a full recognition.

The potential disadvantages of the Categorical Scale are that it is unable to reflect the changes over time (OECD & JRC, 2008). However, the framework could adapt this by evaluating the same streets year by year to compare the differences between values. Besides, the categorical scales might be criticised as "too subjective," and the choice of thresholds are "too arbitrarily" (Jacobs, et al., 2004). Therefore, in order to enhance the robustness and objectiveness of the normalisation process selection of the thresholds abides following principle to all indicators, the thresholds were set according to corresponding national standards, design guidelines, or relevant results of academic researches. Meanwhile, the selection of thresholds and scoring system were checked by the statistics of 236 Shanghai streets in the 1st Field Survey with almost normal distributions. Concerning the different mode of indicators, the details of thresholds' selection were slightly different.

Table 7. 6 provides a summary. Chapter 7.3.1, Chapter 7.3.2, Chapter 7.3.3, and Chapter 7.3.4 introduces the specific normalisation methods and thresholds' selection of indicators of Mode M, Mode D, Mode N, and Mode C respectively in the following sections.

Table 7. 6: Normalisation Methods Corresponding to Different Indicator Modes

Indicator Mode	Indicator Features	Indicator List	Normalisation	
			Method	*Thresholds' Selection*
Mode M	*Indicators linked to on-site measurements*	C2-1; C2-2; C3-1; C7-1; C9-1; C13-1; C13-2; C14-2	The initial diagnoses are transformed into numerical	*The thresholds are set based on national standards, design guidelines, or relevant results of academic researches, and*

Indicator Mode	Indicator Features	Indicator List	Normalisation	
			Method	***Thresholds' Selection***
			categories of 0, 1, 2, and 3	*then checked and optimised by the statistics of 76 Shanghai streets **
Mode D	*Indicators linked to the completion of design requirements*	C1-1; C1-2; C3-2; C4-1; C4-2; C5-1; C5-2; C6-1; C6-2; C7-2; C8-1; C8-2; C9-2; C10-1; C10-2; C11-1; C11-2; C12-1; C14-1	The initial diagnoses are transformed into numerical categories of 0, 1, 2, and 3	*The thresholds are set according to the accomplishment degree of design requirements and are tested by 1st Field Survey and double-checked by the detailed analysis of 76 Shanghai streets. **
Mode N	*Indicators linked to officially published indexes*	C12-2		*The thresholds are set according to the official rating system*
Mode C	*Indicators linked to the calculation of some officially published indexes*	C15-1; C15-2		*The thresholds are set based on the results of academic researches, then checked and optimised by the statistics of 76 Shanghai streets **

** Four streets were randomly selected in each study sites to measure and record relevant street data, which had been explained in 4.4.2.1.*

7.3.1 Indicators of Mode M

Concerning the indicators of Mode M, the initial diagnoses were obtained by on-site measurements. Then, they were transformed into the scores of 0, 1, 2, and 3. In general, the scoring rules were firstly designed based on national standards, design guidelines, or relevant results of academic researches. Then, the selection of thresholds was checked through the Field Notes and the summary of indicator checklists of the streets in the 1st Field Survey. Chapter 4.4.2.1.4 explained that the specific values of 76 streets (4 streets *19 study sites) were measured and recorded during the Field Survey. According to the basic principles of nature and society, the evaluation results of a scientific evaluation system wrere supposed to basically conform to the Normal Distribution. Therefore, the statistical results of 76 streets were used to examine the rationality of normalisation by the principle of the normal distribution.

The following sections give a detailed description of eight indicators of Mode M in the form of datasheets, and they are C2-1, C2-2, C3-1, C7-1, C9-1, C13-1, C13-2, and C14-2 respectively.

C2-1: Street Green Rate

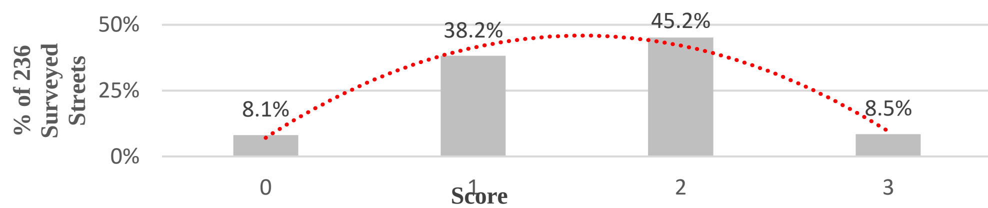
Table 7. 7: Datasheet- indicator C2-1

Indicator	**Code & Name**	C2-1: **Street Green Rate**
	Definition	Percentage of the width of green bands in the street
Initial Diagnosis	**Calculation Method**	$\text{C2-1 (Street Green Rate)} = \dfrac{\text{Total width of green bands}}{\text{Total width of the street}}$
	Measurement Unit	%
Normalisation rules		

Score / Green Rate / Street Width	**0**	**1**	**2**	**3**
<40m	<20%	20%-25%	25%-30%	>30%
40-50m	<25%	25%-30%	30%-35%	>35%
>50	<30%	30%-35%	35%-40%	>40%

Note:

1. *The selection of thresholds within the normalisation rules was generally followed the national design guideline, namely "Code for Planting planning and design on urban roads"* (Ministry of Construction, 1997, p. 4)
   "3.1.2.1 The green rate of landscape streets (the pilot streets) shall not be less than 40%;
   3.1.2.2 The green rate of urban streets with the street width (the street boundary red line) greater than 50m shall not be less than 30%;
   3.1.2.3 The green rate of urban streets with the street width (the street boundary red line) between 40m and 50m shall not be less than 25%;
   3.1.2.4 The green rate of urban streets with the street width (the street boundary red line) less than 40m shall not be less than 20%."
2. *The thresholds selection and normalisation methods were examined by the statistics of 76 surveyed streets with a principle of normal distribution (see the bar chart below).*



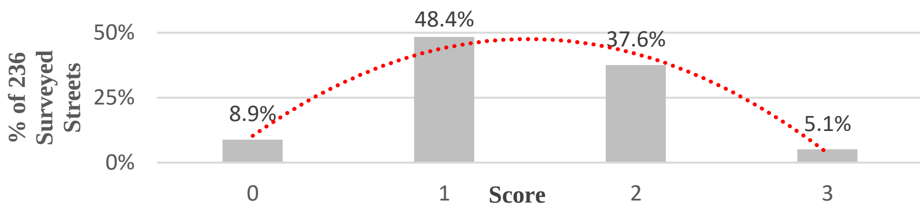
***C2-2:* Air Temp. Difference**

Table 7. 8: Datasheet- indicator C2-2

Indicator	**Code & Name**	C2-2: **Air Temp. Difference**
	Definition	Difference between on-site measured Air Temperature and regional average Air Temperature.
Initial Diagnosis	**Calculation Method**	$\text{C2 2 (Air Temp. Difference)} = \text{Regional Avg. Air Temp.} - \text{Air Temp. in street}$
	Measurement Unit	℃
Normalisation rules		0: <1℃ 1: 1-2 ℃ 2: 2-3℃ 3: >3℃

Note:

1. *The regional average air temperature could be obtained from the officially published data on the website of the Shanghai Meteorological Service (www.smb.gov.cn).*
2. *The Air temperature in the street could be measured on site at research time.*
3. *The selection of thresholds within the normalisation rules was designed based on the academic research on the cooling effect of trees in urban streets by a model study. The model results reveal that "the total attenuation effect in reducing the air temperatures inside the streets may reach as much as 5 K at noontime with a daily average cooling of 3 K"* (Shashua-Bar, et al., 2010, p. 2798)*, and "The average cooling effect in all sites was about 2.8 K, ranging from as low as 1 K in a street with heavy traffic to as high as 4 K in the smallest garden 0.15ha."* (p. 2806).
4. *The thresholds selection and normalisation methods were examined by the statistics of 76 surveyed streets with a principle of normal distribution (see the bar chart below).*



C3-1: Average Emission of Noise

Table 7. 9: Datasheet- indicator C3-1

Indicator	**Code & Name**	C3-1: **Average Emission of Noise**
	Definition	Average noise emitted in the street within 20 minutes during measurement of daytime
Initial Diagnosis	**Calculation Method**	Meter reading
	Measurement Unit	Decibel
Normalisation rules		0: >=75decibel 1: 65-75 decibel 2: 60-65 decibel 3: <=60 decibel

Note:

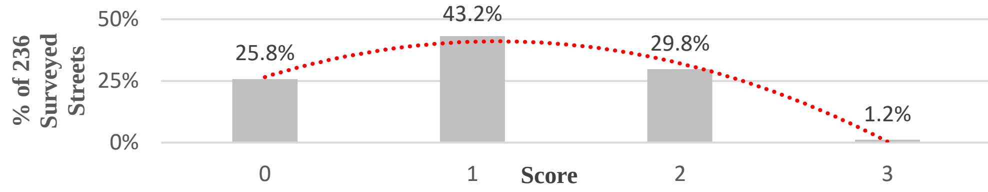
1. *The initial diagnosis of C3-1 could be measured by the noise detector of iPhone 7 "Decibel 10": Version 5.3.3 (2172) which was introduced in Chapter 4.4.3.1.4.*
2. *The selection of thresholds within the normalisation rules was designed based on the national standard of "Environmental quality standard for noise"* (Environmental Protection Department, 2008).

Noise environment level	***Daytime***	***Night-time***
0	*50*	*40*
I	*55*	*45*
II	*60*	*50*
III	*65*	*55*
IV	*70*	*60*

Then, the initial normalisation rule and scoring scale were designed as below:

0: >=70 decibel
1: 60-70 decibel
2: 50-60 decibel
3: <=50 decibel

3. *The national standard above is for some functional areas such as residential and office areas. Streets are normally the source of noise, and this may not be the right standard to for street evaluation. The initial normalisation rule was examined by the statistics of 76 surveyed streets of the 1st Field survey. However, the relationships between streets percentages and assessment scores did not fit the law of Normal Distribution. Hence, the scoring scale was optimised accordingly. The bar chart below shows the relationships between street percentages and optimised score system.*



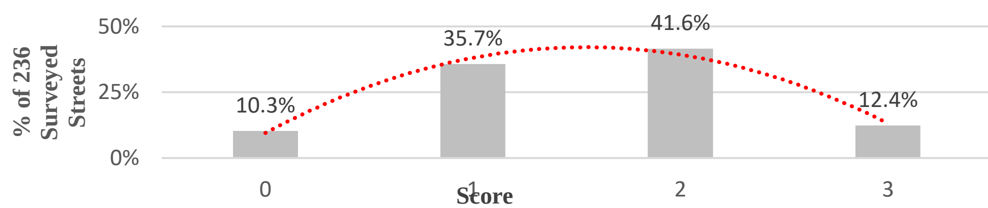
C7-1: Coverage Proportion of Street Camera

Table 7. 10: Datasheet- indicator C7-1

Indicator	**Code & Name**	C7-1: **Coverage Proportion of Street Cameras**
	Definition	The coverage proportion of CCTV cameras within the street
Initial Diagnosis	**Calculation Method**	C7 1 (Coverage Proportion of Street Camera) $= \frac{Length\ covered\ by\ the\ street\ camera}{Total\ length\ of\ the\ street}$
	Measurement Unit	%
Normalisation rules		3: 100% 2: 75%-100% 1: 50%-75% 0: <=50%

Note:

1. *The selection of thresholds within the normalisation rules was designed based on the national plan of "The Plan to strengthen the public safety video surveillance construction network application". It indicates that "by 2020, the monitoring coverage rate of video in main public areas will reach 100%"* (National Development and Reform Commission, 2015).
2. *The thresholds selection and normalisation methods were further specified and checked by the statistics of 76 sample streets. The bar chart below shows the relationships between street percentages and categorical scales at the normal distribution.*



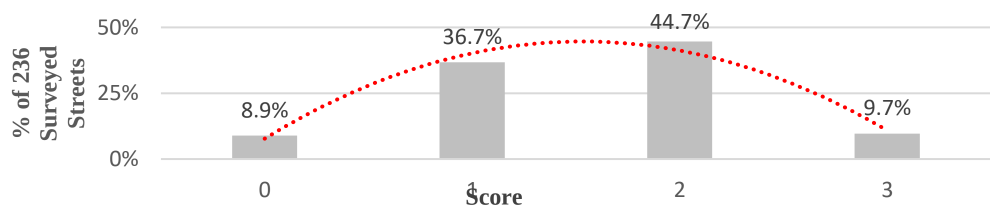
C9-1: Diversity of Street Activities

Table 7. 11: Datasheet- indicator C9-1

Indicator	**Code & Name**	C9-1: **Diversity of Street Activities**
	Definition	Diversity of activities within the street
Initial Diagnosis	**Calculation Method**	Total number of ticks below ___ *Tick the activities observed on the street:* ❑ *Strolling* ❑ *Dog walking* ❑ *Sitting* ❑ *Meeting friends* ❑ *Kids playing* ❑ *Jogging & physical exercise* ❑ *Watching newspaper/reading books* ❑ *Playing chess/cards in groups* ❑ *Shopping* ❑ *Drinking & Eating*
	Measurement Unit	pcs
Normalisation rules		3: 7-10 pcs 2: 4-6 pcs 1: 1-3 pcs 0: 0

Note:

1. *The initial diagnosis could be obtained by on-site observation and counting the total number of activities in the street survey. In order to ensure the survey results objective and comprehensive, the survey time should be covered both weekends and weekdays. All types of activities observed during survey time should be counted for scoring.*
2. *All these activates shown in datasheet were summarised from the 1st Field Survey.*
3. *The thresholds selection and normalisation methods were designed and checked by the statistics of 76 sample streets. The bar chart below shows the relationships between street percentages and categorical scales at the normal distribution.*



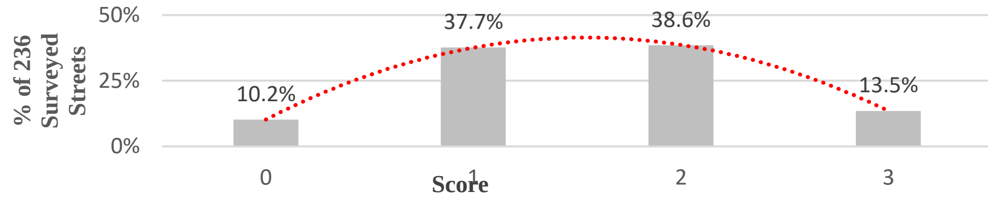
C13-1: Density of shops

Table 7. 12: Datasheet- indicator C13-1

Indicator	**Code & Name**	C13-1: **Density of Shops**
	Definition	Density of shops along the street
Initial Diagnosis	**Calculation Method**	$C13\ 1\ (\text{Density of shops}) = \frac{\text{Number of shops}}{\text{Total length of the street}} * 100$
	Measurement Unit	shops/100meters
Normalisation rules		3: > 7shops/100meters 2: 2-7 shops/100meters 1: 0-2 shops/100meters 0: 0

Note:

1. *The selection of thresholds within the normalisation rules was designed based on academic research. Professor Xu conducted a wide survey of Shanghai streets with an aim to quantitatively study the relationships between shops density and street vitality in 2017. Based on the survey statistics it shows "the shop's density of a vibrant street should be above 7 shops for every100 meters"* (Xu, 2017)
2. *The thresholds and normalisation rules were specified and examined according to the statistics of 76 sample streets with almost normal distribution between sample percentage and scoring scales (See bar chart below).*



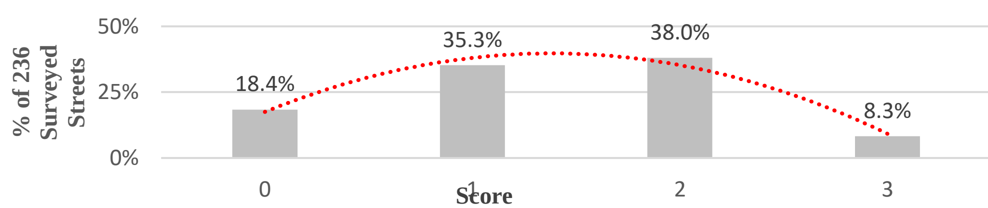
C13-2: Types of Temporary Business

Table 7. 13: Datasheet- indicator C13-2

Indicator	**Code & Name**	C13-2: **Types of Temporary Business**
	Definition	Total types of temporary business
Initial Diagnosis	**Calculation Method**	Total number of ticks below ___ *Tick the items observed on the street:* ❑ Temporary pavement café & F&B; ❑ Temporary food station; ❑ Temporary show spot ❑ Temporary flower station; ❑ Mobility Street vendor (cigarettes, disc, girls' accessory, clothes, portrait drawing, street show, etc.)
	Measurement Unit	pcs
Normalisation rules		3: 4-5 2: 2-3 1: 1 0: 0

Note:

1. *The initial diagnosis could be obtained by on-site observation and counting the total number of types observed during survey time. In order to ensure the survey results objective and comprehensive, the survey time should cover both weekends and weekdays. All types of temporary business observed during survey time should be counted for scoring.*
2. *All these types of temporary business shown in datasheet were summarised from the 1st Field Survey.*
3. *The thresholds selection and normalisation methods were designed and checked by the statistics of 76 sample streets. The bar chart below shows the relationships between street percentages and categorical scales at the normal distribution.*



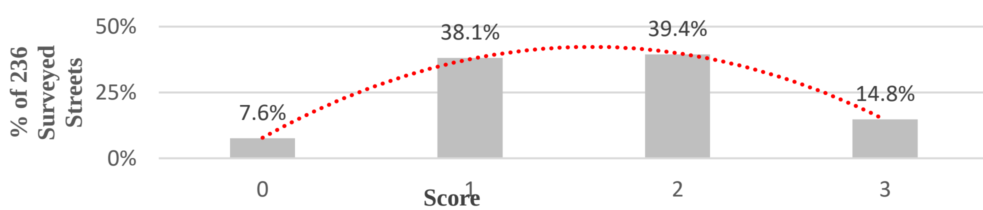
C14-2: Types of Jobs

Table 7. 14: Datasheet- indicator C14-2

Indicator	**Code & Name**	C14-2: **Types of Jobs**
	Definition	The types of jobs in the street
Initial Diagnosis	**Calculation Method**	Total number of ticks below ___ *Tick the items observed on the street:* ❑ salesperson ❑ Waitress ❑ agent ❑ craftsman ❑ officers ❑ Parking administrator ❑ Mobile Street vendor
	Measurement Unit	Pcs
Indicator	**Code & Name**	C14-2: **Types of Jobs**
Normalisation rules		3: 6-7 2: 3-5 1: 1-2 0: 0

Note:

1. *The initial diagnosis could be obtained by on-site observation and counting the total number of jobs' types observed during survey time.*
2. *All these jobs' types in the datasheet were summarised from the 1st Field Survey.*
3. *The thresholds selection and normalisation methods were designed and checked by the statistics of 76 sample streets. The bar chart below shows the relationships between street percentages and categorical scales at the normal distribution.*



7.3.2 Indicators of Mode D

According to the definition, the initial diagnoses of indicators of Mode D were measured by the completion of a list of design requirements, and then their scoring system and thresholds' selection were designed according to the accomplishment degree. Therefore, the critical task was to design reasonable and practical calculation methods (how to obtain the initial diagnoses of indicators) and normalisation methods (how to transfer the initial diagnoses to a categorical score of 0, 1, 2, and 3).

A series of design requirements were selected and organised from the Sustainable Design Toolkit (Table 3. 9) according to the definition and essences of each indicator. The checklists were for on-site observation, and the judger could tick the item if the street accomplished the requirement. So, the calculation methods were to count the number of ticks on the checklists.

How to ensure the calculation methods are practical and comprehensive? All suitable design requirements selected from the toolkit were organised into two groups: one was labelled "Core and Essential"; the other one is "Possible and Potential". The first group was the fundamental and significant requirements according to the evaluation indicator, so they had been designed into the rating system for the 1st Field Survey to confirm their practicality. Meanwhile, the potential requirements were sorted into the checklist (Table 4.4) to examine their feasibility in the 1st Field Survey. Some potential requirements which had been confirmed to be workable were added into the evaluation framework thereby building a set of comprehensive and feasible checklists for the calculation of indicators of Mode D.

To the indicators of Mode D, the normalisation process was to count the number of ticks in the checklists and assign a score among 0, 1, 2, and 3 according to a defined rating scale. There were two steps to promote the objectivity and rationality of the normalisation process in this research. Firstly, the core and essential design requirements and a preliminary rating scale were designed into the evaluation standard of the 1st Field survey. Therefore, the rationality could be checked both by the intuitive feedbacks of the researcher in the application process and by the statistical analysis of 236 samples. Secondly, the preliminary rating system was further optimised by sorting out and refining some feasible scoring requirements from the checklists of the 1st Field Survey to form a relatively comprehensive and reliable system for data normalisation. Then, the optimised system was double-checked through the detailed analysis of 76 streets so that the operability of the normalisation system was tested accordingly.

The following sections give a detailed description of the indicators of Mode D in the form of datasheets. The 19 indicators of Mode D are C1-1, C1-2, C3-2, C4-1, C4-2, C5-1, C5-2, C6-1, C6-2, C7-2, C8-1, C8-2, C9-2, C10-1, C10-2, C11-1, C11-2, C12-1, and C14-1 respectively.

C1-1: Adaptable Capacity to Local Climate

Table 7. 15: Datasheet- indicator C1-1

Indicator	**Code & Name**	C1-1: **Adaptable Capacity to Local Climate**
	Definition	The ability of the street to adapt to local climatic conditions
Initial Diagnosis	**Calculation Method**	Total number of ticks below ___ *Tick the items that fit:*

		❑ *The choice of street trees and other plants suits Shanghai climate (hot summer and cold winter) and helps to maximise the time for comfortable activities in the streets;* ❑ *Street furniture (including the bus station, street seats, & pavement shops) and facilities (like sharing/canopy) in frontage zone suits Shanghai climate (hot summer, cold winter and relatively rainy all year);* ❑ *A reasonable combination of plaza and green space in streets and proving flexibility for future.*
	Measurement Unit	Pcs
Normalisation rules		***3:*** *3 ticks;* ***2****: 2 ticks;* ***1:*** *1 tick;* ***0:*** *no tick.*

C1-2: Adaptable Capacity to Extreme Weather Events

Table 7. 16: Datasheet- indicator C1-2

Indicator	**Code & Name**	C1-2: **Adaptable Capacity to Extreme Weather Events**
	Definition	The ability of the street to adapt to extreme weather events, such as windstorm, rainstorm, and extreme hot/cold weathers
Initial Diagnosis	**Calculation Method**	Total number of ticks below ___ *Tick the items that fit:* ❑ *All street furniture and facilities are durable and secure;* ❑ *Smart alarm and notification for extreme weather events in the street;* ❑ *Emergency safety measurements for extreme weather situation, like windstorm and flooding.*
	Measurement Unit	Pcs
Normalisation rules		***3:*** *3 ticks;* ***2****: 2 ticks;* ***1:*** *1 tick;* ***0:*** *no tick.*

C3-2: Pollution Reduction

Table 7. 17: Datasheet- indicator C3-2

Indicator	**Code & Name**	C3-1: **Pollution Reduction**
	Definition	Measures to reduce pollution during streets' construction and operation
Initial Diagnosis	**Calculation Method**	Total number of ticks below ___ *Tick the items that fit:* ❑ *The usage of Environmentally friendly or recycled materials or construction technologies for pavement, curb and other street furniture to reduce pollution.* ❑ *The usage of the energy-efficient system or renewable energy for lighting;* ❑ *The provision of the bins with clear recycling category in the street.*
	Measurement Unit	Pcs
Normalisation rules		***3:*** *3 ticks;* ***2****: 2 ticks;* ***1:*** *1 tick;* ***0:*** *no tick.*

C4-1: Rainwater management

Table 7. 18: Datasheet- indicator C4-1

Indicator	**Code & Name**	C4-1: **Rainwater management**
	Definition	Management ability for rainfall.
Initial Diagnosis	**Calculation Method**	Total number of ticks below ___ *Tick the items that fit:* ❑ *Reasonable road vertical design and permeable pavement for rainwater drainage;* ❑ *The use of rain garden for rain management;* ❑ *Smart alarm and notification for the rainstorm in the street.*
	Measurement Unit	Pcs
Normalisation Rules		***3:*** *3 ticks;* ***2****: 2 ticks;* ***1:*** *1tick;* ***0:*** *no tick.*

C4-2: Ecological Planting

Table 7. 19: Datasheet- indicator C4-2

Indicator	**Code & Name**	C4-2: **Ecological Planting**
	Definition	Ecological planting in the street
Initial Diagnosis	**Calculation Method**	Total number of ticks below ___ *Tick the items that fit:* ❑ *All streets' plants are native;* ❑ *The diversity of plants (the species of plants within one street are more than 5*)* ❑ *The usage of rainwater recovery or reused water for plant irrigation in streets*
	Measurement Unit	Pcs
Normalisation rules		***3:*** *3 ticks;* ***2****: 2 ticks;* ***1:*** *1 tick;* ***0:*** *no tick.*

C5-1: Green Lifestyle Promotion

Table 7. 20: Datasheet- indicator C5-1

Indicator	**Code & Name**	C5-1: **Green Lifestyle Promotion**
	Definition	The promotion and propaganda of green life and environmental preservation in the street.
Initial Diagnosis	**Calculation Method**	Total number of ticks below ___ *Tick the items that fit:* ❑ *Advertising and publicity of green lifestyle;* ❑ *Regular street show and activities for green life;* ❑ *Space to encourage the green lifestyle, like jogging path, plaza, and open space along the street*
	Measurement Unit	Pcs
Normalisation Rules		***3:*** *3 ticks;* ***2****: 2 ticks;* ***1:*** *1 tick;* ***0:*** *no tick.*

C5-2: Green Travel Support

Table 7. 21: Datasheet- indicator C5-2

Indicator	**Code & Name**	C5-2: **Green Travel Support**
	Definition	Support and promotion of Green Travel.
Initial Diagnosis	**Calculation Method**	Total number of ticks below ___ *Tick the items that fit:* ❑ *Provision of the sidewalks (at least 1.5m width) with comfortable, reliable, and pleasant facilities and atmosphere;* ❑ *Provision of cycling lane (at least 1.5m width), cycling parking space, and sharing bike station.* ❑ *Provision of the comfortable bus station and clear transit information.*
	Measurement Unit	Pcs
Normalisation rules		***3:*** *3 ticks;* ***2****:2 ticks;* ***1:*** *1tick;* ***0:*** *no tick.*

C6-1: Tactile pavement for the blind

Table 7. 22: Datasheet- indicator C6-1

Indicator	**Code & Name**	C6-1: **Tactile pavement for the blind**
	Definition	Provision of reliable tactile pavement for the blind in the sidewalks
Initial Diagnosis	**Calculation Method**	*Tick one description that mostly fits the actual condition of the street:* ❑ ***Excellent:*** *the tactile pavement for the blind in the street are without breakage or cutting off;* ❑ ***Good:*** *the tactile pavement for the blind in the street have some breakages or cutting off;* ❑ ***Medium:*** *the tactile pavement for the blind in the street have many breakages or cutting off;* ❑ ***Bad:*** *there is no tactile pavement for the blind in the street*
	Measurement Unit	-
Normalisation rules		**3**: *Excellent;* **2**: *Good;* **1**: *Medium;* **0**: *Bad*

C6-2: Barrier-free Facilities

Table 7. 23: Datasheet- indicator C6-2

Indicator	**Code & Name**	C6-2: **Barrier-free Facilities**
	Definition	Provision of reliable and convenient barrier-free facilities for all kinds of people in the street
Initial Diagnosis	**Calculation Method**	Total number of ticks below ___ *Tick the items that fit:* ❑ *Enough space for wheelchair and baby stroller;* ❑ *Barrier-free design in street intersection;* ❑ *Barrier-free facilities for vertical differences in the sidewalk.*
	Measurement Unit	Pcs
Normalisation rules		***3:*** *3 ticks;* ***2****: 2 ticks;* ***1:*** *1tick;* ***0:*** *no tick.*

C7-2: Coverage of Safety Equipment

Table 7. 24: Datasheet- indicator C7-2

Indicator	**Code & Name**	C7-2: **Coverage of Safety Equipment**
	Definition	The coverage of relevant equipment and facilities for street safety
Initial Diagnosis	**Calculation Method**	Total number of ticks below ___ *Tick the items that fit:* ❑ *Anti-skidding pavements on the sidewalk;* ❑ *Coloured or marked pavements for cycling lanes;* ❑ *Sufficient lighting at night for street safety;* ❑ *Safe getting up/down in the bus station;* ❑ *Bollards or planting to separate travel lanes and sidewalks;* ❑ *All street signs and signals are clear and efficient;* ❑ *Various ways to control car speed, including the clear sign of allowed car speed, speed hump or chicanes.* ❑ *In the intersection, featured and highlighted marks on the ground to remind of safety and protect cyclists and pedestrians;* ❑ *Various methods for a safety intersection, such as curb extension in the intersection to reduce crossing distance for pedestrian and decrease car speed, provision of medians for safety island if the street intersection is wide, sound reminder if the crossed traffic is large, skyway or underground passages for the pedestrian if necessary*
	Measurement Unit	Pcs
Normalisation rules		***3:*** *7-9 ticks;* ***2****: 4-6 ticks;* ***1:*** *1-3 ticks;* ***0:*** *no tick.*

C8-1: The Variety of Arrival Ways

Table 7. 25: Datasheet- indicator C8-1

Indicator	**Code & Name**	C8-1: **The Variety of Arrival Ways**
	Definition	Provision of various arrival ways.
Initial Diagnosis	**Calculation Method**	Total number of ticks below ___ *Tick the items that fit:* ❑ *Walking: provision of sidewalks (at least 1.5m width for each) on both sides;* ❑ *Cycling: provision of separated or sharing cycling lanes on both sides, and cycling parking space;* ❑ *Public bus: there are bus station within 300m away from the street;* ❑ *Taxi: provision of taxi ranks or taxi Boarding Area;* ❑ *Car: provision of parking lots within 300m away from the street;* *Special car accessibility: guaranteeing emergency cars, like the ambulance, fire-fighting truck, to access.*
	Measurement Unit	Pcs
Normalisation rules		***3:*** *5-6 ticks;* ***2****: 3-4ticks;* ***1:*** *1-2 ticks;* ***0:*** *no tick.*

C8-2: Clear Sign and Guidance System

Table 7. 26: Datasheet- indicator C8-2

Indicator	**Code & Name**	C8-2: **Clear Sign and Guidance System**
	Definition	Provision of clear sign and guidance system for easy street accessibility
Initial Diagnosis	**Calculation Method**	Total number of ticks below ___ *Tick the items that fit:* ❑ *Provision of clear signs of necessary street information, including street name, direction, and traffic regulation;* ❑ *Provision of extra information about the surrounding situation;* ❑ *Provision of smart wayfinding system.*
	Measurement Unit	Pcs
Normalisation rules		***3:*** *3 ticks;* ***2****: 2 ticks;* ***1:*** *1 tick;* ***0:*** *no tick.*

C9-2: Diversity of Street Functions

Table 7. 27: Datasheet- indicator C9-2

Indicator	**Code & Name**	C9-2: **Diversity of Street Functions**
	Definition	The various functions that the street serves in urban life
Initial Diagnosis	**Calculation Method**	Total number of ticks below ___ *Tick the items that fit:* ❑ *Traffic function* ❑ *Social function* ❑ *Commercial function* ❑ *Cultural function* ❑ *Political function* ❑ *Ecological function*
	Measurement Unit	Pcs
Normalisation rules		***3:*** *5-6 ticks;* ***2****: 3-4 ticks;* ***1:*** *1-2 ticks;* ***0:*** *no tick.*

C10-1: Aesthetic Quality of Street Furniture

Table 7. 28: Datasheet- indicator C10-1

Indicator	**Code & Name**	C10-1: **Aesthetic Quality of Street Furniture**
	Definition	The overall aesthetic quality of street furniture
Initial Diagnosis	**Calculation Method**	*Tick one description that mostly fits the actual condition of the street:* *All street elements (including seats, Bollards, Pedestrian Guardrails, Bins, Public art, telephone boxes, parking control equipment, post and pouch boxes, smoke vents, bus station, pavement, lighting system, information station, cycling parks, and curb) are* ❑ ***Excellent:*** *designed dedicatedly and form as a whole and display high aesthetic quality;* ❑ ***Good:*** *not designed as a whole, but harmony and beautiful in general;* ❑ ***Medium:*** *are not well designed, but tidy in general;* ❑ ***Bad:*** *are not well designed and destroy streetscape.*
	Measurement Unit	-
Normalisation rules		**3**: *Excellent Performance;* **2:** *Good Performance;* **1**: *Medium Performance;* **0:** *Bad Performance*

C10-2: Style Consistency with the Surroundings and Local History

Table 7. 29: Datasheet- indicator C10-2

Indicator	**Code & Name**	C10-2: **Style Consistency with the Surroundings and Local History**
	Definition	Style consistency of streetscape with the surrounding landscape and local history.
Initial Diagnosis	**Calculation Method**	*Tick one description that mostly fits the actual condition of the street:* ❑ ***Excellent:*** *Streetscape highlights and well displays local culture and historical heritage* ❑ ***Good:*** *Streetscape is coherent to the surroundings and looks in harmony;* ❑ ***Medium:*** *Streetscape does not match the surrounding landscape well but looks still tidy and ordered;* ❑ ***Bad:*** *Streetscape destroys the local culture or historical features and looks mixed and disorderly.*
	Measurement Unit	-
Normalisation rules		**3**: *Excellent;* **2:** *Good;* **1**: *Medium;* **0:** *Bad*

C11-1: Intensiveness of Street Land

Table 7. 30: Datasheet- indicator C11-1

Indicator	**Code & Name**	C11-1: **Intensiveness of Street Land**
	Definition	Intensive usage of street land
Initial Diagnosis	**Calculation Method**	Total number of ticks below ___ *Tick the items that fit:* ❑ *The reasonable width of travel lanes, cycling lanes, and sidewalk.* ❑ *Reasonable and Intensive design of intersection land;* ❑ *Integration design of street furniture to save street land;*
	Measurement Unit	Pcs
Normalisation rules		***3:*** *3 ticks;* ***2****: 2 ticks;* ***1:*** *1 tick;* ***0:*** *no tick.*

C11-2: Mixed-Use of Street Space

Table 7. 31: Datasheet- indicator C11-2

Indicator	**Code & Name**	C11-2: **Mixed-Use of Street Space**
	Definition	Mixed-usage and multi-function of street space.
Initial Diagnosis	**Calculation Method**	Total number of ticks below ___ *Tick the items that fit:* ❑ *To open building setback space and design together between building line and the sidewalks inside the street red line* ❑ *Sharing street, such as tidal changeable lanes, travel & cycling sharing street;* ❑ *Multi-functional street space: changeable parking strip, temporary pavement cafe.*
	Measurement Unit	Pcs
Normalisation rules		***3:*** *3 ticks;* ***2****: 2 ticks;* ***1:*** *1tick;* ***0:*** *no tick.*

C12-1: Intelligent Transportation System

Table 7. 32: Datasheet- indicator C12-1

Indicator	**Code & Name**	C12-1**: Intelligent Transportation System**
	Definition	Usage and coverage of the intelligent transportation system
Initial Diagnosis	**Calculation Method**	Total number of ticks below ___ *Tick the items that fit:* ❑ *Intelligent public bus system to show real-time bus arrival time in bus station;* ❑ *Intelligent parking system to show real-time number of parking spaces;* ❑ *Intelligent traffic system to show real-time traffic condition.*
	Measurement Unit	Pcs
Normalisation Rules		***3:*** *3 ticks;* ***2****: 2 ticks;* ***1:*** *1 tick;* ***0:*** *no tick.*

C14-1: Employment Creation

Table 7. 33: Datasheet- indicator C14-1

Indicator	**Code & Name**	C14-1: **Employment Creation**
	Definition	Ability of the street to create employment positions
Initial Diagnosis	**Calculation Method**	*Tick one description that mostly fits the actual condition of the street:* ❑ ***Excellent:*** *There are various jobs created in/along the street, and the employment creation is not only on the first floor but also in the whole sided buildings.* ❑ ***Good:*** *There are many jobs created in/along the street on the first floor of the sided buildings.* ❑ ***Medium:*** *There are some jobs in/along the street, like on-street parking assistants, security guards, convenient shops retailers.* ❑ ***Bad:*** *there is no employment position created in/along the street.*
	Measurement Unit	-
Normalisation rules		**3**: *Excellent;* **2:** *Good;* **1**: *Medium;* **0:** *Bad*

7.3.3 Indicators of Mode N

There was only one indicator of Mode N, namely, C12-2 (Traffic Performance Index). The initial diagnosis of C12-2 was an officially published index which contained a four-level evaluation. Therefore, the normalisation rule naturally linked the score of 0, 1, 2, and 3 with the four levels accordingly. The datasheet below will provide a detailed explanation.

C12-2: Traffic Performance Index

Table 7. 34: Datasheet- indicator C12-2

Indicator	**Code & Name**	C12-1: **Traffic Performance Index**
	Definition	Year average Traffic Performance Index
Initial Diagnosis	**Calculation Method**	*Tick one description that mostly fits the actual condition of the street:* ❑ ***Very Smooth:*** *The traffic is in good condition. The average traffic density of the road is small, and the speed is high;* ❑ ***Relative Smooth:*** *The traffic condition is good. The average traffic density of the road network is smaller, and the speed is higher. Only a small part of the road is congested or blocked;* ❑ ***Crowded:*** *The traffic condition is average. The average traffic density of the road network is large, and the speed is not high. A remarkable proportion of the road is congested or blocked;* ❑ ***Congestion:*** *Traffic condition is very poor. The average network traffic density is high, and the speed is very low or even suspended in congested roads occupy a very high proportion*
Indicator	**Code & Name**	C12-1: **Traffic Performance Index**
	Measurement Unit	-
Normalisation rules		**3**: *Very Smooth;* **2:** *Relative Smooth;* **1**: *Crowded;* **0:** *Congestion*

Note: the traffic performance index was referenced from the National benchmarks: "Traffic performance index" (Shanghai Urban and Rural Construction and Traffic Development Insitute, 2011)

7.3.4 Indicators of Mode C

Concerning indicators of Mode C, the initial diagnoses were obtained from the calculation of some officially published indexes, and then the initial diagnoses were transformed into categorical scores that were 0, 1, 2 and 3 accordingly. The thresholds were set based on the results of academic researches and then optimised by the statistics of 76 Shanghai streets, which had been explained in both Chapter 4.4.2.1.4 and Chatper 7.3.1. It must be acknowledged that Mode C included two indicators, namely C15-1 (Added-value of Commercial Rents) and C15-2 (Add-value of Housing Price).

Because of the indicator's characteristics, the thresholds' selection and scoring rules of these indicators were based on percentiles of the distribution of 76 sample streets. The distribution feature was not with a normal distribution as that was used for other indicators, but with a top-down principle. Specifically speaking, the top 10% of units received a score of 3, the next 10% received 2, the next 20% received 1, and the last 50% received 0.

The following sections show the outcomes of normalisation methods of Mode M's indicators, namely C15-1 and C15-2, in the form of datasheets.

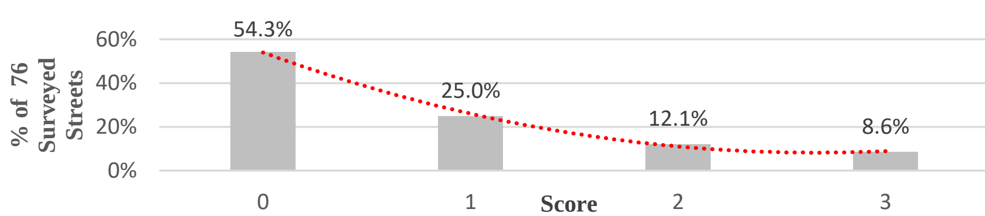
C15-1: Added-value of Commercial Rents

Table 7. 35: Datasheet- indicator C15-1

Indicator	**Code & Name**	C15-1: **Added-value of Commercial Rents**
	Definition	Value-added rate of commercial leases & rents along the street
Initial Diagnosis	**Calculation Method**	C15a (Added Value of Commerical Rents) $= \frac{\text{(Unit Price of Commercial Rent along the Street} - \text{Average Unit Price of Commercial Rent in this District)}}{\text{Average Unit Price of Commercial Rent in this District}}$
	Measurement Unit	%
Normalisation rules		3: >10% 2: 3%-10% 1: 0-2% 0: <0%

Note:

1. *The selection of thresholds within the normalisation rules initially referenced the following two academic studies:*
    - *The condition of urban streets and traffic is the main factor that affects the price of commercial rents, and the influencing weigh is 35.52% according to the calculation of Hedonic Model in Tianjin, China* (Xiao, 2010),
    - *Urban streets and overall accessibility largely influence the rental price of commercial space, and the added-value can reach 10%-20% according to the research in Hangzhou, China* (Li, 2011).
2. *The thresholds selection and normalisation methods were optimised and specified by the statistics of 76 surveyed streets based on the percentiles of the distribution (See the bar chart below).*



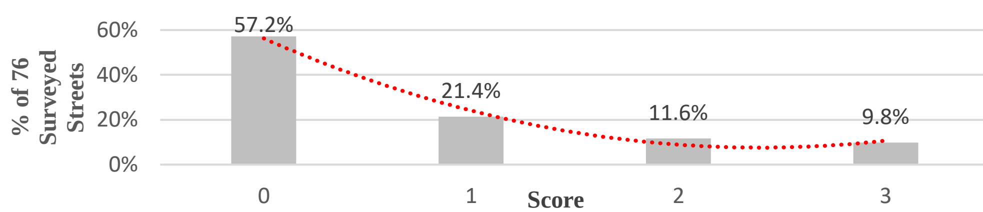
C15-2: Add-value of Housing Prices

Table 7. 36: Datasheet- indicator C15-2

Indicator	**Code & Name**	C15-2: **Add-value of Housing Prices**
	Definition	Value-added rate of Real Estate Transactions & Market Sales along the street
Initial Diagnosis	**Calculation Method**	C15b (added Value of Housing Price) $= \frac{\text{(Unit Housing Price along the Street} - \text{Average Unit Housing Price in this District)}}{\text{Average Unit Housing Price in this District}}$
	Measurement Unit	%
Normalisation rules		3: >10% 2: 3%-10% 1: 0-2% 0: <0%

Note:

1. *The selection of thresholds within the normalisation rules initially referenced the following academic researches:*
   - *In Boston, the prices of real estate near the streets with metro is 6.7% higher than the others* (Amstrong, 1994)*;*
   - *In San Diego housing prices along the street railway are 2.9-4.7% higher* (Agostini & Palmucci, 2008)*;*
   - *In Shenzhen, China, the housing prices along the subway line rise 16.95-23.03%* (Zheng, 2004)*;*
   - *The construction of the subway and street renovation boost the housing price by 7.6 – 9.4%* (Yang, 2010)*;*
2. *The thresholds selection and normalisation methods were optimised and specified by the statistics of 76 surveyed streets based on the percentiles of the distribution (See the bar chart below).*



7.4 Weighting System

Building the Weighting System is to give equal or different weights to variables according to their priority, reliability, importance, or other characteristics of the indicators (Freudenberg, 2003).

Therefore, Chapter 7.4 presents the method, process and final results of constructing the Weighting System. Firstly, Chapter 7.4.1 builds the structure of the Weighting System based on the overall evaluation framework. Chapter 7.4.2 expounds the analysis and statistical results of the Expert Questionnaire. Given this, Chapter 7.4.3 elaborates on the calculation process and outcomes of weight coefficients, thereby forming the Weighting System for the Indicator System.

7.4.1 System Structure

Above all, the structure of the Weighting System should be accord with the established evaluation framework of the Indicator System.

There were four layers in the structure of the evaluation framework:

- Target Layer (*the overall goal of sustainability*);
- Sub-Target Layer (*three pillars of sustainability: environmental, social, and economic sustainability*);
- Criteria Layer (*a total of 15 criteria*); and
- Indicator Layer (*a total of 30 indicators*).

Hence, the Weighting System was also built based on the structure of four layers.

The fundamental principle of the theoretical framework was that three aspects of sustainability were equally essential and untradeable. Accordingly, if the overall target got the weight coefficient of 1.0, then the three aspects of sustainability in the sub-target layer shared equally the weight of 1/3 ($\approx$0.333).

As the weights of the target and sub-target layers had been determined, the weight coefficients of the other two layers, namely criteria layer and indicator layer, needed to be specified. The Expert Questionnaire was designed based on the criteria layer rather than the indicator layer because of the considerations of logic soundness, implementation feasibility, and results' accuracy. Firstly, the questionnaire should be clear and direct. If the questionnaire contained two layers of variables and asked the importance of both criteria layer and indicator layer simultaneously, the interviewees would feel confusing, which might cause the survey failure. Therefore, from the perspective of survey implementation, the questionnaire focusing on one level of variables was more feasible. Secondly, from the perspective of the quality of the survey results, the questionnaire that was based on 15 evaluation criteria could deliver more accurate outcomes. If the questionnaire was to ask the importance of 30 indicators without the explanation of the overall framework, the survey results could not reflect the theoretical framework and further cause the inaccuracy of the survey results. If the questionnaire was designed with a whole explanation, the experts might be inevitable to consider and compare the relativity of the indicators with criteria. Then, the judgments of a total of 30 indicators and the balance of relativity and correlation would inevitably lead to the confusion and antipathy of respondents, which might considerably affect the result accuracy. The last but not the least, the Weighting System should be built layer by layer from top to bottom. Therefore, the weights of the criteria layer should be calculated before those of the indicator layer.

The weight coefficients of the criteria layer could be calculated according to the statistical results of the Expert Questionnaire. In theoretical, the weights of the indicator layer should also be figured out according to their reliability, importance, and other principles. However, concerning the potential uncertainties and limited research conditions, the weights of two indicators which consisted of the same criterion were assumed the same. The Equal Weight was adopted for the indicator layer also because many researchers pointed out that it is the best solution when there is no reliable data, or the research condition is limited (Jacobs, et al., 2004; OECD & JRC, 2008).

Therefore, ***the overall structure of the Weighting System for the Indicator System was clarified in Figure 7. 1***.

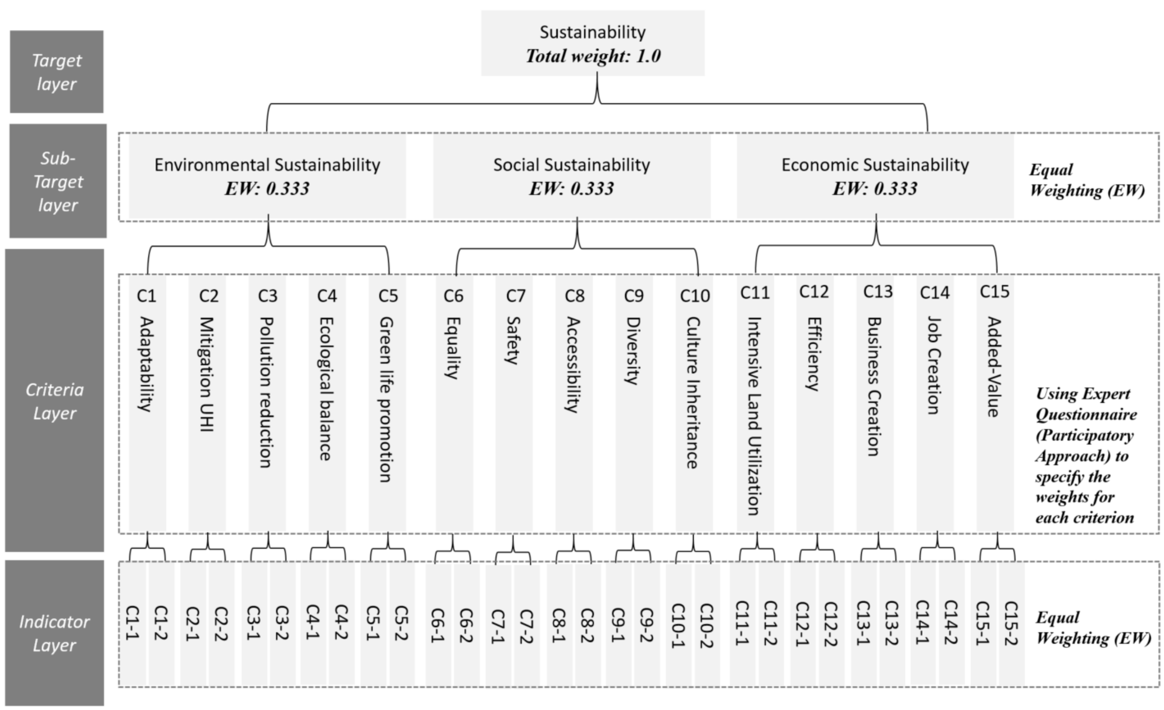


Figure 7. 1: Overall structure of weighting system in the evaluation framework

7.4.2 Expert Questionnaire

Chapter 4.4.2.2 has explained the rationale of selecting the Expert Questionnaire to build Weighting System. Hence, this section mainly introduces the statistical results of the Expert Questionnaire.

A total of 50 expert questionnaires were distributed, and 50 were effectively recovered Appendix EE. shows the data statistics results. Specifically speaking, there were three steps in the data analysis:

1) ***Data Processing and Inspecting:*** All data of questionnaire results were downloaded from the website platform, and processed in one spreadsheet in Microsoft Excel. After that, the integrity

and effectiveness of these questionnaire answers were examined. The inspection contents included whether all answers were complete by the respondents to ensure the integrity of all questionnaires, whether the answers of each questionnaire contained duplicates or errors to ensure results' effectiveness, and whether the answer time of each questionnaire was reasonable to examine the quality of survey results. According to the statistics of the electronic questionnaire platform, the average answer time of 50 questionnaires was 142 seconds, at least 60 seconds, at most 526 seconds. The online questionnaire was designed to be simple, and it only required the respondents to click the options in one table. Regarding to the 15 evaluation criteria, if the experts thought about each choice for 3 seconds, the total time for answering was 45 seconds theoretically. Therefore, from this point of view, combined with the time consumption of introduction reading at the beginning and other unpredictable reasons, if the time for questionnaire answering was more than 60 seconds, the questionaiare should be considered valid. Based on the above inspection and analysis, all 50 issued questionnaires were deemed to be valid.

2) ***Data Cleaning and Transforming:*** Fifty valid questionnaires were cleaned and transformed into a workable table for data analysis. The original data table that was downloaded from the survey platform included not only the questionnaire answers but also the survey information, such as the submission time, IP address, and network terminal types. However, this survey information was unnecessary for the data statistics and analysis. So, the information was cleaned up. Meanwhile, the data table was reorganised, and the columns and rows in the table were renamed to transform the original information into a workable data sheet and get prepared for the data analysis.

3) ***Data Analysing:*** Once the data got prepared, they were analysed by descriptive statistics. The calculation included Average, Median, Mode, Standard Deviation, Variance, Kurtosis, and Skewness. The statistics of Average, Median, and Mode, were to analyse the central tendency of survey results. The values of importance judgments of each evaluation criterion of 50 samples were between 4 and 5. According to the statistics of standard deviation and variance, it could be found that the dispersion degree of 50 samples was relatively small. Moreover, the calculation of Kurtosis and Skewness of questionnaire results reflected the shape of the data distribution to further understand the influential factors and frequency distribution of all collected data. Therefore, ***the average scores of evaluation criteria in the Expert Questionnaire were selected for the calculation the weights of the criteria layer.***

7.4.3 Weights of Variables

Based on the structure of the Weighting System built in Chapter 7.4.1 (Figure 7. 1) and the statistical results of the Questionnaire shown in Chapter 7.4.2 (see Appendix EE), the weight coefficients of 15 criteria could be calculated accordingly.

The average score of each evaluation criterion in the Expert Questionnaire were used for the calculation of the weights at the criteria layer, and the calculation followed the principle of Linear Algebra. The specific calculation formulas to calculate the weights of each evaluation criterion were as following:

If n $\in$(1,2,3,4,5)

$$Weight\ Coefficient\ (Cn) = \frac{0.333 * \mathrm{Avg.Cn}}{\mathrm{Avg.C1} + \mathrm{Avg.C2} + \mathrm{Avg.C3} + \mathrm{Avg.C4} + \mathrm{Avg.C5}}$$

If n $\in$(6,7,8,9,10)

$$Weight\ Coefficient\ (Cn) = \frac{0.333 * \mathrm{Avg.Cn}}{\mathrm{Avg.C6} + \mathrm{Avg.C7} + \mathrm{Avg.C8} + \mathrm{Avg.C9} + \mathrm{Avg.C10}}$$

If n $\in$(11,12,13,14,15)

$$Weight\ Coefficient\ (Cn) = \frac{0.333 * \mathrm{Avg.Cn}}{\mathrm{Avg.C11} + \mathrm{Avg.C12} + \mathrm{Avg.C13} + \mathrm{Avg.C14} + \mathrm{Avg.C15}}$$

Note: Avg. Cn is the average value of Cn calculated in the Expert Questionnaire

As the weights for the criteria layer were worked out, the weight for each indicator was easily obtained according to the principle of Equal Weight. The formulas for indicator calculation was:

$$Weight\ Coefficient\ (Cn-1) = Weight\ Coefficient\ (Cn-2)\ = \frac{\mathrm{Weight\ Coefficient\ (Cn)}}{2}$$

Based on the calculation formulas, the weighting system of the Indicator System could be figured out accordingly. ***Figure 7. 2 and Table 7. 37 illustrate the established Weighting System by the form of graph and table respectively.***

It is important to note that the weight coefficient of each hierarchy in the weighting system was close, and the main reasons were summarised as follows three points:

Firstly, the overall structure and calculation principle had an impact on the homogeneous distribution of weights. According to the theoretical framework, the importance of three sustainable aspects was the same and untradeable, which caused the weights in the sub-target layer to be the same. Meanwhile, the total number of criteria making up one sustainable aspect was the same, and the number of indicators making up one evaluation criterion was also the same, which further led the weights distribution evenly.

Secondly, the statistic results of the expert questionnaire were approximate, which made the weights in criteria layer similar. The rating scores of the importance of 15 criteria from 50 experts were basically between 4 and 5. Also, the values of average, median, and mode (statistic) were nearly the same. The standard deviation of rating judgments on each evaluated criterion was reasonably small, which indicated the similarity of expert's judgments to each evaluated criterion and between different criteria as well. The survey results of the expert questionnaire were the fundamental data to calculate the weighting system, so the approximate results of questionnaire inevitably made the similarity of the weight coefficients in the criteria layer.

Thirdly, the equal allocation of the weights to two indicators that represented to the same criterion further caused the weight coefficients similar in the indicator layer. It was introduced in Chapter 7.4.1 that the weights of two indicators which represented one criterion were the same and their values equalled to half of the weight of their representative criterion. As the weights in the criteria layer were similar, the weights of the indicator layer were close.

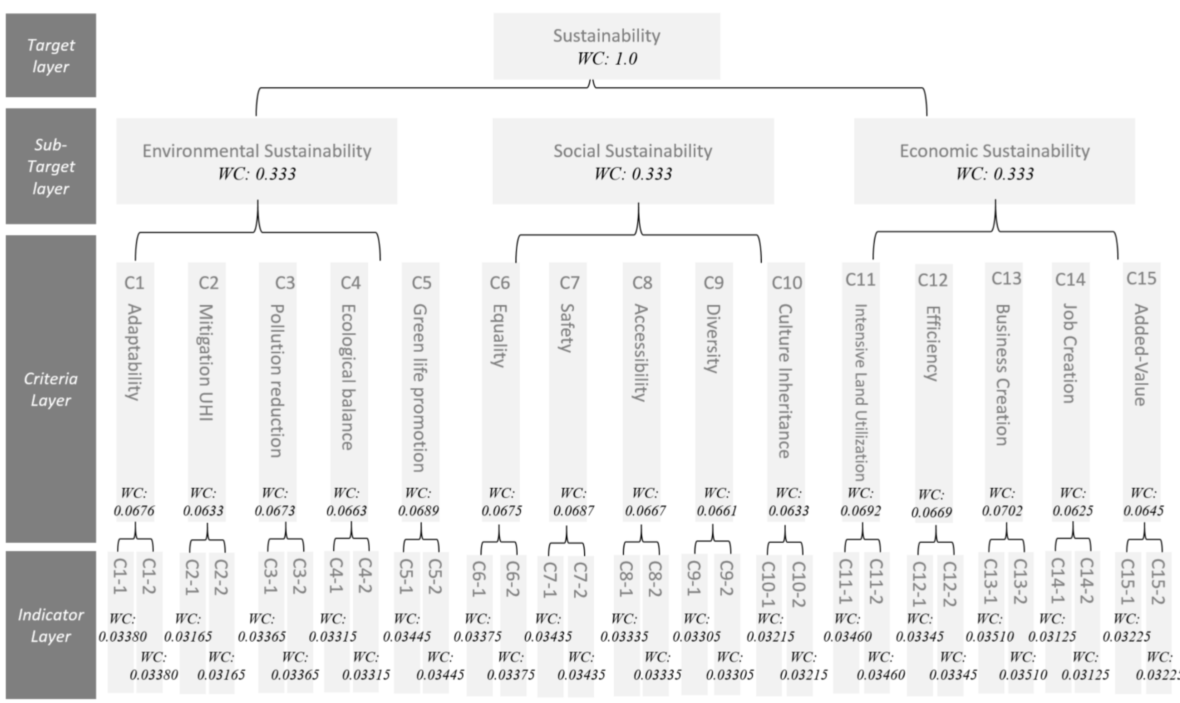


Figure 7. 2: Structure Graph of Weighting System

Table 7. 37: Weighting system of the sustainability evaluation framework

Evaluation Framework				Weighing System			
Target Layer	*Sub-Target Layer*	*Criteria Layer*	*Indicator Layer*	*Weight Coefficient*			
Sustainability	Environmental Sustainability	C1: Adaptability	C1-1: Adaptable Capacity to Local Climate	1.0	0.333	0.0676	0.03380
			C1-2 Adaptable Capacity to Extreme Weather Events				0.03380
		C2: Mitigation UHI	C2-1: Street Green Rate			0.0633	0.03165
			C2-2: Air Temp. Difference				0.03165
		C3: Pollution reduction	C3-1: Average Emission of Noise			0.0673	0.03365
			C3-2: Pollution Reduction				0.03365
		C4: Ecological balance	C4-1: Rainwater management			0.0663	0.03315
			C4-2: Ecological Planting				0.03315
		C5: Green life promotion	C5-1: Green Lifestyle Promotion			0.0689	0.03445
			C5-2: Green Travel Support				0.03445
	Social Sustainability	C6: Equality	C6-1: Tactile pavement for the blind		0.333	0.0675	0.03375
			C6-2: Barrier-Free Facilities				0.03375
		C7: Safety	C7-1: Coverage Proportion of Street Cameras			0.0687	0.03435
			C7-2: Coverage Safety Equipment				0.03435
		C8: Accessibility	C8-1: The Variety of Arrival Ways			0.0667	0.03335
			C8-2: Clear Sign and Guidance System				0.03335
		C9: Diversity	C9-1: Diversity of Street Activities			0.0661	0.03305
			C9-2: Diversity of Street Functions				0.03305
		C10: Culture Inheritance	C10-1: Aesthetic Quality of Street Furniture			0.0633	0.03215
			C10-2: Style Consistency with Surroundings				0.03215
	Economic Sustainability	C11: Intensive Land Utilisation	C11-1: Intensiveness of Street Space		0.333	0.0692	0.03460
			C11-2: Mixed-Use of Street Land				0.03460
		C12: Efficiency	C12-1: Intelligent Transportation System			0.0669	0.03345
			C12-2: Traffic Performance Index				0.03345
		C13: Business Creation	C13-1: Density of Shops			0.0702	0.03510
			C13-2: Types of Temporary Business				0.03510
		C14: Job Creation	C14-1: Employment Creation			0.0625	0.03125
			C14-2: Types of Jobs				0.03125
		C15: Added-Value	C15-1: Added Value of Commercial Rents			0.0645	0.03225
			C15-2: Added-Value of Housing Prices				0.03225

7.5 Aggregation Method

The process of aggregation is to combine all dimensions, objectives, criterion, indicators, and variables used for its construction, thereby reaching a composite index to represent the overall evaluation results. Therefore, Chapter 7.5 introduces the selection of aggregation method and the aggregation rules for the final composite indicator. Chapter 7.5.1 explains the rationale and process of the method selection firstly, and then Chapter 7.5.2 further elaborates on the techniques and rules for getting the composite indicator of the evaluation.

7.5.1 Method Selection

There are various techniques to aggregate composite indicators, and the fundamental issues in aggregation are the compensability of the evaluated dimension, criteria, and indicators (Talukder, et al., 2017; Tarabusi & Guarini, 2013). Based on an in-depth study, three commonly applied aggregation options, namely Additive Aggregation (AA), Geometric Aggregation (GA) and Multi-Criteria Analysis (MCA), were studied and compared (See Table 7. 38), thereby selecting the appropriate technique for this work based on the theoretical framework and established evaluation structure.

Additive Aggregation (AA) is to use an arithmetic way to aggregate all variables by linear functions. It is the most widespread aggregation method because of its simple procedure and easy understanding. The commonly adopted techniques of AA include the summation or arithmetic mean of weighted and normalised Individual indicators. Though widely used, the aggregation rule imposes restrictions on the nature of individual indicators, which causes the loss of absolute or interval information (OECD & JRC, 2008). In other words, a deficit in one indicator or dimension can be compensated for by a surplus in another, which is also the main disadvantage of a compensable rule (Tate, 2012; Hudrlíková & Kramulová, 2013; Talukder, et al., 2017). Given this, the strong condition for choosing this method is the indicators are mutually preferentially independent (Debreu, 1960; Keeney & Raiffa, 1976; OECD & JRC, 2008). In this way, the trade-off ratio among variables is acceptable, and these marginal contributions can then be summed up to form a total value.

Geometric Aggregation (GA) is to use a geometric way to aggregate all variables by geometric functions. The critical advantage of GA is that it takes into consideration differences in achievement across dimensions/indicators. By the multiplication of calculation principle, poor performance in any dimension/indicators is directly reflected (Talukder, et al., 2017). Though aggregation rule of the geometric method is often described as non-compensatory, some researchers point out that this technique is partly compensable because the final composite indicator is still rewarded by the higher scores of some indicators (Hudrlíková & Kramulová, 2013; Talukder, et al., 2017).

Multi-Criteria Analysis (MCA) is considered the methods for the aggregation of non-compensatory data (Saisana & Saltelli, 2011; Munda & Nardo, 2005). It provides an overall ranking and forms a matrix based on the weights and values of the evaluated indicators. Based on the "outranking matrix" and pairwise comparison of the weighted performance of each criterion, the composite indicator scores of the criteria by adding the values of the row of the outranking matrix is calculated accordingly. The critical advantage of MCA is the feature of non-compensability and emphasis on the judgment of the decision-making team. However, it is also criticised due to its subjectivity. Moreover, the number of indicators to aggregate is limited because outranking matrix contains pairwise comparisons (*there are (n(n-1))/2 comparisons for n options*). The more indicators the system contains, the more amount of work it multiplies.

The established evaluation system in this research was made up of four layers, namely the target layer (*sustainability*), sub-target layer (*environmental, social, and economic sustainability*), criteria layer (*15 criteria*), and the indicator layer (*30 indicators*). So, it could be seen that there were three steps of aggregation in this system to obtain the final composite evaluation result. After comparing the pros and cons of the three types of aggregation methods, the specific techniques were selected for these three steps according to the theoretical framework and evaluation structure.

The first step of aggregation was to calculate the values in the criteria layer by the variable data of the indicator layer. The arithmetic summation was adopted as the calculation technique of aggregation. Specifically speaking, the work of this step was to calculate the value of Cn by the weighted and normalised values of Cn_1 and Cn_2, and the arithmetic addition could both reflect the power of weights and achieve the purpose of comprehensive evaluation. Regarding the potential issues of the methods of arithmetic summation, the complementary and trade-off between the two indicators were acceptable at this level. The two selected indicators that represented the same criterion were internally correlated and mutually interacted. Also, the aggregation of this stage was to calculate an integrated result, rather than to elaborate the features absolute/interval information or any individual data. For example, the criterion of C1 (Adaptability) was aggregated by the indicator of C1_1 (Adaptable Capacity to Local Climate) and C1_2 (Adaptable Capacity to Extreme Weather Events), then the measures that were able to help the street to adapt to local climate could also contribute to the enhancement of the adaptable capacity to extreme weather events to some extent. Also, from the perspective of the theoretical framework the evaluation, the evaluation criteria for C1 (Adaptability) should be a comprehensive result of balancing C1-1 and C1-2, rather than highlighting the features and extreme value of one single indicator.

The second step of aggregation was to calculate the three-composite index of the sub-target layer by fifteen variables in criteria layer. The arithmetic summation was selected as the aggregation method. The reasons and rationale of method selection were similar to those of step one. Each composite index in the sub-target layer was made up of five criteria, and these five criteria were mutually independence. So, the arithmetic way of aggregation and the critical rule of full compensability were suitable for this step from the perspective of the theoretical framework and system structure as well. Taking the sub-target of Social Sustainability as an example, it should be a comprehensive summation of C6 (Equality), C7 (Safety), C8 (Accessibility), C9 (Diversity), and C10 (Culture Inheritance). If the score of C10 was 0 due to the poor performance of history inheritance while all the other four criteria (C6, C7, C8, and C9) were relatively high. In such case, the aggregation result should follow the linear functions to calculate the score of Social Sustainability by balancing the overall performance, rather than showing the score of 0 by geometric aggregation.

The last step of aggregation was to transform the three scores of the Environmental Sustainability Index (EnSI), the Social Sustainability Index (SoSI), and the Economic Sustainability Index (EcSI) into one composite score of Sustainable Index. The geometric mean was employed as the aggregation technique in this step. Firstly, the selection was determined by the theoretical framework and the core principle of this evaluation work that the three aspects of sustainability were not mutually complementary. In other words, a high score in one aspect could not masked a low score in another, and the values of the three sub-targets should be objectively and comprehensively aggregated into the final composite indicator. Secondly, different from MCA, the GA is an in-between solution as it is partly compensable. Specifically speaking, an extremely low score of one aspect, such as 0, could drive the aggregation result to 0 directly while a higher score of one aspect could also make the aggregation result higher.

Figure 7. 3 illustrates the aggregation methods of these three steps in the evaluation structure.

Table 7. 38: Comparison of Three Aggregation Methods

Methods	Brief	Rules & Conditions	Features
Additive Aggregation (AA)	- It is an arithmetic way to aggregate all variables by linear functions. - The most popular aggregation technique is to calculate the summation ($CI_c = \sum_{q=1}^{Q} w_q I_{qc}$), or the arithmetic mean ($\overline{x} = \frac{\sum_{i=1}^{n} \overline{x}}{N}$) of weighted and normalised Individual indicators.	***Key rule:*** *Full compensability.* ***Key condition:*** *indicators are mutually preferentially independence;*	***Pros:*** - *Simple and unaffected by outliers;* - *Important implications for the interpretation of weights.* ***Cons:*** - *The loss of absolute/interval information;* - *Restrictions on the nature of individual indicators;* - *A high value in one indicator masks a low value in another.*
Geometric Aggregation (GA)	- It is a geometric way (Multiplication) to aggregate all variables by geometric functions. - The typical technique of geometric aggregation is to calculate the geometric mean by such formula as $\left(\prod_{i=1}^{n} x_i\right)^{\frac{1}{n}} = \sqrt[n]{x_1 x_2 \cdots x_n}$	***Key rule:*** *Part compensability* ***Key condition:*** *All indicators are strictly positive.*	***Pros:*** - *Taking into consideration differences in achievement across dimensions/indicators;* - *Poor performance in any dimension/indicators is directly reflected.* ***Cons:*** - *The technique is partly compensable since it rewards composite indicators with higher indicator scores.*
Multi-Criteria Analysis (MCA)	- It provides an overall ranking based on the weight and values of the given indicators; - It is based on an "outranking matrix" by pairwise comparison of the weighted performance of each criterion, and then to calculate the composite indicator score of the criteria by adding the values of the row of the outranking matrix.	***Key Rule:*** *No compensability* ***Key conditions:*** *A clear set of evaluation objectives, criteria, and weightings system.*	***Pros:*** *Emphasising on the judgment of the decision-making team.* ***Cons:*** - *Subjectivity* - *It is unable to deal with the system with too many indicators since the outranking matrix contains pairwise comparisons and number is* $\frac{n(n-1)}{2}$

The table was summarised and made by the author.

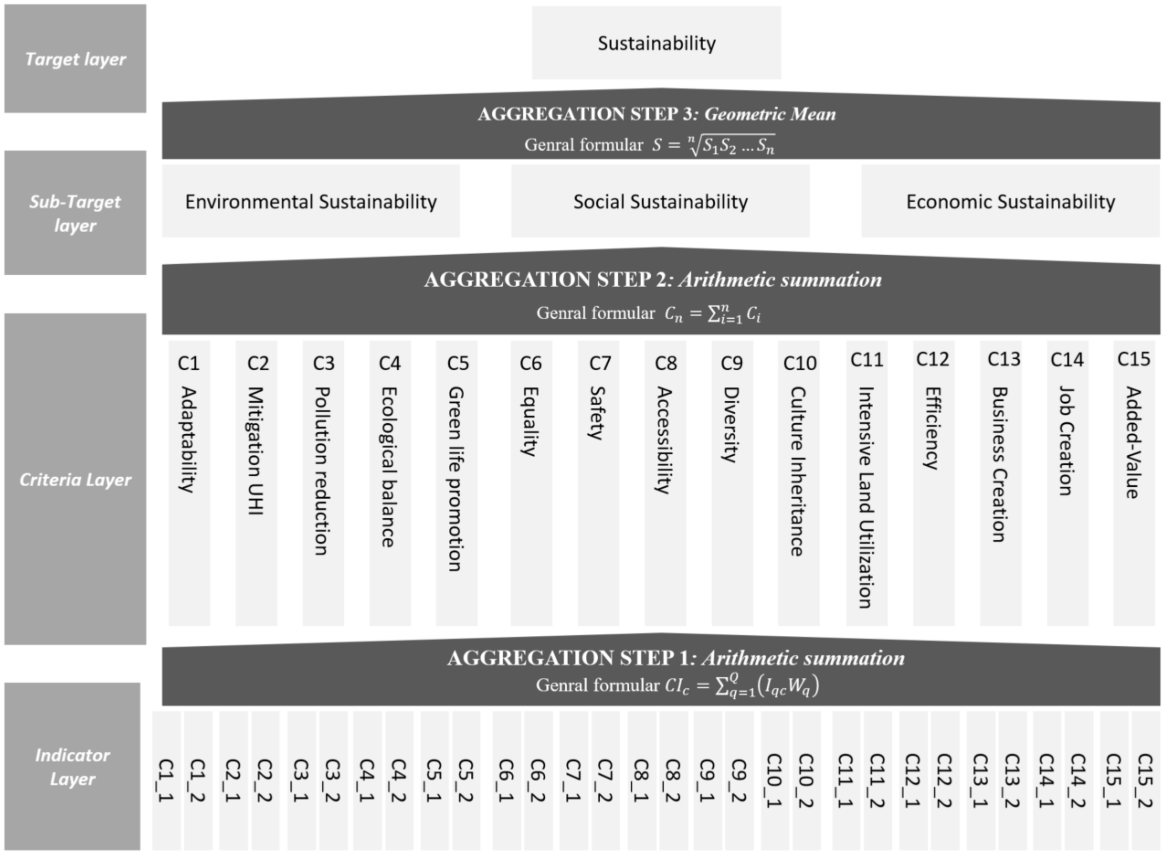


Figure 7. 3: Aggregation Methods of Three Steps in the Evaluation Framework

7.5.2 Aggregation Procedure

The previous part analysed the rationale for the aggregation phase and selected the aggregation methods of three steps. Based on the identified aggregation model, the Weighting System was incorporated into the evaluation framework, thereby building a complete Indicator System of Sustainability Evaluation for Shanghai streets.

AGGREGATION STEP 1: FROM INDICATORS TO CRITERIA

The principal objective of this step was to transform the values in the indicator layer to that of the criteria layer, and the aggregation method was selected to be arithmetic summation. There were 30 indicators in the indicator layer, and two indicators corresponded to one criterion. Therefore, the calculation process was to add these two indicator's values after weighted respectively to obtain the score of 15 criteria.

The formula was:

$$C_n = C_{n\_1} W_{n\_1} + C_{n\_2} W_{n\_2} \quad n \in (1, 2, 3, 4, \ldots, 15)$$

AGGREGATION STEP 2: FROM CRITERIA TO SUB-TARGETS

Step Two was to aggregate 15 criteria into three composite indicators, namely EnSI, SoSI, and EcSI, in the sub-target layer. The three composite indicators were calculated separately, because like the typical advantages of composite indicators they allow for cross-comparisons, enable evaluation of results, and set the bar for performance (Munda & Saisana, 2011). The arithmetic summation was selected as the aggregation method. Therefore, the calculation process was to sum up the values of five criteria that represent the sub-target of sustainability. It was found through the pre-test that if the score of indicators was between 0 and 3 then the aggregated results of EnSI, SoSI, and EcSI were from 0 to 1. The value between 0 and 1 tended to be complicated to express, difficult to compare and cause more reading problems than others. Hence, the three indexes (EnSI, SoSI, and EcSI) were uniformly multiplied by 10, which made the scores of EnSI, SoSI, and EcSI between 0 and 10. In this step, all the aggregated results were amplified synchronously in a linear manner, which was not only to the benefit of reading and presenting but also without affecting the data properties and aggregation of next step.

The formula to calculate these three composite indicators of sub-target were:

$$EnSI = (C1 + C2 + C3 + C4 + C5) * 10$$

$$SoSI = (C6 + C7 + C8 + C9 + C10) * 10$$

$$EcSI = (C11 + C12 + C13 + C14 + C15) * 10$$

AGGREGATION STEP 3: FROM SUB-TARGETS TO THE TARGET

The last step was to calculate the Sustainable Street Index (SSI) by the scores of EnSI, SoSI, and EcSI, and the geometric mean was identified as the aggregation technique. Therefore, the calculation formula was

$$SSI = (EnSI * SoSI * EcSI)^{1/3}$$

Hence, ***Table 7. 39 presents the aggregation model, including three aggregation steps and calculation formulas.***

Therefore, the full score of SSI was 10 according to the system design: 0-2 is Very Poor; 2-4 is Poor, 4-6 is Medium, 6-8 is good, and 8-10 is Excellent.

Table 7. 39: Aggregation Procedure

AGGREGATION STEP ONE			**AGGREGATION STEP TWO**		**AGGREGATION STEP THREE**		
Basic Data		*Calculation formula*	*Basic Data*	*Calculation formula*	*Basic Data*	*Calculation formula*	*Result*
Indicator Code	**Weight Code**		Criteria Code		Sub-Target		Target
C_{1-1}	W_{1-1}	$\boldsymbol{C_n} = \boldsymbol{C_{n-1} W_{n-1}} + \boldsymbol{C_{n-2} W_{n-2}}$, $n \in (1,2,3,\ldots,15)$	C_1	***EnSI* = (C1+C2+C3 +C4+C5) *10**	*EnSI*	**SSI = (EnSI*SoSI*EcSI)$^{1/3}$**	SSI
C_{1-2}	W_{1-2}						
C_{2-1}	W_{2-1}		C_2				
C_{2-2}	W_{2-2}						
C_{3-1}	W_{3-1}		C_3				
C_{3-2}	W_{3-2}						
C_{4-1}	W_{4-1}		C_4				
C_{4-2}	W_{4-2}						
C_{5-1}	W_{5-1}		C_5				
C_{5-2}	W_{5-2}						
C_{6-1}	W_{6-1}		C_6	***SoSI* = (C6+C7+C8 +C9+C10) *10**	*SoSI*		
C_{6-2}	W_{6-2}						
C_{7-1}	W_{7-1}		C_7				
C_{7-2}	W_{7-2}						
C_{8-1}	W_{8-1}		C_8				
C_{8-2}	W_{8-2}						
C_{9-1}	W_{9-1}		C_9				
C_{9-2}	W_{9-2}						
C_{10-1}	W_{10-1}		C_{10}				
C_{10-2}	W_{10-2}						
C_{11-1}	W_{11-1}		C_{11}	***EcSI* = (C11 +C12+C13 +C14+C15) *10**	*EcSI*		
C_{11-2}	W_{11-2}						
C_{12-1}	W_{12-1}		C_{12}				
C_{12-2}	W_{12-2}						
C_{13-1}	W_{13-1}		C_{13}				
C_{13-2}	W_{13-2}						
C_{14-1}	W_{14-1}		C_{14}				
C_{14-2}	W_{14-2}						
C_{15-1}	W_{15-1}		C_{15}				
C_{15-2}	W_{15-2}						

7.6 Robustness Analysis

The establishment of the evaluation system and composite indicators is often criticised by its subjective judgments, including the selection of indicators, the design of data normalisation, the distribution of weights, and the choice of aggregation model (Cherchye, et al., 2008; Saisana, et al., 2005). Therefore, it is necessary to analyse the robustness of the evaluation system and the soundness of a series of assumptions (Paton, et al., 2013; OECD & JRC, 2008). The robustness analysis includes a systematic study of uncertainty factors within the system, and an assessment the degree of influence of these uncertainty factors, so as to examine the reliability of the evaluation system, to gauge the robustness of the composite indicators, to increase the transparency of the entire mechanism. Many analysis methods are useful for assessing the system robustness, such as Uncertainty Analysis (UA), Sensitivity Analysis (SA), Model Calibration, and Model diagnostic evaluation. These methods share some standard features and hold their characteristics respectively. Among them, UA and SA are the most widely used methods to analyse the robustness of a composite Indicator System. These two methods share many in common, such as similar mathematical techniques, standard methodologies, and close basic concepts (Pianosi, et al., 2016), but also retain their respective characteristics and scope of application. The "Handbook on Constructing Composite Indicators" (OECD & JRC, 2008) introduces the implementation of a combination of uncertainty and sensitivity analysis, but more researchers adopted UA to review and optimise the established model (Freudenberg, 2003; Jamison & Sandbu, 2001; Kann & Weyant, 1999).

Table 7. 40 illustrates a detailed comparison between UA and SA from the perspective of definition, main approaches, typical techniques, and implementation purpose. Based on the comparison of these two methods and the in-depth analysis of the key objectives of this stage, ***the qualitative UA was employed to assess the robustness of the established Indicator System.***

First, UA was more suitable for the nature of this work and the primary objectives of this stage. The principal objective of the robustness analysis in this phase was to systematically examine the established evaluation framework, to identify the potential uncertainty, and also to estimate the impacts of these uncertainties on the outcomes. Given this, compared with three primary purposes of SA, namely ranking, screening, and mapping, the application of UA was more suitable for inspection. Some researchers suggested that UA aims at quantifying the uncertainty and SA focuses on apportioning output uncertainty to the various input factors (Saltelli, et al., 2008; Pianosi, et al., 2016). Given this, UA is a fundamental step to gauge the robustness.

Secondly, compared with quantitative approaches of UA, the qualitative UA was flexible and adaptable for this research. There are two types of UA: the quantitative UA (estimating the magnitude of uncertainties in numerical terms) and qualitative UA (describing/categorising the main uncertainties), and both have pros and cons. Quantitative UA can provide more precise and results through mathematic calculation and models, but it suffers from many disadvantages, such as its complexity and the limitation of uncertainty sources (issue-framing or value-based judgments). Though qualitative UA is tricky to compare due to its nature, it is often adopted because of its high flexibility and adaptability. Qualitative UA can be schemed according to the specific circumstance and research context. This research was to build the Indicator System of sustainability evaluation for Shanghai streets, which was an exploratory academic study. The study had its particularity in the research field, assessment object, and system construction. So, most of the quantitative methods of UA which were introduced in some pieces of literature were not applicable to this study.

The last but not the least, qualitative UA was employed because its analysis process was relatively simple and straightforward. Different from quantitative approaches which mostly rely on complicated mathematical models and massive computer calculation, qualitative UA can also provide detailed results of uncertainties and potential risk to the endpoints by logic analysis. Moreover, its analysis results are easy to understand and more readable.

Table 7. 40: Comparison between Uncertainty Analysis and Sensitivity Analysis

Methods	Definition	Approaches & Techniques	Purpose & Settings
Uncertainty Analysis (UA)	UA is to analyse how uncertainty in the input factors propagates through the evaluation system and affects the composite indicator values	Quantitative Approaches: - *Monte Carlo Simulation,* - *Taylor Series Approximation,* - *Bayesian Statistical Modelling* Qualitative approaches	• Predicting: *To identify the potential uncertain factors within the system;* • Simulating: *To assess the potential impacts this uncertainty bring to the output data* • Managing: *To optimise the system and manage risk.*
Sensitivity Analysis (SA)	SA investigates how the variation in the output of a numerical model can be attributed to variations of its input factors.	One-At-a-Time (OAT): - *Elementary Effect Test (EET)* - *Distributed Evaluation of Local Sensitivity Analysis (DELSA)* All-At-a-Time (AAT): - *Regional Sensitivity Analysis (RSA)* - *Classification and Regression Trees (CART)* - *Fourier Amplitude Sensitivity Test (FAST*	• Ranking (Factor Prioritization): t*o generate the ranking of the input factors;* • Screening (Factor Fixing): t*o identify the input factors that have a negligible influence on the output variability.* • Mapping: *to determine the region of the input variability space that produces significant output values.*

The table was summarised and made by the author, the definitions were referenced from (Pianosi, et al., 2016; OECD & JRC, 2008; Mahadevan & Sarkar, 2009)

7.6.1 Qualitative Uncertainty Analysis

Concerning the techniques and practices of qualitative UA, Salway and Shaddick (2010) provided a detailed guidance, including analysis logic, practical procedure, and report format. Hence, this part of the analysis mainly followed the three-step procedure in the guidance to finally present a report of qualitative uncertainty.

The first step was to identify the sources of uncertainty and list all possible sources of uncertainty. The uncertainties in the development of the Indicator System of evaluation might arise from the following several aspects (Saisana, et al., 2005; OECD & JRC, 2008; Cherchye, et al., 2008):

a) Indicator Selection;
b) Data Normalisation;
c) Weighting scheme;
d) Indicator Aggregation.

Therefore, the list of uncertainty sources was built based on the four main components and the three main types of uncertainty sources, namely scenario, model, and parameter. Just as what was emphasised in the guidance paper (Salway & Shaddick, 2010), the critical task of this step was to list the sources of uncertainty, and category of three types of source (scenario, model, and parameter) was to help generate a comprehensive list. Given this, based on this structure all potential uncertainties were listed in the first row (sources of uncertainty) in Table 7. 43.

The second step was to qualify the characteristics of the possible uncertainties. This step could be specified into two parts of the work: assessing the magnitude of the effect of each source of uncertainty and determining the associated uncertainty in the knowledge base (scientific evidence). According to the guidance (Salway & Shaddick, 2010, p. 5),

> *"The magnitude of uncertainty is rated low when it is judged that large changes within the source of uncertainty would have only a small effect on the assessment results and when the values of the data sets needed for the assessment are known.*
>
> *A designation of medium implies that a change within the source of uncertainty is likely to have a moderate effect on the results and the values of the data sets needed for the assessment are unknown (completely or partially).*
>
> *A characterisation of high implies that a small change in the source would have a large effect on results and the values of the data sets needed for the assessment are unknown."*

The specific design of the rating criteria should be based on the research context and the identification of endpoints. Regarding the sustainability evaluation of this research, the endpoint was the final assessment result of SSI, and thus the bias of the evaluation result of SSI caused by potential uncertainties was the core issue. The absolute value of SSI might vary with the normalisation process and aggregation methods, but the differences between the values of SSI obtained in this established framework, and what would the actual value might be if there was no uncertainty could be calculated accordingly. Therefore, bias was measured by proportion. Referenced from the magnitude category in the guideline (Salway & Shaddick, 2010), Table 7. 41 shows a development process of the magnitude scale with a list of possible effects that uncertain might have on the endpoint, and a classification of high, medium, and low, which was assigned to each of these possible effects.

Moreover, Table 7. 42 displays the category of uncertainty related to the knowledge base which was referenced from the guidance (Salway & Shaddick, 2010). Therefore, based on the defined criteria, each source of uncertainty listed before was given a qualitative assessment of Low, Medium, and High according to their magnitude of uncertainty on the results and the knowledge about the uncertainty sources.

Finally, the sources and dimensions of potential uncertainties were identified and analysed accordingly. ***The final report of Uncertainty Analysis showed that the established Indicator System was robust in general. The most uncertainties lied in the stage of indicator selection and data normalisation, but the dimensions of all potential uncertainties were between low and medium.*** More details of the uncertainty analysis could be seen in Table 7. 43.

Table 7. 41: Magnitude Scale for the Effect of Uncertainty

Effect of uncertainty on the endpoint	**Magnitude category**
Bias is between 0% and 10% (including 0%)	*Low*
Bias is between 10% and 20% (including10%)	*Low*
Bias is between 20% and 30% (including 20%)	*Low*
Bias is between 30% and 40% (including 30%)	*Medium*
Bias is between 40% and 50% (including 40%)	*Medium*
Bias is between 50% and 60% (including 50%)	*Medium*
Bias is between 60% and 70% (including 60%)	*Medium*
Bias is between 70% and 80% (including 70%)	*High*
Bias is between 80% and 90% (including 80%)	*High*
Bias is between 90% and 100% (including 90%)	*High*
Bias is over 100%	*High*

Table Source: (Salway & Shaddick, 2010).

Table 7. 42: Uncertainty Scale for Assessing the Knowledge Base

State of Knowledge Base	Uncertainty Category
Consistently extensive scientific evidence of many different types from many different sources	*Low*
Consistently extensive scientific evidence of a single type or from a single source	*Low*
Consistently scientific evidence but all suffering from the same limitation(s)	*Medium*
Scientific evidence is mixed; the bulk of it supports the conclusion	*Medium*
Consistently scientific evidence for related population/scenario but limited for this situation	*Medium*
Scientific evidence is limited or inconsistent	*High*
No external scientific evidence exists; internal analysis to support	*High*
No external scientific evidence exists; expert opinion is generally consistent	*High*
Nothing is known	*High*

Table Source: (Salway & Shaddick, 2010).

Table 7. 43: Report of Uncertainty Analysis

Sources of Uncertainty		Dimensions of Uncertainty		Justification
		Magnitude	**Knowledge Base**	
1- INDICATOR SELECTION				
1.1 Scenario	1.1.1 Comprehensiveness of potential indicators list	Low	Low	*The potential indicators summarised in this research are 80, and among them, 30 are selected. Moreover, the weight of each indicator is about 0.0333. The data searching and literature review lasted for three years, and more than 1182 relevant academic papers and policies were reviewed. The reviewed literature and study duration can maximally ensure the comprehensiveness of the indicator list. So, the bias is not above 30%.*
	1.1.2 Selection of indicators of type O is based on the statistics of 236 Shanghai Streets	Low	Low	*236 streets are enough to be representative sample size, and consistent, extensive scientific evidence supports it. Also, the assessment of whether the indicator could be measured by the on-site survey is a straightforward determination. So, the bias is not above 30%.*
	1.1.3 Selection of indicators of type D is based on the limited condition (limitation of time and data publicity)	Medium	Medium	*Considering the uncertainty of information disclosure and searching comprehensiveness, seven evaluation criteria (C3, C4, C7, C8, C12, C13, and C14) might be represented by better indicators. The uncertainty in this aspect can lead to a deviation of about 42% (7 criteria* 6% average weight).*
	1.1.4 The Indicator System is built based on a balanced structure (1 criterion consists of 2 indicators)	Low	Low	*Based on the theoretical framework and statistics results of the expert questionnaire, the weight of each criterion is about 6%. Therefore, even supposing that one criterion consists of 13 indicators (all in the potential list are selected) and the other is only 1, the total value accounting for the calculation of SSI is controlled by the weight coefficient. Considering the correlation between indicators, the effects of this uncertainty source is less than 30%.*
1.2 Model	1.2.1 The rationality of the concept model of indicator selection of Type O.	Low	Low	*The selection model of indicators of Type O consists of three steps (preliminary check, the category of Acquisition mode, and feasibility check), which is based on the supports of sufficient theoretical basis and practical experiences. It can be said that the bias is below 30%.*
	1.2.2 The rationality of the concept model of indicator selection of Type D.	Low	Low	*The selection model of indicators of Type D consists of three steps (preliminary check, the category of Acquisition mode, and feasibility check), which is based on the supports of sufficient theoretical basis and practical experiences. It can be said that the bias is below 30%.*

Sources of Uncertainty		Dimensions of Uncertainty		Justification
		Magnitude	Knowledge Base	
1.2 Model	1.2.3 The uncertainty of C2d, C9a, and C13e in the indicator selection procedure	Low	Low	*Three indicators (C2d, C9a, and C13e) are marked in Table 7. 1 due to the uncertainty. Therefore, assuming the uncertainty of these three indicators last to the final calculation of SSI, the maximum error is below 10% (3 indicators * 0.033 average weight coefficient).*
	1.2.4 The rationality of integrating C8f, C8g, C8i, C8j, C8k into C8l	Low	Low	*In theory, the concept of C8l (the variety of arrival ways) contains the evaluation of C8f (bus lane network), C8g (cycling lane network), C8i (pedestrian access), C8j (Bicycle access), and C8k (Transit Access). Extensive evidence supports this. The overall weight of C8 (Accessibility) is 0.0675, so the maximum bias is below 6.75%.*
	1.2.5 The rationality of integrating C10b into C10c	Low	Low	*In theory, the concept of street furniture is broader than that of urban art. So C10b (Aesthetic Quality of urban art) can be integrated into C10c (Aesthetic Quality of street furniture), which is supported by sufficient theoretical evidence. The overall weight of C10 (Culture Inheritance) is 0.0675, so the maximum bias is below 6.75%.*
	1.2.6 The rationality of integrating C10e into C10d	Low	Low	*In theory, the history and culture of one street should coherent with its surroundings. Hence the evaluation of C10e (Historical inheritance & culture display) contains that of C10d (Style consistency with surroundings). The overall weight of C10 (Culture Inheritance) is 0.0675, so the maximum bias is below 6.75%.*
	1.2.7 The rationality of integrating C12b into C12d	Low	Low	*In theory, Intelligent transportation system consists of smart parking program, real-time traffic condition broadcasting, smart bus system, and so on. Hence the evaluation of C12b (Parking Smart program) contains that of C12d (Intelligent transportation system), which is supported by sufficient scientific evidence. The overall weight of C12 (Efficiency) is 0.0675, so the maximum bias is below 6.75%.*
1.3 Parameter	1.3.1 The relativity of all selected indicators	Low	Low	*The relativity of 30 selected indicators is analysed and rated by good, medium, and poor respectively (Table 7. 5). Seven indicators are marked as "medium" after qualitative comparison. Assuming that the medium level of subjectivity means 50% error, then the uncertainty of the subjectivity of these seven indicators can maximally cause the error of 11.7% (7*0.033*0.5) of final SSI evaluation.*
	1.3.2 The sensitivity of selected indicators to criteria	medium	Low	*The sensitivity of 30 selected indicators is analysed and rated by good, medium, and poor respectively (Table 7. 5). 7 indicators are marked as "poor", and fifteen indicators are marked as "medium" based on the comparison. Assuming that the poor and medium level of subjectivity means 80%, and 50% error respectively, then the uncertainty of the subjectivity of these 20 indicators can maximally cause the error of 43.6% (7*0.033*0.8 + 15*0.033380.5) of final SSI results.*

Sources of Uncertainty		Dimensions of Uncertainty		Justification
		Magnitude	**Knowledge Base**	
1.3 Parameter	1.3.3 The objectiveness of all selected indicators	Medium	Low	*The objectivity of 30 selected indicators is analysed and rated by good, medium, and poor respectively (Table 7. 5). 19 indicators are marked as "medium" because they are rated according to the qualitative standard, which inevitably contains subjective judgments. Assuming that the medium level of subjectivity means 50% error, then the uncertainty of the subjectivity of these 20 indicators can maximally cause the error of 31.6% (19*0.033*0.5) of final SSI results.*
	1.3.4 The uncertainty of measurement of outdoor temperature.	Low	Low	*The uncertainty might lie in the measurement of the initial diagnosis of Indicator C2-2 (Temp. Difference) due to the measurement tool and other unexpected issues. However, the potential errors can be weakened by the rating system and aggregation methods. According to the calculation, the maximal bias of the final SSI that causes by C2-2 is 3.3%.*
	1.3.5 The uncertainty of measurement of average street noise.	Low	Low	*The uncertainty might lie in the measurement of the initial diagnosis of the indicator C3-1 (Average emission of noise) due to the measurement tool and other unexpected issues. However, the potential errors can be weakened by the rating system and aggregation methods. According to the calculation, the maximal bias of the final SSI that causes by C3-1 is 3.3%.*
2. DATA NORMALISATION				
2.1 Scenario	2.1.1. The 3-point-system is designed to the method of categorical scale.	Low	Low	*The other practical choices could be a 5-points system and a 10-points system. The possible error of SSI comes from the error of conversion of different systems, and the maximum error is 23.3% (1/3-1/10).*
2.2 Model	2.2.1 The threshold selection of indicators of Type M.	Low	Low	*The threshold selection for indicators of Type M is based on various and extensive pieces of literature, national policies, and local design guidance. They are checked by statistics of 76 sample streets with the principle of a general normal distribution. Then if the accuracy of the normal distribution is required strictly (the distribution with more than 10% variation causes uncertainty), then the potential uncertainty might lie in the indicators of C3-1 and C13-2 and might result in 6.7% (2indicators *0.333 Avg. weights) to the maximum.*
	2.2.2 The threshold selection of indicators of Type D.	Medium	Low	*The thresholds selection for indicators of Type D is based on various and extensive pieces of literature, national policies, and local design guidelines. Also, they are preliminarily tested in the 1st Field Survey and optimised by the detailed analysis of 38 typical streets. If accounting the subjectivity lying in the design of normalisation method for these 19 indicators, the potential error which result in final SSI is 31.6% (19*0.0333*0.5) (which is similar to calculation logic for 1.3.3).*

Sources of Uncertainty		Dimensions of Uncertainty		Justification
		Magnitude	Knowledge Base	
2.2 Model	2.2.3 The threshold selection o of indicators of Type C	Low	Low	*The thresholds selection for indicators of Type C is based on the basic calculation of officially published indexes. Also, they are checked by the statistics of 236 sample streets. The added value of urban street is difficult to calculate separately because of other conditions like location and buildings quality. So even assuming the potential uncertainty goes to the maximum, the errors which result in final SSI is 6.7% (2 indicators*0.0333 Avg. weight).*
2.3 Parameter	2.3.1 The accuracy of measurement and normalisation method of C2-2 (Air Temp. Difference)	Low	Medium	*Some academic researches convince the design and selection of data measurement and the thresholds of the rating system. Also, the design of survey times and specific procedure further increase the accuracy. The potential uncertainty can lead 3.3% (Avg. Weight) the error of the final SSI to the max.*
	2.3.2 the usage of 10-mins-survey results of daytime as the initial diagnosis for C3-1 (Avg. emission of Noise)	Low	Medium	*Some academic paper can prove the reliability of the survey design. However, even assuming there are still some unexpected uncertainties causing the error of final SSI results, the maximal bias is 3.3% (Avg. Weight).*
	2.3.3 The calculation scheme of initial diagnosis and rating system of indicators of C9-1 (Diversity of Street Activities) are designed based on the survey results of 76 sample streets.	Low	Low	*Sufficient literature indicates that the sample size of 76 Shanghai streets is relatively representative. Also, the design of observation time further promotes the survey results comprehensive and objective. However, the potential uncertainty might still lie in special street activities. The uncertainty can lead to 3.3% (Avg. Weight) error of the final SSI to the max.*
	2.3.4 The calculation scheme of initial diagnosis and rating system of indicators of C13-1 (Density of shops) are designed based on academic research and the survey results of 76 sample streets.	Low	Medium	*Some academic studies can prove the reliability of the calculation scheme and rating system. However, considering the potential uncertainties, like the cultural influence, various land use, and different commercial types, the maximum error of the final SSI which caused by C13-1 is 3.3% (Avg. Weight).*

Sources of Uncertainty		Dimensions of Uncertainty		Justification
		Magnitude	Knowledge Base	
2.3 Parameter	2.3.5 The calculation scheme of initial diagnosis and rating system of indicators of C13-2 (Types of temporary business) are designed based on the survey results of 76 sample streets.	Low	Low	*Sufficient literature indicates that the sample size of 76 Shanghai streets is relatively representative, and the design of observation time further promotes the comprehensiveness and objectivity of the survey. However, the potential uncertainty might still exist due to the other unexpected issues, and the uncertainty of C13-2 can lead to 3.3% (Avg. Weight) error of the final SSI to the max.*
	2.3.6 The calculation scheme of initial diagnosis and rating system of indicators of C14-2 (Types of jobs) are designed based on the survey results of 76 sample streets.	Low	Low	*Sufficient literature indicates that the sample size of 236 Shanghai streets is relatively to be representative, and the design of observation time further promotes the comprehensiveness and objectivity of the survey. However, the potential uncertainty might still exist due to the other unexpected issues, and the uncertainty of C13-2 can lead to 3.3% (Avg. Weight) error of the final SSI to the max.*
	2.3.7 The normalisation scheme of C15-1 (added-value of commercial rents)	Low	Medium	*The normalisation scheme and rating system of C15-1 are designed based on the combination of both some academic studies and statistics of 76 sample streets. Considering the potential uncertainty, such as the influence of location, culture, and social activities, the maximum error of the final SSI which caused by this could be 3.3% (Avg. Weight).*
	2.3.8 The normalisation scheme of C15-2 (added-value of housing prices)	Low	Medium	*The normalisation scheme and rating system of C15-2 are designed based on the combination of both some academic studies and statistics of 76 sample streets. Considering the potential uncertainty, such as the influence of location, culture, and social activities, the maximum error of the final SSI which caused by this could be 3.3% (Avg. Weight).*
3. WEIGHTING SCHEME				
3.1 Scenario	3.1.1 The selection and authority of the expert panel	Low	Low	*Sufficient evidence can prove the selection of expert panel reasonable, like the education background and working experiences. Some potential uncertainties might still exist, like personal prejudice and the misunderstanding of questions. However, the maximum influence on the final SSI is limited. The weighted coefficient of each sub-targets is constant, namely 0.333, so the results of the questionnaire survey only affect the weights of those criteria and indicators within the same sub-target. Therefore, objectively speaking, the impact of this uncertainty on the final SSI is less than 30%.*

Sources of Uncertainty		Dimensions of Uncertainty		Justification
		Magnitude	Knowledge Base	
3.2 Model	3.2.1 The uncertainty of the calculation of weighing system from the expert questionnaire	Low	Low	*Sufficient literature and scientific evidence can prove the reliability of the calculation of weighing system. Even assuming that there are still some uncertainties due to unexpected issues, the impact of them on the final SSI is less than 30%. Because the weighted coefficient of each sub-targets is constant, namely 0.333, so the results of the questionnaire survey only affect the weights of those criteria and indicators within the same sub-target.*
3.3 Parameter	3.3.1 The accuracy of questionnaire results	Low	Low	*Survey procedure, respondent selection, results' review, and the check of survey time are identified as the methods to promote the accuracy of questionnaire survey by sufficient literature and evidence. Even assuming that there are still some uncertainties due to unexpected issues, the impact of them on the final SSI is less than 30%. Because the weighted coefficient of each sub-targets is constant, namely 0.333, so the results of the questionnaire survey only affect the weights of those criteria and indicators within the same sub-target.*
4. INDICATOR AGGREGATION				
4.1 Scenario	4.1.1 The uncertainty of aggregation rule	Low	Low	*No compensability among three aspects of sustainability is defined as the key aggregation rule, which is supported by the various academic literature. Also, the different choice of aggregation methods does not cause the error of final SSI but the different numerical interval.*
4.2 Model	4.2.1 The uncertainty of aggregation method from the indicator layer to criteria layer.	Low	Low	*Sufficient academic literature convinces the linear relationship between the indicator layer and criteria layer. Also, the different choice of aggregation methods does not cause the error of final SSI but a different numerical interval.*
	4.2.2 The uncertainty of aggregation method from criteria layer to sub-target layer.	Low	Low	*Sufficient academic literature convinces the linear relationship between the sub-target layer and criteria layer. Also, the different choice of aggregation methods does not cause the error of final SSI but a different numerical interval.*
	4.2.3 The uncertainty of aggregation method from sub-target layer to the target layer.	Low	Low	*Sufficient academic literature convinces the geometric relationship between the sub-target layer and the target layer. Also, the different choice of aggregation methods does not cause the error of final SSI but a different numerical interval.*

Sources of Uncertainty		Dimensions of Uncertainty		Justification
		Magnitude	Knowledge Base	
4.3 Parameter	4.3.1 The evaluation results of EnSI, SoSI, and EcSI are 10 times their initial results.	Low	Low	*The initial results are amplified synchronously in a linear manner, which does not cause any error of the final SSI.*
5. FULL CHAIN				
5.1 Scenario	5.1.1 Suitability of long-term versus short-term effects for this evaluation	Low	Low	*The performance of an urban street should be a relatively steady situation except for retrofit or the experience of special events. However, four indicators (C2-2, C9-1, C12-2, and C13-2) are pointed out in Table 4.10 since the assessment results might vary with the observation time. In other words, the assessment results might be inaccurate regarding the long-term/short-term effects, and the maximal errors are 13.3% (4 indicators *0.033 Avg. Weights).*
5.2 Model	5.2.1 Three valid numbers are retained throughout the calculation.	Low	Low	*Sufficient literature shows the calculation rule that three valid numbers are retained is reasonable. Even there is a little bit of error within the aggregation, but the error is within 1%.*
5.3 Parameter	5.3.1 The indicators of Mode M are unavailable due to various reasons.	Low	Low	*There are eight indicators of Mode M, five of which are measured on site and the other three are from field counting. So given some unpredictable circumstances, if the five indicators which rely on on-site measurement are not available or the obtained data is not accurate, then the error of final SSI is 16.7% (5 indicators * 0.033 Avg. Weights).*

Magnitude Category:

- ***Low**: bias is between 0% and 30% (including 30%)*
- ***Medium**: bias is between 0% and 60% (including 60%)*
- ***High:** bias is over 60%*

Knowledge Category:

- ***Low:** consistent extensive scientific evidence*
- ***Medium**: less extensive or mixed evidence*
- ***High:** limited, inconsistent or no evidence*

7.7 Summary

Chapter 7 introduced the establishment procedure of the Indicator System of sustainability evaluation of Shanghai streets, including the selection of indicators, the design of normalisation methods, calculation of weighting system, and choice of aggregation model. **The established system consisted of 1 composite Index (SSI), 3 Sub-Index (EnSI, SoSI, and EcSI), 15 evaluation criteria, 30 indicators (Table 7. 4), a series of normalisation methods (30 Datasheets in Chapter 7.3), a set of weighting system (Table 7. 37), and corresponding aggregation model (Table 7. 39).**

Firstly, a total of 30 indicators were selected for the evaluation system based on an in-depth analysis of feasibility. The characteristics, including the definition, calculation methods, measurement units, and acquisition mode, of selected indicators were illustrated in Table 7. 4. Also, the quality of selected indicators and the soundness of the Indicator System were examined in Table 7. 5.

Regarding the indicators' normalisation, the Categorical Scale was selected as the normalisation method because of the characteristics of selected indicators and evaluation property, and the three-point system (a score between 0 and 3) was adopted for the scoring system. The specific normalisation methods and thresholds' selection of all selected indicators were identified respectively in Chapter 7.3.

The Weighting System was built accordingly based on the overall evaluation framework (Figure 7. 2). The Equal Weighting was adopted for the sub-target and indicator layers, and the average scores of evaluation criteria in the Expert Questionnaire were used to calculate the weight coefficients of the criteria layer.

Regarding the aggregation model, the method of arithmetic summation was employed for the step one and step two of the aggregation, and the Geometric Mean was adopted for the step three of aggregation. Table 7. 39 shows a whole aggregation procedure and calculation formulas for the Indicator System.

Finally, the research established the Indicator System of Sustainability Evaluation for Shanghai streets. The qualitative Uncertainty Analysis (UA) was employed to assess the robustness of the established Indicator System. Assessment results showed the system was robust in general. The most uncertainties lied in the stage of indicator selection and data normalisation, but the dimensions of all potential uncertainties were between low and medium.

Chapter 8. Sustainability Evaluation of Three Shanghai Streets

8.1 Introduction

Chapter 8 introduces the two sets of assessment results of three Shanghai streets that were obtained from the Indicator System of sustainability evaluation and street questionnaire of sustainability appraisal respectively. Through the cross-comparison of evaluation results and cases, a series of optimisation points of Indicator System is summarised accordingly.

Chapter 8.2, Chapter 8.3, and Chapter 8.4 analyse the assessment results and statistical comparison of Madang Rd, Daxue Rd, and Sujiatun Rd respectively. The analysis of each street consists of four parts:

1) A brief introduction of the street background, including street location, length, type, and features;
2) Analysis of the statistical results of the Indicator System of sustainability evaluation of the street;
3) Analysis of the statistical results of the questionnaire survey of the street;
4) A comparison between two sets of assessment results of the street.

Finally, Chapter 8.5 presents a comprehensive cross-comparison among the assessment results and studied cases. Based on the comparison findings, the application experiences the Indicator System will be further analysed, thereby summarising a series of improvement points of Indicator System.

8.2 Case One: Madang Rd

8.2.1 Brief

Madang Rd is in the centre of Shanghai. Its total length is 1700 meters, from the north side of West Jinlin Rd to the south side of Xujiahui Rd. This road was firstly built in Qing Dynasty (1898) and named Langshan Rd. After that, this area became the French concession, and in 1906 this street was renamed as Rue Brenier de Montmorand which was the name of French consul general in Shanghai.

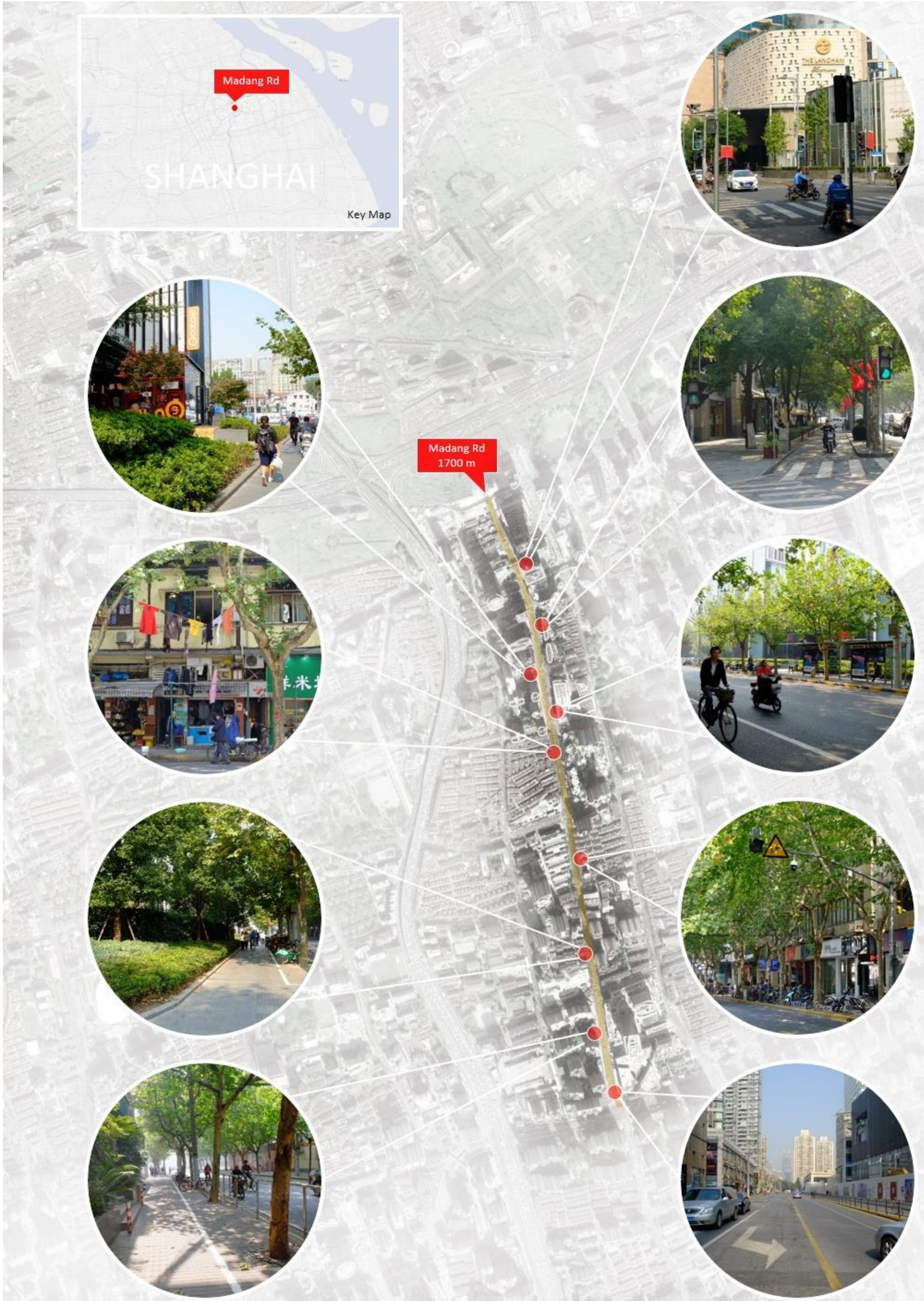
In about 1946, the Chinese government took back the concession and renamed the street again as the current name of “Madang Rd” which was a city name of Jiangxi Province.

In history, the two sides of this street were mainly Shikumen-Style residential buildings. Shikumen is a typical style of Shanghai residential buildings that integrated both western and traditional Chinese architectural style. Many cultural celebrities used to live here. Madang Rd has been experienced several renovations since 1949 (the foundation of the People’s Republic of China). Unfortunately, many historic buildings were knocked down, and some office towers and big commercial squares were built along the street. After 2000, People started to realise the significance of historic preservation and inheritance. The Xintiandi was developed in 2007. It is one of the most significant development projects along Madang Rd. The texture and façade of Shikumen buildings were retained and space was transformed from residential into commercial function. Nowadays, Xintiandi has been a tourist attraction. Also, Madang Rd became a famous tourist destination. More and more business activities, like cafés, dining, and product displaying, happen along the street. Today, Madang Rd is no longer a densely populated residential street in history, but a famous multi-functional street in the city centre which is integrated with tourism, culture display, leisure, and entertainment.

In the 1st Field survey, Madang Rd got the highest score among 236 sample streets concerning sustainability assessment and was prominent in social and economic sustainability.

Table 8. 1: Brief of Madang Rd

Location	City Center
Total Length	1700 meters
Built	In 1898
Type	multi-functional urban branch
Feature	- A history of 120 years - Sided by typical Shikumen-style buildings - One of the most popular tourist destinations in Shanghai for site-visiting and entertaining.



Photoed and made by the author. Source of satellite map: (Baidu, 2017)

Figure 8. 1: Analysis Graph of Madang Rd

8.2.2 Evaluation Results of the Indicator System

Madang Rd was investigated three times on 15th Jul., 3rd Nov., and 5th Nov. 2017 respectively. Table 8. 2 illustrates the results and details of the initial diagnosis and normalisation process of each indicator. Table 8. 3 shows the aggregation results and the detailed scores at all levels of the evaluation framework.

It can be seen from the score statistics that the average of 30 evaluated indicators was 2.33 (score range was from 0 to 3 points). Among them, the number of indicators getting the full score of 3 points was 17, accounting for 56.7%; the number of indicators getting 2 points was 8, accounting for 26.7%; the indicators getting 1 point were C2-1 (Street Green Rate), the C4-1 (Rainwater management), C12-2 (Traffic Performance Index) respectively, accounting for 10%; and two indicators getting 0 point were C2-2 (Air Temp. Difference) and C3-1 (Average Emission of Noise) respectively, accounting for 6.7% of the total.

Based on the designed aggregation methods, the values of 15 evaluation criteria were calculated by the 30 indicators. The average score of 15 criteria was 0.156 (range from 0 to 0.208). The criterion of C11 (Intensive Land Use) gained the highest score of 0.208, followed by C7 (safety) with a score of 0.206 and C6 (Equality) with a score of 0.203. The lowest score was gotten by C2 (Mitigation UHI) with a score of 0.032, and followed by C3 (Pollution Reduction) with a score of 0.0067 and C4 (Ecological Balance) with a score of 0.099.

Then, the values at the sub-target layer were calculated according to the aggregation formula. In the sub-target layer, Social Sustainability Index (SoSI) obtained the highest score of 9.67 (range from 0 to 10), and Economic Sustainability Index (EcSI) got 8.29. However, Environmentally Sustainable Index (EnSI) was only 5.4. It can be found that the variation among the three aspects of sustainability of Madang Rd was relatively large: it was excellent in the aspect of social sustainability and at a low level concerning environmental sustainability.

At last, the final Sustainable Street Index (SSI) of Madang Rd was 7.56.

Figure 8. 2 and Figure 8. 3 present the sustainable evaluation results of Madang Rd and illustrate the scores in each evaluation layers as well as the relationships among four evaluation layers in the form of bar chart and radar graph respectively. It can be seen that with regard to the social sustainability of Madang Rd, nine out of total ten evaluation indicators gained the highest 3 points and only C8-2 (Clear Sign and Guidance System) got 2 points, therefore the corresponding evaluation criteria, namely C6 (Equality), C7 (Safety), C8 (Accessibility), C9 (Diversity), and C10 (Culture Inheritance), obtained relatively high scores, and consequently the score of SoSI was 9.67

which almost reached the full score. In the aspect of environmental sustainability, the average score of ten corresponding evaluation indicators was only 1.6, and two indicators got 0 point. This directly led to the lower scores of corresponding evaluation criteria, and the scores of C2 (Mitigation UHI), C3 (Pollution Reduction) and C4 (Ecological Balance) were the lowest three in the total 15 criteria. As a result, the EnSI of Madang Rd was only 5.4 which was a pretty low score in the evaluation framework. Regarding the economic sustainability of Madang Rd, the overall performance was good. Explicitly speaking, six out of ten indicators got the full score of 3 points, three indicators got 2 points, and only one indicator, namely C12-2 (Traffic Performance Index), got 1 point. Therefore, after aggregation, the average of the five corresponding criteria was 0.166 (range from 0 to 0.208) which was above the average level. Consequently, the EcSI of Madang Rd was 8.29 which was also a pretty high score.

Table 8. 2: Detailed Calculation Process of Indicators of Madang Rd

<table>
<thead>
<tr><th>Indicators Code</th><th>Indicators Title</th><th>Acquisition Mode</th><th>Initial Diagnoses</th><th>Normalised Values</th><th>Details of Initial Diagnoses and Normalisation</th></tr>
</thead>
<tbody>
<tr><td>C1-1</td><td>Adaptable Capacity to Local Climate</td><td>D</td><td>3 ticks</td><td>3</td><td>Total number of ticks below is 3
✓ The choice of street trees and other plants suits Shanghai climate (hot summer and cold winter) and helps to maximise the time for comfortable activities in streets;
✓ Street furniture (including the bus station, street seats, & pavement shops) and facilities (like sharing/canopy) in frontage zone suits Shanghai climate (hot summer, cold winter and relatively rainy all year);
✓ A reasonable combination of plaza and green space in streets and proving flexibility for future.
Therefore, according to the normalisation rules, the normalised value of the indicator C1-1 is 3 since it has 3 ticks in the initial diagnosis.</td></tr>
<tr><td>C1-2</td><td>Adaptable Capacity to Extreme Weather Events</td><td>D</td><td>2 ticks</td><td>2</td><td>Total number of ticks below is 2
✓ All street furniture and facilities are durable and secure;
❑ Smart alarm and notification for extreme weather events in the street;
✓ Emergency safety measurements for extreme weather situation, like windstorm and flooding.
Therefore, according to the normalisation rules, the normalised value of the indicator C1-2 is 2 since it has 2 ticks in the initial diagnosis.</td></tr>
<tr><td>C2-1</td><td>Street Green Rate</td><td>M</td><td>21%</td><td>1</td><td>The street width is below 40 meters, and the street green rate is 21%. Hence according to the normalisation rules, the normalised value of the indicators C2-1 is 1.</td></tr>
<tr><td>C2-2</td><td>Air Temp. Difference</td><td>M</td><td>-0.17℃</td><td>0</td><td>Details of temperature measurement and the calculation of temperature difference:
Measurement Date: 25th Jul. 2017; Weather: Sunny
<table>
<tr><td>Measurement Time</td><td>10am</td><td>12am</td><td>2pm</td></tr>
<tr><td>Regional Air Temp. (℃)</td><td>36</td><td>39</td><td>40</td></tr>
<tr><td>Air Temp. of On-site Measurement (℃)</td><td>36.2</td><td>38.5</td><td>40.8</td></tr>
<tr><td>Temp. Difference (℃)</td><td>-0.2</td><td>0.5</td><td>-0.8</td></tr>
<tr><td>Average Temp. Difference (℃)</td><td></td><td></td><td>-0.17</td></tr>
</table>
Therefore, according to normalisation rules, the normalised value of the indicator C2-2 is 0 as the Air Temp. Difference is -0.17 ℃ (below 1℃).</td></tr>
</tbody>
</table>

<table>
<thead>
<tr><th>Indicators Code</th><th>Indicators Title</th><th>Acquisition Mode</th><th>Initial Diagnoses</th><th>Normalised Values</th><th>Details of Initial Diagnoses and Normalisation</th></tr>
</thead>
<tbody>
<tr><td>C3-1</td><td>Average Emission of Noise</td><td>M</td><td>74.825 Decibel</td><td>0</td><td>Details of on-site Measurement are shown in the table below:
<table>
<tr><td>Measurement Date (weather)</td><td colspan="2">03/11/2017 (Cloudy)</td><td colspan="2">05/11/2017 (Cloudy)</td></tr>
<tr><td>Measurement Time</td><td>7-8am</td><td>1-2am</td><td>11-12am</td><td>2-3m</td></tr>
<tr><td>Noise (Decibel)</td><td>79.5</td><td>71.5</td><td>76.5</td><td>73.4</td></tr>
<tr><td colspan="4"><u>Average of Noise (Decibel)</u></td><td><u>75.2255</u></td></tr>
</table>
Therefore, according to normalisation rules, the normalised value of the indicator C3-1 is <u>0</u> as the measured average noise is <u>above 75 Decibel.</u></td></tr>
<tr><td>C3-2</td><td>Pollution Reduction</td><td>D</td><td>2 ticks</td><td>2</td><td>Total number of ticks below is <u>2</u>
✓ The usage of Environmentally friendly or recycled materials or construction technologies for pavement, curb and other street furniture to reduce pollution.
❑ The usage of the energy-efficient system or renewable energy for lighting;
✓ The provision of the bins with clear recycling category in street.
Therefore, according to the normalisation rules, the normalised value of the indicator C3-2 is <u>2</u> since it has <u>2 ticks</u> in the initial diagnosis.</td></tr>
<tr><td>C4-1</td><td>Rainwater management</td><td>D</td><td>1 tick</td><td>1</td><td>Total number of ticks below is <u>1</u>:
✓ Reasonable road vertical design and permeable pavement for rainwater drainage;
❑ The use of rain garden for rain management;
❑ Smart alarm and notification for the rainstorm in the street.
Therefore, according to the normalisation rules, the normalised value of the indicator C4-1 is <u>1</u> since it has <u>1 tick</u> in the initial diagnosis.</td></tr>
<tr><td>C4-2</td><td>Ecological Planting</td><td>D</td><td>2 ticks</td><td>2</td><td>Total number of ticks below is <u>2</u>
✓ All streets' plants are local;
✓ Diversity of plants (the species of plants within one street are more than 5*)
❑ The usage of rainwater recovery or reused water for plant irrigation in streets
Therefore, according to the normalisation rules, the normalised value of the indicator C4-2 is <u>2</u> since it has <u>2 ticks</u> in the initial diagnosis.</td></tr>
</tbody>
</table>

Indicators Code	Indicators Title	Acquisition Mode	Initial Diagnoses	Normalised Values	Details of Initial Diagnoses and Normalisation
C5-1	***Green Lifestyle Promotion***	D	2 ticks	2	Total number of ticks below is 2 ❑ *Advertising and publicity of green lifestyle;* ✓ *Regular street show and activities for green life;* ✓ *Space to encourage green lifestyle, like jogging path, plaza and open space along the street* Therefore, according to the normalisation rules, the normalised value of the indicator C5-1 is 2 since it has 2 ticks in the initial diagnosis.
C5-2	***Green Travel Support***	D	3 ticks	3	Total number of ticks below is 3 ✓ *Provision of a minimum-1.5m-width sidewalk with comfortable, reliable and pleasant facilities and atmosphere;* ✓ *Provision of a minimum-1.5m-width cycling lane, cycling parking space, and sharing bike station.* ✓ *Provision of the comfortable bus station and clear transit information.* Therefore, according to the normalisation rules, the normalised value of the indicator C5-2 is 3 since it has 3 ticks in the initial diagnosis.
C6-1	***Tactile pavement for the blind***	D	Excellent Performance	3	According to the normalisation rules, the normalised value of the indicator C6-1 is 3 since it shows "Excellent Performance" (t*he tactile pavement for the blind in the street are without breakage or cutting off*) in terms of tactile pavement for the blind.
C6-2	***Barrier-Free Facilities***	D	3 ticks	3	Total number of ticks below is 3 ✓ *Enough space in through zone for wheelchair and baby stroller;* ✓ *Barrier-free design in street intersection;* ✓ *Barrier-free facilities when there is a vertical difference within the sidewalk.* Therefore, according to the normalisation rules, the normalised value of the indicator C6-2 is 3 since it has 3 ticks in the initial diagnosis.
C7-1	***Coverage Proportion of Street Cameras***	M	100%	3	According to the normalisation rules, the normalised value of the indicator C7-1 is 3 since the coverage proportion of street cameras is 100%.

Indicators Code	Indicators Title	Acquisition Mode	Initial Diagnoses	Normalised Values	Details of Initial Diagnoses and Normalisation
C7-2	***Coverage Safety Equipment***	D	7 ticks	3	Total number of ticks below is 7 ✓ *Anti-skidding pavement in the sidewalk;* ❑ *Coloured or marks pavement for cycling lanes;* ✓ *Sufficient lighting at night for street safety;* ✓ *Safe getting up/down in bus station;* ✓ *Bollards or planting to separate travel lanes and sidewalks;* ✓ *All street signs and signals are clear, tide-ordered and visible;* ✓ *Various ways to control car speed, including the clear sign of allowed car speed, speed hump or chicanes.* ✓ *In the intersection, featured and highlighted marks on the ground to remind of safety and protect cyclists and pedestrians;* ❑ *Various methods for a safety intersection, such as the curb extension in intersection to reduce crossing distance for pedestrian and decrease car speed, provision of medians for safety island if the street intersection is wide, sound reminder if the crossed traffic is large, skyway or underground passages for pedestrians if necessary* Therefore, according to the normalisation rules, the normalised value of the indicator C7-2 is 3 since it has 7 ticks (between 7-9 ticks) in the initial diagnosis.
C8-1	***The Variety of Arrival Ways***	D	6 ticks	3	Total number of ticks below is 6 ✓ *Walking: provision of sidewalks (at least 1.5m width for each) on both sides;* ✓ *Cycling: provision of separated or sharing cycling lanes on both sides, and cycling parking space;* ✓ *Public bus: there are bus station within 300m away from the street;* ✓ *Taxi: provision of taxi ranks or taxi Boarding Area;* ✓ *Car: provision of parking lots within 300m away from the street;* ✓ *Special car accessibility: guaranteeing emergency cars, like the ambulance, fire-fighting truck, to access.* Therefore, according to the normalisation rules, the normalised value of the indicator C8-1 is 3 since it has 6 ticks in the initial diagnosis.

Indicators Code	Indicators Title	Acquisition Mode	Initial Diagnoses	Normalised Values	Details of Initial Diagnoses and Normalisation
C8-2	***Clear Sign and Guidance System***	D	2 ticks	2	Total number of ticks below is 2 ✓ *Provision of clear signs of basic street information, including street name, direction, and traffic regulation;* ✓ *Provision of extra information of surrounding situation;* ❑ *Provision of smart wayfinding system.* Therefore, according to the normalisation rules, the normalised value of the indicator C8-2 is 2 since it has 2 ticks in the initial diagnosis.
C9-1	***Diversity of Street Activities***	M	9 pcs	3	Total number of activities observed on the street is 9 ✓ *Strolling* ✓ *Dog walking* ✓ *Sitting* ✓ *Meeting friends* ✓ *Kids playing* ✓ *Jogging & physical exercise* ✓ *Watching newspaper/reading books* ❑ *Playing chess/cards in groups* ✓ *Shopping* ✓ *Drinking & Eating* Therefore, according to the normalisation rules, the normalised value of the indicator C9-1 is 3 since the number of activity types observed in the street is 9 (between 7 and 10) in the initial diagnosis.
C9-2	***Diversity of Street Functions***	D	5 ticks	3	Total number of ticks below is 5 ✓ *Traffic function* ✓ *Social function* ✓ *Commercial function* ✓ *Cultural function* ✓ *Political function* ❑ *Ecological function* Therefore, according to the normalisation rules, the normalised value of the indicator C9-2 is 3 since it has 5 ticks (between 5 and 6) in the initial diagnosis.

Indicators Code	Indicators Title	Acquisition Mode	Initial Diagnoses	Normalised Values	Details of Initial Diagnoses and Normalisation
C10-1	***Aesthetic Quality of Street Furniture***	D	Excellent Performance	3	According to the normalisation rules, the normalised value of the indicator C10-1 is 3 since it shows an Excellent Performance in terms of aesthetic quality of street furniture. (*All street elements (including seats, Bollards, Pedestrian Guardrails, Bins, Public art, telephone boxes, parking control equipment, post and pouch boxes, smoke vents, bus station, pavement, lighting system, information station, cycling parks, and kerb) are designed dedicatedly and form as a whole and display high aesthetic quality)*
C10-2	***Style Consistency with Surroundings***	D	Excellent Performance	3	According to the normalisation rules, the normalised value of the indicator C10-2 is 3 since it shows an Excellent Performance in terms of style consistency with surroundings (*Streetscape highlights and well displays local culture and historic heritage).*
C11-1	***Intensiveness of Street Space***	D	3 ticks	3	Total number of ticks below is 3 ✓ *The reasonable width of travel lanes, cycling lanes, and sidewalk.* ✓ *Reasonable and Intensive design of intersection land;* ✓ *Integration design of street furniture to save the street land* Therefore, according to the normalisation rules, the normalised value of the indicator C11-1 is 3 since it has 3 ticks in the initial diagnosis.
C11-2	***Mixed-Use of Street Land***	D	3 ticks	3	Total number of ticks below is 3 ✓ *To open building setback and design together between building line and the sidewalks inside the street red line* ✓ *Sharing street, such as tidal changeable lanes, travel & cycling sharing street;* ✓ *Multi-functional street space: changeable parking strip, temporary pavement cafe.* Therefore, according to the normalisation rules, the normalised value of the indicator C11-2 is 3 since it has 3 ticks in the initial diagnosis.
C12-1	***Intelligent Transportation System***	D	2 ticks	2	Total number of ticks below is 2 ✓ *Intelligent public bus system to show real-time bus arrival time in bus station;* ✓ *Intelligent parking system to show real-time number of parking spaces;* ❑ *Intelligent traffic system to show real-time traffic condition.* Therefore, according to the normalisation rules, the normalised value of the indicator C12-1 is 2 since it has 2 ticks in the initial diagnosis.

<table>
<tr><th>Indicators Code</th><th>Indicators Title</th><th>Acquisition Mode</th><th>Initial Diagnoses</th><th>Normalised Values</th><th>Details of Initial Diagnoses and Normalisation</th></tr>
<tr><td>C12-2</td><td>Traffic Performance Index</td><td>N</td><td>Crowded</td><td>1</td><td>Based on the normalisation rules, the normalised value of the indicator C12-2 is 1 since according to the official published data from Shanghai Urban and Rural Construction and Traffic Development Institute the Year Average Traffic Performance of Madang Rd is Crowded (The traffic condition is average, the average traffic density of the road network is large, the speed is not high, and a remarkable proportion of the road is congested or blocked).</td></tr>
<tr><td>C13-1</td><td>Density of Shops</td><td>M</td><td>5.24 shops/ 100meters</td><td>2</td><td>The detail information of shops number and the calculation process are shown in the table below:
<table>
<tr><th></th><th>East Side</th><th>West Side</th><th>Total</th></tr>
<tr><td>Number of Shops along Street</td><td>111</td><td>67</td><td>178</td></tr>
<tr><td>Street Length (Meters)</td><td>1700</td><td>1700</td><td>3400</td></tr>
<tr><td>Average Shops per 100 Meters</td><td></td><td></td><td>5.24</td></tr>
</table>
Therefore, according to the normalisation rules, the normalised value of the indicator C13-1 is 2 as its initial diagnosis is 5.24 shops/100meters (between 2 and 7shops/meters).</td></tr>
<tr><td>C13-2</td><td>Types of Temporary Business</td><td>M</td><td>3 ticks</td><td>2</td><td>Total number of ticks below is 3
✓ Temporary pavement café & F&B;
❑ Temporary food station;
✓ Temporary show spot
❑ Temporary flower station;
✓ Mobility Street vendor (cigarettes, disc, girls' accessory, clothes, portrait drawing, street show and etc.)
Therefore, according to the normalisation rules, the normalised value of the indicator C13-2 is 2 since it has 3 ticks (2-3 ticks) above.</td></tr>
<tr><td>C14-1</td><td>Employment Creation</td><td>D</td><td>Excellent Performance</td><td>3</td><td>According to the normalisation rules, the normalised value of the indicator C14-1 is 3 since it shows Excellent Performance in terms of jobs creation (There are various jobs created in/along the street, and the employment creation is not only on the first floor but also in the whole sided buildings.)</td></tr>
</table>

<table>
<tr><th>Indicators Code</th><th>Indicators Title</th><th>Acquisition Mode</th><th>Initial Diagnoses</th><th>Normalised Values</th><th>Details of Initial Diagnoses and Normalisation</th></tr>
<tr><td>C14-2</td><td>Types of Jobs</td><td>M</td><td>7 ticks</td><td>3</td><td>Total number of ticks below is 7
✓ salesperson
✓ Waitress
✓ agent
✓ craftsman
✓ officers
✓ Parking administrator;
✓ Mobile Street vendor

Therefore, according to the normalisation rules, the normalised value of the indicator C14-2 is 3 since it has 7 ticks (between 6 and 7) in the initial diagnosis.</td></tr>
<tr><td>C15-1</td><td>Added Value of Commercial Rents</td><td>C</td><td>14.6%</td><td>3</td><td>Details of data calculation are shown in the table below:<table>
<tr><td>Average Rental fee along Madang Rd (RMB/㎡/Day)</td><td>14.43</td></tr>
<tr><td>Average rental fee in Huangpu District (RMB/㎡/Day)</td><td>12.33</td></tr>
<tr><td>Added Value of Commercial Rents (%)
$= \frac{(\textbf{Unit Price of Commercial Rent along the Street} - \textbf{Average Unit Price of Commercial Rent in this D}}{\textbf{Average Unit Price of Commercial Rent in this District}}$</td><td>14.6%</td></tr>
</table>Therefore, according to the normalisation rules, the normalised value of the indicator C15-1 is 3 since the initial diagnosis is 14.6% (above 10%) in the initial diagnosis.</td></tr>
<tr><td>C15-2</td><td>Added-Value of Housing Prices</td><td>C</td><td>37.3%</td><td>3</td><td>Details of data calculation are shown in the table below:<table>
<tr><td>Average housing price along Madang Rd (10,000RMB/㎡)</td><td>15.8</td></tr>
<tr><td>Average housing price in Huangpu District (10,000RMB/㎡)</td><td>9.9</td></tr>
<tr><td>Added Value of Housing Prices (%)
$\frac{(\textbf{Unit Housing Price along the Street} - \textbf{Average Unit Housing Price in this District})}{\textbf{Average Unit Housing Price in this District}}$</td><td>37.3%</td></tr>
</table>Therefore, according to the normalisation rules, the normalised value of the indicator C15-2 is 3 since the initial diagnosis is 37.3% (above 10%) in the initial diagnosis.</td></tr>
</table>

Table 8. 3: Table of Sustainability Evaluation Results of Madang Rd

Evaluation Framework				Weights	Evaluation Values			
Target Layer	Sub-Target Layer	Criteria Layer	Indicator Layer		Indicator Layer	Criteria Layer	Sub-Target Layer	Target Layer
SSI	***EnSI***	C_{1}	C_{1-1}	0.0338	3	0.169	5.40	7.56
			C_{1-2}	0.0338	2			
		C_{2}	C_{2-1}	0.0317	1	0.032		
			C_{2-2}	0.0317	0			
		C_{3}	C_{3-1}	0.0337	0	0.067		
			C_{3-2}	0.0337	2			
		C_{4}	C_{4-1}	0.0332	1	0.099		
			C_{4-2}	0.0332	2			
		C_{5}	C_{5-1}	0.0345	2	0.172		
			C_{5-2}	0.0345	3			
	SoSI	C_{6}	C_{6-1}	0.0338	3	0.203	9.67	
			C_{6-2}	0.0338	3			
		C_{7}	C_{7-1}	0.0344	3	0.206		
			C_{7-2}	0.0344	3			
		C_{8}	C_{8-1}	0.0334	3	0.167		
			C_{8-2}	0.0334	2			
		C_{9}	C_{9-1}	0.0331	3	0.198		
			C_{9-2}	0.0331	3			
		C_{10}	C_{10-1}	0.0322	3	0.193		
			C_{10-2}	0.0322	3			
	EcSI	C_{11}	C_{11-1}	0.0346	3	0.208	8.29	
			C_{11-2}	0.0346	3			
		C_{12}	C_{12-1}	0.0335	2	0.100		
			C_{12-2}	0.0335	1			
		C_{13}	C_{13-1}	0.0351	2	0.140		
			C_{13-2}	0.0351	2			
		C_{14}	C_{14-1}	0.0313	3	0.188		
			C_{14-2}	0.0313	3			
		C_{15}	C_{15-1}	0.0323	3	0.194		
			C_{15-2}	0.0323	3			

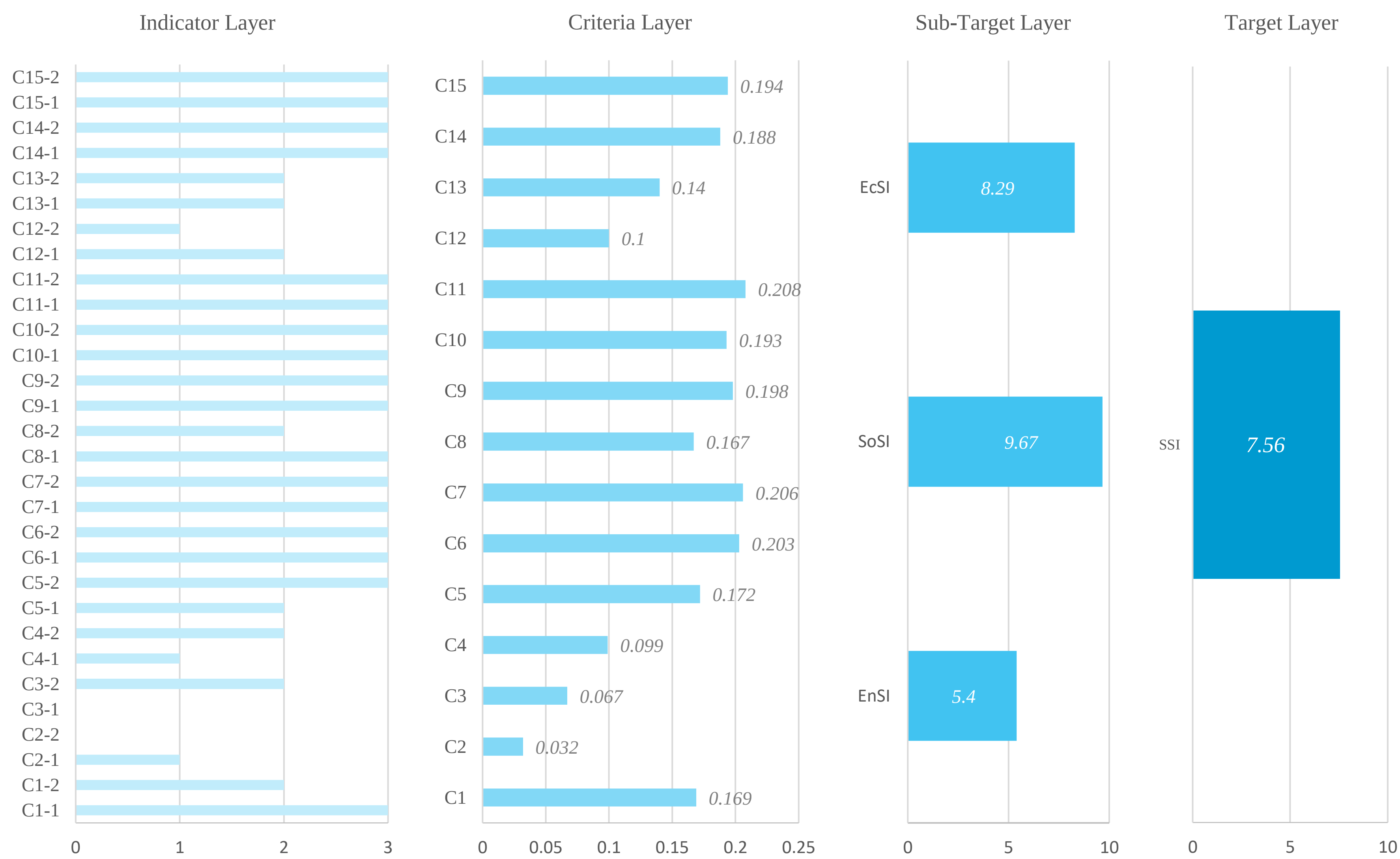
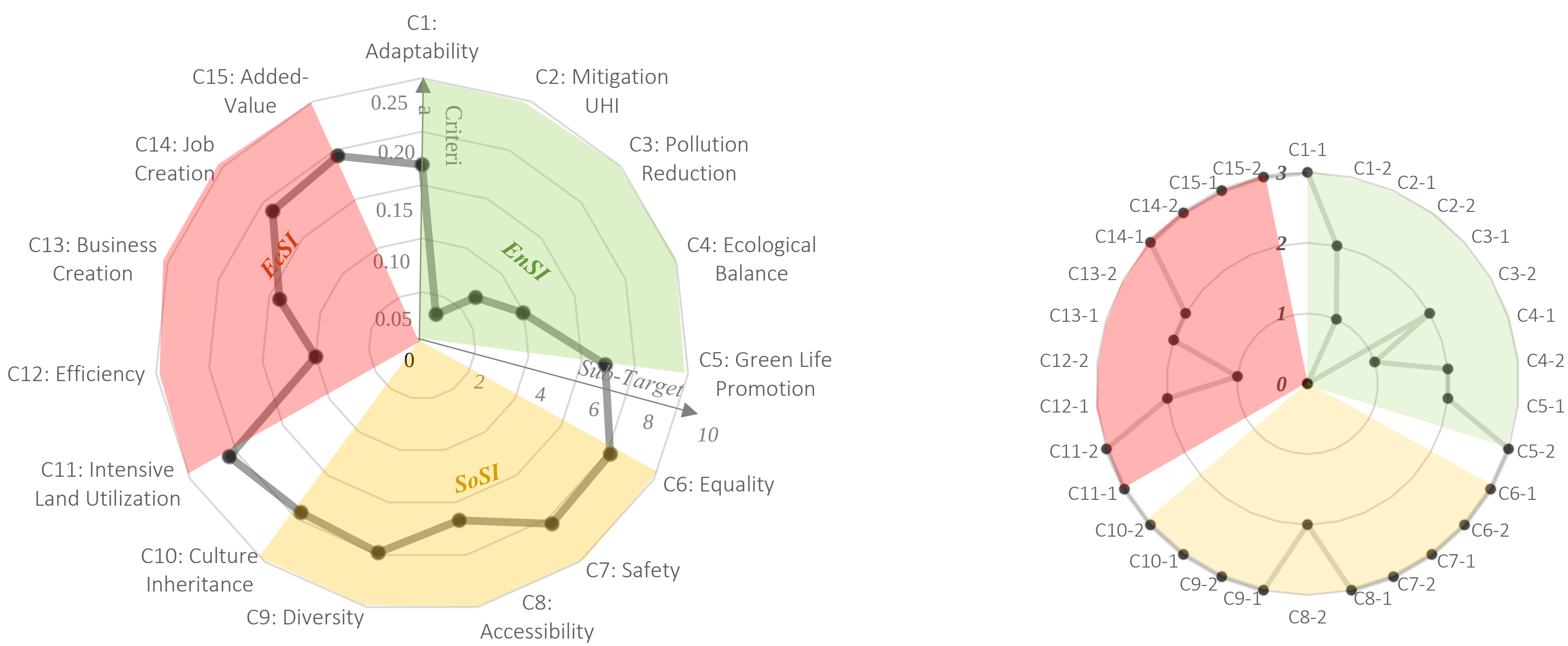


Figure 8. 2: Analysis Graphs of Sustainability Evaluation Results of Madang Rd



C1-1	Adaptable Capacity to Local Climate	**C2-1**	Street Green Rate	**C3-1**	Average Emission of Noise	**C4-1**	Rainwater management	**C5-1**	Green Lifestyle Promotion
C1-2	Adaptable Capacity to Extreme Weather Events	**C2-2**	Air Temp. Difference	**C3-2**	Pollution Reduction	**C4-2**	Ecological Planting	**C5-2**	Green Travel Support
C6-1	Tactile pavement for the blind	**C7-1**	Coverage Proportion of Street Cameras	**C8-1**	The Variety of Arrival Ways	**C9-1**	Diversity of Street Activities	**C10-1**	Aesthetic Quality of Street Furniture
C6-2	Barrier-Free Facilities	**C7-2**	Coverage Safety Equipment	**C8-2**	Clear Sign and Guidance System	**C9-2**	Diversity of Street Functions	**C10-2**	Style Consistency with Surroundings
C11-1	Intensiveness of Street Space	**C12-1**	Intelligent Transportation System	**C13-1**	Density of Shops	**C14-1**	Employment Creation	**C15-1**	Added Value of Commercial Rents
C11-2	Mixed-Use of Street Land	**C12-2**	Traffic Performance Index	**C13-2**	Types of Temporary Business	**C14-2**	Types of Jobs	**C15-2**	Added-Value of Housing Prices

Figure 8. 3: Radar Graphs of Sustainability Evaluation Results of Madang Rd

8.2.3 Evaluation Results of the Questionnaire Survey

The questionnaire surveys were issued on Madang Rd on 3rd Nov. 2017 and 5th Nov. 2017.

The on-site survey results were processed and organised into one spreadsheet of Microsoft Excel. Then, the integrity and effectiveness of the questionnaires were checked. The inspection was to check whether the respondents completed all answers and whether the answers of each questionnaire contained duplicates or errors. Based on this, 6 questionnaires were regarded as invalid due to the issues of integrity and effectiveness. Therefore, a total of 50 questionnaires were deemed to be valid.

Once the data was cleaned and get prepared, they were analysed and statistics accordingly so as to confirm the validness of these selected data (See Table 8. 4). The statistics of Average, Median, and Mode were to analyse the central tendency of survey results and to compare the differences among these three values of each evaluation criterion. According to the statistics of Standard Deviation and Variance, it can be found that the dispersion degree of 50 samples was relatively small. Moreover, the calculation of Kurtosis and Skewness of questionnaire results reflected the shape of the data distribution to further understand the influential factors and frequency distribution of all collected data.

Then, the survey data were put into the evaluation framework to calculate the street sustainability of Madang Rd based on the judgments of street users. The average values of 50 questionnaires were filled in the column of "criteria" in the evaluation framework, and then the values at sub-target layer as well as the target layer were calculated accordingly based on the established aggregation methods. Table 8. 5 and Figure 8. 5 show the results of sustainability appraisal based on the questionnaire results of Madang Rd. According to the statistical results, the EnSI, SoSI, and EcSI of Madang Rd were 6.10, 6.93, and 6.70 respectively and the final SSI of Madang Rd was 6.57.

Photoed by the author

Figure 8. 4: Questionnaire Survey on Madang Rd

Table 8. 4: Statistic Table of Questionnaire Results (Madang Rd)

Questionnaire NO.		Environmental Sustainability					Social Sustainability					Economic Sustainability				
		C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**	**C15**
Raw data	*1*	2	2	1	2	2	1	2	1	2	2	1	1	2	2	2
	2	1	2	1	2	3	2	1	1	1	1	2	1	1	2	2
	3	1	1	1	1	2	2	2	3	3	3	2	1	3	3	3
	4	2	0	1	2	2	2	2	2	2	3	2	1	2	1	2
	5	1	1	1	1	0	0	1	1	2	2	2	1	1	1	2
	6	2	3	0	1	3	3	2	0	2	3	1	2	3	3	2
	7	2	1	2	1	2	3	2	3	1	2	3	1	1	2	2
	8	3	3	3	3	3	3	3	3	3	3	3	3	3	1	1
	9	2	0	2	3	2	1	2	2	3	3	1	2	3	3	1
	10	3	2	2	1	2	1	2	3	3	2	1	2	2	1	3
	11	0	0	0	1	1	1	1	1	1	2	1	1	2	2	2
	12	1	3	3	3	3	3	3	3	3	3	3	3	3	2	3
	13	2	1	1	2	1	2	2	1	3	3	2	3	3	3	2
	14	2	1	1	2	2	3	3	2	1	2	1	1	1	1	1
	15	2	1	2	2	2	3	2	3	3	2	2	2	2	2	2
	16	2	2	1	1	2	2	3	2	2	3	3	1	3	3	3
	17	2	2	3	2	3	1	1	2	3	3	3	1	2	3	3
	18	2	1	2	1	2	3	3	3	3	3	2	1	3	3	3
	19	1	1	0	1	1	2	1	2	3	2	1	1	3	2	2
	20	1	1	1	1	1	2	2	2	1	1	2	1	2	2	2
	21	2	2	2	3	3	3	3	3	2	3	3	3	3	3	3
	22	3	3	3	3	3	1	3	3	1	3	3	3	3	3	3
	23	0	1	1	0	1	2	0	1	3	3	2	1	3	3	3
	24	1	1	1	1	2	2	2	2	2	3	2	2	3	3	3
	25	3	3	2	3	2	2	2	2	1	2	1	3	1	1	1
	26	3	3	3	3	3	2	2	1	2	1	2	3	1	1	1
	27	1	2	1	2	1	1	1	2	1	1	1	2	1	1	1
	28	2	3	3	3	3	2	3	2	2	1	2	3	3	3	2
	29	1	3	2	3	2	2	2	1	2	2	2	2	2	2	1

Questionnaire NO.		Environmental Sustainability					Social Sustainability					Economic Sustainability				
		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
Raw data	*30*	3	3	3	3	3	3	3	1	1	3	1	3	1	1	1
	31	2	2	2	3	2	2	2	2	2	2	2	3	2	2	2
	32	1	2	3	2	2	2	2	2	2	2	1	1	2	2	2
	33	3	3	3	3	2	2	2	2	3	1	1	1	1	1	1
	34	1	2	2	3	1	1	2	3	3	1	2	2	2	3	2
	35	1	1	1	1	2	2	3	2	2	2	3	2	2	3	1
	36	3	3	2	2	2	3	2	3	2	2	3	3	2	2	2
	37	2	3	3	3	3	3	1	2	1	2	2	3	2	2	1
	38	2	2	2	2	1	3	2	2	3	2	2	2	3	3	1
	39	1	2	2	3	3	3	1	2	1	2	2	2	1	2	3
	40	2	1	2	1	1	1	3	3	3	3	2	1	3	3	3
	41	1	2	1	2	3	2	2	2	3	2	2	1	2	2	2
	42	1	1	1	1	2	2	2	2	3	3	2	1	3	3	3
	43	2	0	2	3	2	1	2	2	3	3	1	2	3	3	2
	44	2	2	2	1	2	1	2	3	3	2	1	2	2	1	3
	45	0	0	0	0	1	1	1	1	1	2	2	2	2	2	2
	46	3	2	2	1	2	1	2	3	3	2	1	2	2	2	3
	47	1	0	3	2	3	3	3	3	3	3	3	3	3	2	2
	48	2	1	2	2	2	3	2	3	3	2	2	2	3	2	3
	49	2	2	3	2	3	1	1	2	3	3	3	1	2	3	3
	50	2	1	2	1	2	3	3	3	3	3	2	1	3	3	3
Descriptive Analysis	**Average**	**1.74**	**1.68**	**1.78**	**1.90**	**2.06**	**2.00**	**2.02**	**2.10**	**2.24**	**2.28**	**1.92**	**1.84**	**2.22**	**2.18**	**2.12**
	Median	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	Statistical Mode	2	2	2	1	2	2	2	2	3	2	2	1	3	3	2
	Standard Deviation	0.84	0.98	0.92	0.91	0.77	0.83	0.74	0.79	0.82	0.70	0.73	0.82	0.76	0.77	0.77
	Variance	0.67	0.94	0.81	0.81	0.58	0.68	0.54	0.61	0.66	0.48	0.51	0.65	0.57	0.59	0.59
	Kurtosis	-0.49	-0.98	-0.76	-1.15	-0.37	-0.99	-0.19	-0.50	-1.35	-0.85	-1.03	-1.43	-1.16	-1.24	-1.28
	Skewness	-0.15	-0.12	-0.22	-0.14	-0.39	-0.22	-0.34	-0.44	-0.48	-0.45	0.12	0.31	-0.40	-0.33	-0.21
	Max.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Min.	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1

Table 8. 5: Table of Sustainability Evaluation from Questionnaire Results of Madang Rd

Evaluation Framework				Questionnaire Results		
Criteria Code	**Sub-Target Code**	**Target Code**	**Weights**	**Criteria[1]**	**Sub-target[2]**	**Target[2]**
C_1	EnSI	SSI	0.0676	*1.74*	6.10	6.57
C_2			0.0633	*1.68*		
C_3			0.0673	*1.78*		
C_4			0.0663	*1.90*		
C_5			0.0689	*2.04*		
C_6	SoSI		0.0675	*1.96*	6.93	
C_7			0.0687	*1.96*		
C_8			0.0667	*2.08*		
C_9			0.0661	*2.20*		
C_{10}			0.0630	*2.24*		
C_{11}	EcSI		0.0692	*1.86*	6.70	
C_{12}			0.0669	*1.78*		
C_{13}			0.0702	*2.18*		
C_{14}			0.0625	*2.12*		
C_{15}			0.0645	*2.12*		

Note:

1: The values of criteria layer are the averages of the survey results of street questionnaires;

2: The values of sub-target layer and target layer are calculated based on the values of criteria layer and weights according to the aggregation methods of evaluation framework.

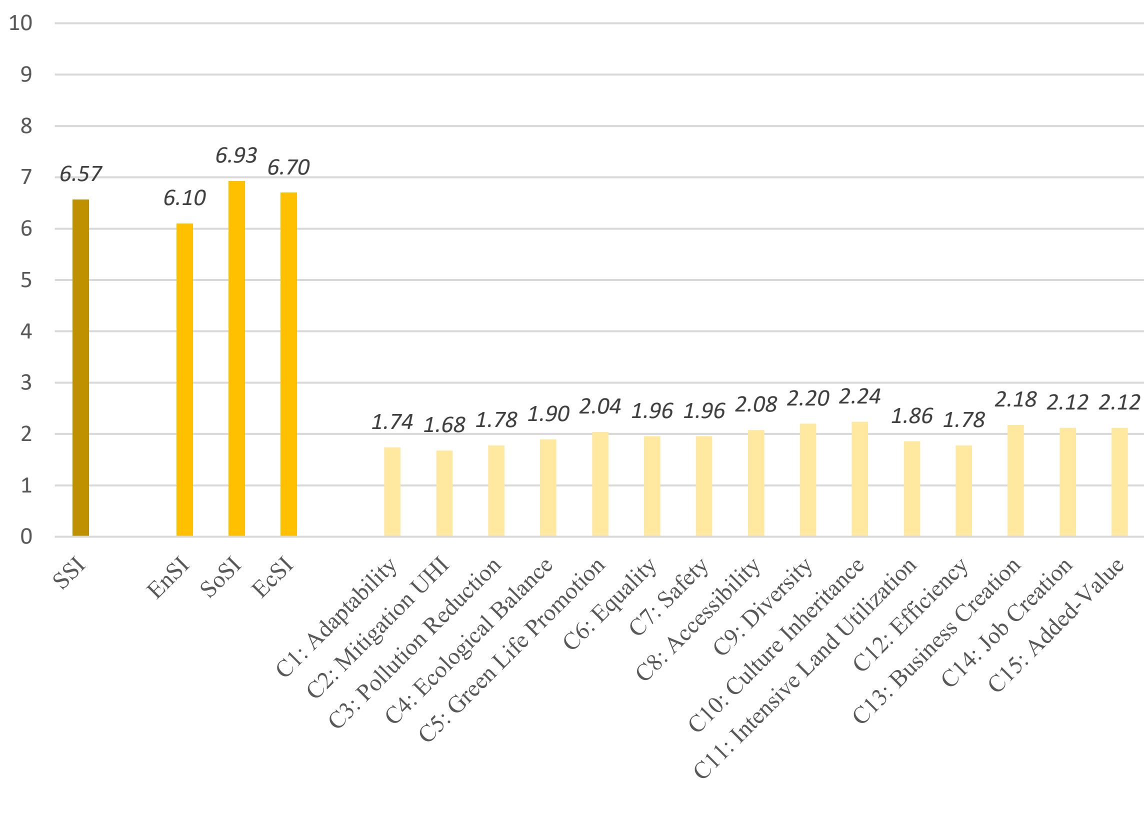


Figure 8. 5: Bar Chart of Sustainability Evaluation from Questionnaire Results of Madang Rd

8.2.4 Comparison and Analysis

Regarding the sustainability of Madang Rd, two sets of evaluation results were worked out based on the Indicator System and the Questionnaire Survey of street users. Table 8. 6 presents the comparison of two sets of data, and Figure 8. 6 illustrates the similarities and differences of two sets of data through the bar chart and radar diagram.

First of all, from the perspective of the target layer, the SSI of the Indicator System was 7.56, while the SSI of the Questionnaire Survey was 6.57. It can be found that the former was 9.9% higher than the latter.

At the sub-target layer, the evaluation indexes of the sub-target layer calculated from the Questionnaire Survey was very close, and the SoSI, EcSI, and EnSI were 6.93, 6.71, and 6.10 respectively. However, those evaluation indexes from the Indicator System varied a lot, and the SoSI, EcSI, and EnSI were 9.67, 8.29, and 5.40 respectively. It can be found that the rankings of two sets of data were consistent concerning three aspects of sustainability: SoSI got the highest score, followed by EcSI, and the EnSI was the lowest one. Nevertheless, the differences between two sets of data were obvious: SoSI and EcSI calculated from questionnaire results were lower than those from the Indicator System, and the gaps were 19.2% and 28.3% respectively; while in contrary the EnSI from questionnaire data was 13.0% higher than that from the Indicator System.

Concerning the comparison of two sets of data at the criteria layer, there were three main three main features:

1) The criteria's value from the Questionnaires Survey were lower than those from the Indicator System. Specifically speaking, the average of 15 criteria indexes from questionnaire data was 1.98, which was 18.1% lower than the average value of the Indicator System (2.33).
2) The fluctuation of criteria's values from the Indicator System was much more obvious than those from the Questionnaire Survey. All values of 15 criteria from questionnaires were close to 2 points, and the difference between the highest score and the lowest score was only 0.56. However, the values of 15 criteria calculated from the Indicator System ranged from 1 point to 3 points, and their Standard Deviation was 0.81 which was 4.63 times of that from questionnaire data (0.17).
3) The trends in the two sets of evaluation criteria were consistent. In other words, the changes from C1 to C15 were basically the same and the highest and lowest values in the two sets of data appeared in the same position among 15 criteria.

In summary, ***it can be found through a detailed comparison that the overall variations of the two sets of data were consistent in general. The key differences were that the SSI of Madang Rd from questionnaire survey was 9.9% lower than that from Indicator System, and the evaluation results from the Indicator System were more fluctuated than those from the questionnaire survey.***

Table 8. 6: Comparison between Sustainability Evaluation and Questionnaire Results (Madang Rd)

Evaluation Framework				Indicator System				***Questionnaire Survey***		
Target layer	**Sub-Target layer**	**Criteria layer**	**Indicator layer**	**Indicators**	**Criteria**	**Sub-Target**	**Target**	***Criteria***	***Sub-target***	***Target***
SSI	*EnSI*	C_1	C_{1-1}	3	2.50	5.40 ***	7.56	*1.74*	*6.10 ****	*6.57*
			C_{1-2}	2						
		C_2	C_{2-1}	1	0.50			*1.68*		
			C_{2-2}	0						
		C_3	C_{3-1}	0	1.00			*1.78*		
			C_{3-2}	2						
		C_4	C_{4-1}	1	1.50			*1.9*		
			C_{4-2}	2						
		C_5	C_{5-1}	2	2.50			*2.04*		
			C_{5-2}	3						
	SoSI	C_6	C_{6-1}	3	3.00	9.67 *		*1.96*	*6.93 **	
			C_{6-2}	3						
		C_7	C_{7-1}	3	3.00			*1.96*		
			C_{7-2}	3						
		C_8	C_{8-1}	3	2.50			*2.08*		
			C_{8-2}	2						
		C_9	C_{9-1}	3	3.00			*2.20*		
			C_{9-2}	3						
		C_{10}	C_{10-1}	3	3.00			*2.24*		
			C_{10-2}	3						
	EcSI	C_{11}	C_{11-1}	3	3.00	8.29 **		*1.86*	*6.71 ***	
			C_{11-2}	3						
		C_{12}	C_{12-1}	2	1.50			*1.78*		
			C_{12-2}	1						
		C_{13}	C_{13-1}	2	2.00			*2.18*		
			C_{13-2}	2						
		C_{14}	C_{14-1}	3	3.00			*2.12*		
			C_{14-2}	3						
		C_{15}	C_{15-1}	3	3.00			*2.12*		
			C_{15-2}	3						

*Note: *,**, and *** means the rank order*

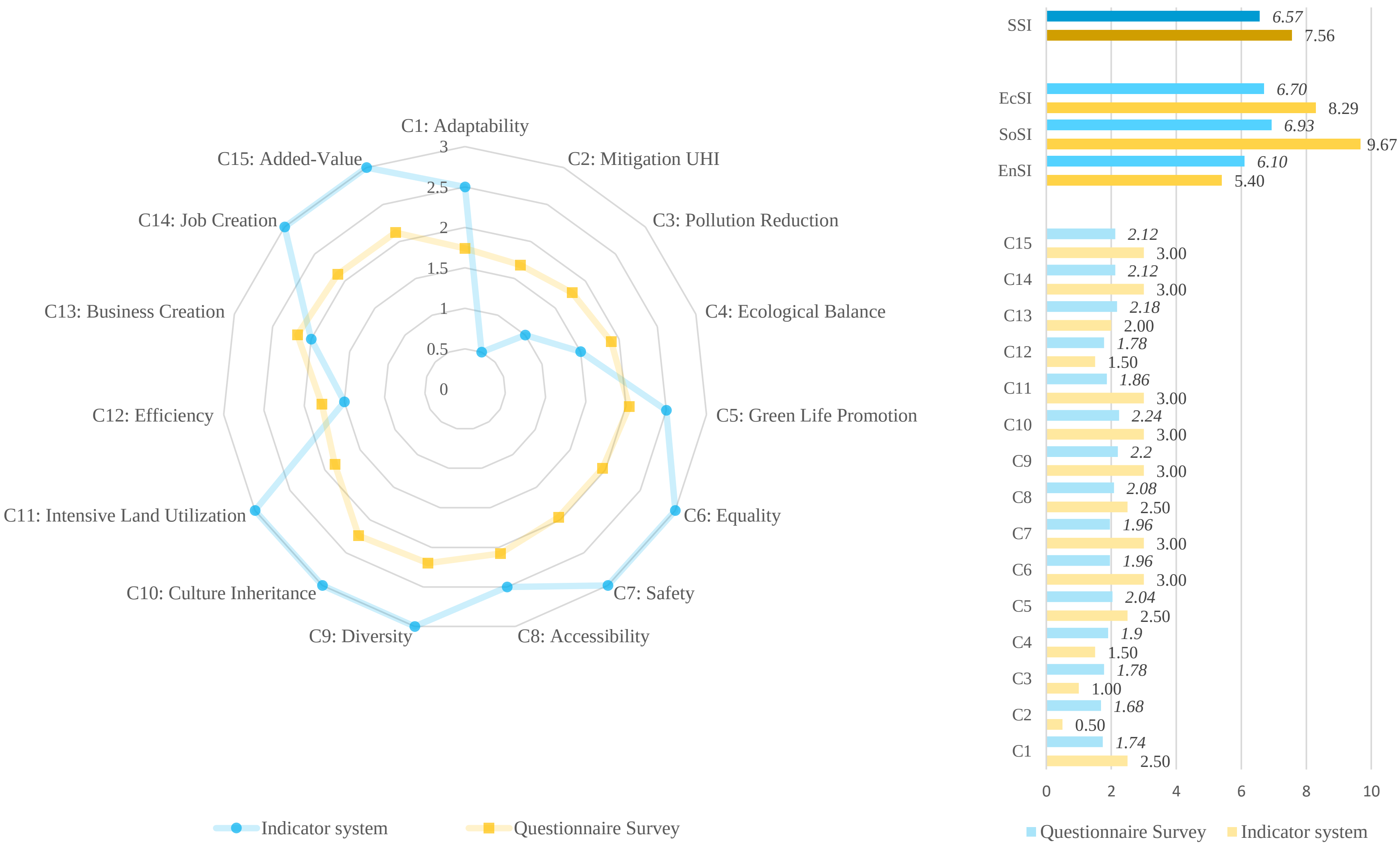


Figure 8. 6: Analysis Graphs of Comparison between Sustainability Evaluation and Street Questionnaire Results (Madang Rd)

8.3 Case Two: Daxue Rd

8.3.1 Brief

Daxue Rd is located in the Wujiaochang Area, one of Shanghai Sub-Centers and 9 kilometres away from the city centre. It is next to the two famous universities of Shanghai, namely Fudan University and University of Finance and Economics, so it is named Daxue Rd (the pronunciation of Daxue in Chinese is the meaning of university). Its total length is 530 meters, from the east side of Songhu Rd to the west side of Guoding Rd. With the renewal of Wujiaochang Area, Daxue Rd is built in 2005 as a community commercial street.

When it comes to the Daxue Rd, it is necessary to mention the project of New Jiangwan City that is a 49-hectare urban development project in Wujiaochang Area. New Jiangwan City is a knowledge community that integrates the campus, community, and science and technology parks. Daxue Rd was built for this community. The project highlights “Phasing Development, Open Blocks, and Multi-Function”. These three main features are also fully reflected in the development of Daxue Rd.

In early 2005, few people would like to come and visit the newly-built street due to the empty of surroundings. So, the ground floor of the buildings along the street firstly introduced some discount stores for sports brands to attract visitors and the upper floors remained as residential function.

By about 2010, the offices’ blocks were completed, and subway of line 10 opened. The commercial types along Daxue Rd were upgraded. These discount stores were moved out, and some business forms of the higher added-value were introduced in, like restaurants, café, and bars. Moreover, as the local planning department approved the concept of "Pavement Dining", the frontage zone in sidewalks was divided out for the fixed outdoor dining space. Furthermore, the street greening was enriched, and street furniture was retrofit to be more artistic, thereby beautifying the streetscape. More and more young people came to visit during the weekends. Also, the second floor of the buildings along Daxue Rd had been transformed into various commercial usage, like Nails Beauty, Agency, and Hair Salon.

By 2012, in order to further promote the commercial vitality and enhance the street’s accessibility, Daxue Rd was retrofitted from original one-way street to a two-way street. Also, the space for ground parking was enlarged. The intersections were retrofitted into several different types aimed at controlling the car speed and ensuring the street safety. With the renewal of the surroundings, two pieces of open space along Daxue Rd was renovated, including the expansion of green space, promotion of plants diversity, and the increase of public seats. At the same time, a flexible plaza was added in one piece of open space which was in the centre of Daxue Rd for outdoor market and road shows, which provided more opportunities for street activities. With the increasing improvement of street quality, the commercial activities also got further spread.

Since 2017, the whole buildings (from ground floor to 8th Floor) along Daxue Rd have been used for commercial functions, and the business types are very diverse, including restaurants, bars, nail art, flower store, dessert, café, tree room, design studio, massage, foot massage, fitness, SPA, mini-cinema, jewellery store, and so on. Furthermore, 20% of the inner buildings of the open blocks are transformed into various types of businesses like photography studio, kids' education, and board game salon. Increasing people would like to spend time in Daxue Rd, not only on weekends but also during working days. It was selected as one of the top 10 Art and Commercial Streets in Shanghai in 2016 (Sina Shanghai, 2016). Today, Daxue Rd has been a vibrant and pleasant street.

In the 1st Field survey, Daxue Rd got the second highest score among 236 sample streets regarding sustainability assessment and showed a relatively balanced performance in three aspects of sustainability.

Table 8. 7: Brief of Daxue Rd

Location	City Sub-Center
Total Length	530 meters
Built	In 2005
Type	Community commercial branch
Feature	- Continuous upgrades and improvements - Mixed-use and fixed pavement dining - One of top 10 Art and Commercial Streets in Shanghai.

Photoed and made by the author. Source of satellite map: (Baidu, 2017)

Figure 8. 7: Analysis graph of Daxue Rd

8.3.2 Evaluation Results of the Indicator System

Daxue Rd was investigated three times on 12th Jul., 27th Oct., and 18th Oct. 2017 respectively. Table 8. 8 illustrates the results and details of the initial diagnosis and normalisation process of each indicator. Table 8. 9 shows the aggregation results and the detailed scores at all levels of the evaluation framework.

It can be seen from the score statistics that the average of 30 evaluated indicators was 2.13 (score range is from 0 to 3 points). Among them, the number of indicators getting the full score of 3 points was 13, accounting for 43.3%; the number of indicators getting 2 points was 11, accounting for 36.7%; the indicators getting 1 point were C1-2 (Adaptable Capacity to Local Climate), C2-2 (Air Temp. Difference), and C3-2 (Pollution Reduction), accounting for 10.0%, and the indicators getting 0 point were C3-1 (Average Emission of Noise), the C4-1 (Rainwater management), and C12-1 (Intelligent Transportation System) respectively, accounting for 10.0% of the total.

Based on the designed aggregation methods, the values of 15 evaluation criteria were calculated by the 30 indicators. The average score of 15 criteria was 0.142 (range from 0 to 0.208). The criterion of C11 (Intensive Land Use) gained the highest score of 0.208, followed by C10 (Culture Inheritance) with a score of 0.193 and C14 (Job Creation) with a score of 0.188. The lowest score was gotten by C3 (Pollution Reduction) with a score of 0.034, and followed by C4 (Ecological Balance) with a score of 0.066 and C12 (Efficiency) with a score of 0.067.

Then, the values at the sub-target layer were calculated according to the aggregation formula. In the sub-target layer, SoSI obtained the highest score of 8.65 (range from 0 to 10), EcSI got 7.99, and EnSI was only 4.69. It can be found that the variation among the three aspects of sustainable performance of Daxue Rd was not small: it performed well in the aspect of social sustainability but got a pretty low score regarding environmental sustainability.

Finally, the SSI of Daxue Rd was 6.87 based on the calculation.

Figure 8. 8 and Figure 8. 9 presents the sustainable evaluation results of Daxue Rd and illustrates the scores in each evaluation layers as well as the relationships among four evaluation layers in the form of the bar chart and radar graph respectively. It can be seen from the radar graph that the fluctuation of the indicators' scores was great. Concerning the social sustainability of Daxue Rd, seven indicators got the full score of 3 points, and three indicators, namely C6-2 (Barrier-Free Facilities), C7-2 (Coverage Safety Equipment), and C8-2 (Clear Sign and Guidance System), got 2 points. Given this, the evaluation results of the corresponding criteria were relatively high, and the average was 0.173. Therefore, the score of SoSI obtained the highest score of 8.98 within three

aspects' evaluation of sustainability. In terms of economic sustainability of Daxue Rd, the EcSI was just 7.99. Specifically speaking, six out of ten indicators got the full score of 3 points, three indicators, namely C12-2 (Traffic Performance Index), C13-1 (Density of Shops), and C15-1 (Added Value of Commercial Rents), got 2 points, and only one indicator, namely C12-1 (Intelligent Transportation System), got the lowest 0 point. Therefore, after aggregation, the four corresponding criteria was relatively high. The evaluation scores of C11 (Intensive Land use), C13 (Business Creation), C14 (Job-Creation), and C15 (Added-Value) were 0.208, 0.176, 0.188, and 0.161 respectively. But C12 (Efficiency) was low, which was also the main reason why the EcSI of Daxue Rd was not very high. In the aspect of environmental sustainability, the performance of Daxue Rd was unsatisfactory. The average score of ten relevant evaluation indicators were only 1.4. Two indicators got 0 point, namely C3-1 (Average Emission of Noise) and C4-1 (Rainwater management). Three indicators got 1 point, namely C1-2 (Adaptable Capacity to Extreme Weather Events), C2-2 (Air Temp. Difference), and C3-2 (Average Emission of Noise) respectively. This directly led to the lower scores of corresponding evaluation criteria, and the scores of C3 (Pollution Reduction), C4 (Ecological Balance), C2 (Mitigation UHI), and C1 (Adaptability) were relatively low which were 0.034, 0.066, 0.095, and 0.101 respectively. As a result, the EnSI of Daxue Rd was only 4.69.

Table 8. 8: Detailed Calculation Process of Indicators of Madang Rd

<table>
<tr><th>Indicators Code</th><th>Indicators Title</th><th>Acquisition Mode</th><th>Initial Diagnoses</th><th>Normalised Values</th><th>Details of initial diagnoses and normalisation</th></tr>
<tr><td>C1-1</td><td>Adaptable Capacity to Local Climate</td><td>D</td><td>2 ticks</td><td>2</td><td>Total number of ticks below is 2
❑ The choice of street trees and other plants suits Shanghai climate (hot summer and cold winter) and helps to maximise the time for comfortable activities in streets;
✓ Street furniture (including the bus station, street seats, & pavement shops) and facilities (like sharing/canopy) in frontage zone suits Shanghai climate (hot summer, cold winter and relatively rainy all year);
✓ A reasonable combination of plaza and green space in streets and proving flexibility for future.
Therefore, according to the normalisation rules, the normalised value of the indicator C1-1 is 2 since it has 2 ticks in the initial diagnosis.</td></tr>
<tr><td>C1-2</td><td>Adaptable Capacity to Extreme Weather Events</td><td>D</td><td>1 tick</td><td>1</td><td>Total number of ticks below is 1
✓ All street furniture and facilities are durable and secure;
❑ Smart alarm and notification for extreme weather events in the street;
❑ Emergency safety measurements for extreme weather situation, like windstorm and flooding.
Therefore, according to the normalisation rules, the normalised value of the indicator C1-2 is 1 since it has 1 tick in the initial diagnosis.</td></tr>
<tr><td>C2-1</td><td>Street Green Rate</td><td>M</td><td>28%</td><td>2</td><td>The street width is below 40 meters, and the street green rate is 28%. Hence according to the normalisation rules, the normalised value of the indicator C2-1 is 2.</td></tr>
<tr><td>C2-2</td><td>Air Temp. Difference</td><td>M</td><td>1.27℃</td><td>1</td><td>Details of temperature measurement and the calculation of temperature difference:
Measurement Date: 12th Jul. 2017; Weather: Cloudy
<table>
<tr><td>Measurement Time</td><td>10am</td><td>12am</td><td>2pm</td></tr>
<tr><td>Regional Air Temp. (℃)</td><td>32</td><td>35</td><td>37</td></tr>
<tr><td>Air Temp. of On-site Measurement (℃)</td><td>29.3</td><td>33.4</td><td>37.5</td></tr>
<tr><td>Temp. Difference (℃)</td><td>2.7</td><td>1.6</td><td>-0.5</td></tr>
<tr><td>Average Temp. Difference (℃)</td><td></td><td></td><td>1.27</td></tr>
</table>
Therefore, according to normalisation rules, the normalised value of the indicator C2-2 is 1 as the Air Temp. Difference is 1.27 ℃ (between 1℃ and 2℃).</td></tr>
</table>

<table>
<tr><th>Indicators Code</th><th>Indicators Title</th><th>Acquisition Mode</th><th>Initial Diagnoses</th><th>Normalised Values</th><th>Details of initial diagnoses and normalisation</th></tr>
<tr><td>C3-1</td><td>Average Emission of Noise</td><td>M</td><td>76.075 Decibel</td><td>0</td><td>Details of on-site Measurement are shown in the table below:
<table>
<tr><td>Measurement Date (weather)</td><td colspan="2">27/10/2017 (Cloudy)</td><td colspan="2">28/10/2017 (Cloudy)</td></tr>
<tr><td>Measurement Time</td><td>7-8am</td><td>1-2am</td><td>11-12am</td><td>2-3m</td></tr>
<tr><td>Noise (Decibel)</td><td>78.6</td><td>72.7</td><td>74.6</td><td>78.4</td></tr>
<tr><td></td><td></td><td colspan="2"><u>Average of Noise (Decibel)</u></td><td><u>76.075</u></td></tr>
</table>
Therefore, according to normalisation rules, the normalised value of the indicator C3-1 is <u>0</u> as the measured average noise is <u>76.075 Decibel (above 75 Decibel).</u></td></tr>
<tr><td>C3-2</td><td>Pollution Reduction</td><td>D</td><td>1 tick</td><td>1</td><td>Total number of ticks below is <u>1</u>
❑ The usage of Environmentally friendly or recycled materials or construction technologies for pavement, curb, and other street furniture to reduce pollution.
❑ The usage of the energy-efficient system or renewable energy for lighting;
✓ The provision of the bins with clear recycling category in the street.
Therefore, according to the normalisation rules, the normalised value of the indicator C3-2 is <u>1</u> since it has <u>1 tick</u> in the initial diagnosis.</td></tr>
<tr><td>C4-1</td><td>Rainwater management</td><td>D</td><td>0 tick</td><td>0</td><td>Total number of ticks below is <u>1</u>:
❑ Reasonable road vertical design and permeable pavement for rainwater drainage;
❑ The use of rain garden for rain management;
✓ Smart alarm and notification for the rainstorm in the street.
Therefore, according to the normalisation rules, the normalised value of the indicator C4-1 is <u>0</u> since it has <u>0 tick</u> in the initial diagnosis.</td></tr>
<tr><td>C4-2</td><td>Ecological Planting</td><td>D</td><td>2 ticks</td><td>2</td><td>Total number of ticks below is <u>2</u>
✓ All streets plants are local;
✓ Diversity of plants (the species of plants within one street are more than 5*)
❑ The usage of rainwater recovery or reused water for plant irrigation in streets
Therefore, according to the normalisation rules, the normalised value of the indicator C4-2 is <u>2</u> since it has <u>2 ticks</u> in the initial diagnosis.</td></tr>
</table>

Indicators Code	Indicators Title	Acquisition Mode	Initial Diagnoses	Normalised Values	Details of initial diagnoses and normalisation
C5-1	***Green Lifestyle Promotion***	D	3 ticks	3	Total number of ticks below is 3 ✓ *Advertising and publicity of green lifestyle;* ✓ *Regular street show and activities for green life;* ✓ *Space to encourage green lifestyle, like jogging path, plaza and open space along the street.* Therefore, according to the normalisation rules, the normalised value of the indicator C5-1 is 3 since it has 3 ticks in the initial diagnosis.
C5-2	***Green Travel Support***	D	2 ticks	2	Total number of ticks below is 2 ✓ *Provision of a minimum-1.5m-width sidewalk with comfortable, reliable and pleasant facilities and atmosphere;* ✓ *Provision of a minimum-1.5m-width cycling lane, cycling parking space, and sharing bike station.* ❑ *Provision of the comfortable bus station and clear transit information.* Therefore, according to the normalisation rules, the normalised value of the indicator C5-2 is 2 since it has 2 ticks in the initial diagnosis.
C6-1	***Tactile pavement for the blind***	D	Excellent Performance	3	According to the normalisation rules, the normalised value of the indicator C6-1 is 3 since it shows Excellent Performance (*The tactile pavement for the blind in the street are without breakage or cutting off*) in terms of tactile pavement for the blind.
C6-2	***Barrier-Free Facilities***	D	2 ticks	2	Total number of ticks below is 2 ✓ *Enough space in through zone for wheelchair and baby stroller;* ✓ *Barrier-free design in street intersection;* ❑ *Barrier-free facilities when there is a vertical difference within sidewalk.* Therefore, according to the normalisation rules, the normalised value of the indicator C6-2 is 2 since it has 2 ticks in the initial diagnosis.
C7-1	***Coverage Proportion of Street Cameras***	M	100%	3	According to the normalisation rules, the normalised value of the indicator C7-1 is 3 since the coverage proportion of street cameras is 100%.

Indicators Code	Indicators Title	Acquisition Mode	Initial Diagnoses	Normalised Values	Details of initial diagnoses and normalisation
C7-2	***Coverage Safety Equipment***	D	6 ticks	2	Total number of ticks below is 6 ✓ *Anti-skidding pavement in the sidewalk;* ❑ *Coloured or marks pavement for cycling lanes;* ✓ *Sufficient lighting at night for street safety;* ❑ *Safe getting up/down in bus station;* ✓ *Bollards or planting to separate travel lanes and sidewalks;* ✓ *All street signs and signals are clear, tide-ordered and visible;* ✓ *Various ways to control car speed, including the clear sign of allowed car speed, speed hump or chicanes.* ✓ *In the intersection, featured and highlighted marks on the ground to remind of safety and protect cyclists and pedestrians;* ❑ *Various methods for a safety intersection, such as the curb extension in the intersection to reduce crossing distance for pedestrian and decrease car speed, provision of medians for safety island if the street intersection is wide, sound reminder if the crossed traffic is large, skyway or underground passages for pedestrians if necessary* Therefore, according to the normalisation rules, the normalised value of the indicator C7-2 is 2 since it has 6 ticks (between 4 and 6 ticks) in the initial diagnosis.
C8-1	***The Variety of Arrival Ways***	D	6 ticks	3	Total number of ticks below is 5 ✓ *Walking: provision of sidewalks (at least 1.5m width for each) on both sides;* ✓ *Cycling: provision of separated or sharing cycling lanes on both sides, and cycling parking space;* ❑ *Public bus: there are bus station within 300m away from the street;* ✓ *Taxi: provision of taxi ranks or taxi Boarding Area;* ✓ *Car: provision of parking lots within 300m away from the street;* ✓ *Special car accessibility: guaranteeing emergency cars, like the ambulance, fire-fighting truck, to access.* Therefore, according to the normalisation rules, the normalised value of the indicator C8-1 is 3 since it has 5 ticks (5-6 ticks) in the initial diagnosis.

Indicators Code	Indicators Title	Acquisition Mode	Initial Diagnoses	Normalised Values	Details of initial diagnoses and normalisation
C8-2	***Clear Sign and Guidance System***	D	2 ticks	2	Total number of ticks below is 2 ✓ *Provision of clear signs of basic street information, including street name, direction, and traffic regulation;* ✓ *Provision of extra information of surrounding situation;* ❑ *Provision of smart wayfinding system.* Therefore, according to the normalisation rules, the normalised value of the indicator C8-2 is 2 since it has 2 ticks in the initial diagnosis.
C9-1	***Diversity of Street Activities***	M	10 pcs	3	Total number of activities observed on the street is 10 ✓ *Strolling* ✓ *Dog walking* ✓ *Sitting* ✓ *Meeting friends* ✓ *Kids playing* ✓ *Jogging & physical exercise* ✓ *Watching newspaper/reading books* ✓ *Playing chess/cards in groups* ✓ *Shopping* ✓ *Drinking & Eating* Therefore, according to the normalisation rules, the normalised value of the indicator C9-1 is 3 since the number of activity types observed in the street is 10 (between 7 and 10) in the initial diagnosis.
C9-2	***Diversity of Street Functions***	D	4 ticks	2	Total number of ticks below is 4 ✓ *Traffic function* ✓ *Social function* ✓ *Commercial function* ✓ *Cultural function* ❑ *Political function* ❑ *Ecological function* Therefore, according to the normalisation rules, the normalised value of indicator of C9-2 is 2 since it has 4 ticks (between 3 and 4) in the initial diagnosis.

Indicators Code	Indicators Title	Acquisition Mode	Initial Diagnoses	Normalised Values	Details of initial diagnoses and normalisation
C10-1	***Aesthetic Quality of Street Furniture***	D	Excellent Performance	3	According to the normalisation rules, the normalised value of the indicator C10-1 is 3 since it shows Excellent Performance in terms of aesthetic quality of street furniture. (*All street elements, including seats, Bollards, Pedestrian Guardrails, Bins, Public art, telephone boxes, parking control equipment, post and pouch boxes, smoke vents, bus station, pavement, lighting system, information station, cycling parks, and kerb, are designed dedicatedly and form as a whole and display high aesthetic quality)*
C10-2	***Style Consistency with Surroundings***	D	Excellent Performance	3	According to the normalisation rules, the normalised value of the indicator C10-2 is 3 since it shows Excellent Performance in terms of style consistency with surroundings (*Streetscape highlights and well displays local culture and historic heritage).*
C11-1	***Intensiveness of Street Space***	D	3 ticks	3	Total number of ticks below is 3 ✓ *The reasonable width of travel lanes, cycling lanes, and sidewalk.* ✓ *Reasonable and Intensive design of intersection land;* ✓ *Integration design of street furniture to save the street land* Therefore, according to the normalisation rules, the normalised value of the indicator C11-1 is 3 since it has 3 ticks in the initial diagnosis.
C11-2	***Mixed-Use of Street Land***	D	3 ticks	3	Total number of ticks below is 3 ✓ *To open building setback and design together between building line and the sidewalks inside the street red line* ✓ *Sharing street, such as tidal changeable lanes, travel & cycling sharing street;* ✓ *Multi-functional street space: changeable parking strip, temporary pavement cafe.* Therefore, according to the normalisation rules, the normalised value of the indicator C11-2 is 3 since it has 3 ticks in the initial diagnosis.
C12-1	***Intelligent Transportation System***	D	0 tick	0	Total number of ticks below is 0 ❑ *Intelligent public bus system to show real-time bus arrival time in bus station;* ❑ *Intelligent parking system to show real-time number of parking spaces;* ❑ *Intelligent traffic system to show real-time traffic condition.* Therefore, according to the normalisation rules, the normalised value of the indicator C12-1 is 0 since it has 0 tick in the initial diagnosis.

<table>
<tr><th>Indicators Code</th><th>Indicators Title</th><th>Acquisition Mode</th><th>Initial Diagnoses</th><th>Normalised Values</th><th>Details of initial diagnoses and normalisation</th></tr>
<tr><td>C12-2</td><td>Traffic Performance Index</td><td>N</td><td>Relative Smooth</td><td>2</td><td>Based on the normalisation rules, the normalised value of indicator of C12-2 is 2 since its according to the official published data from Shanghai Urban and Rural Construction and Traffic Development Institute Year Average Traffic Performance of Daxue Rd is “Smooth” (The traffic condition is good, the average traffic density of the road network is smaller, and the speed is higher. Only a small part of the road is congested or blocked).</td></tr>
<tr><td>C13-1</td><td>Density of Shops</td><td>M</td><td>5.75 shops/ 100meters</td><td>2</td><td>The detail information of shops number and the calculation process are shown in the table below:
<table>
<tr><th></th><th>South Side</th><th>North Side</th><th>Total</th></tr>
<tr><td>Number of Shops along Street</td><td>25</td><td>36</td><td>61</td></tr>
<tr><td>Street Length (Meters)</td><td>530</td><td>530</td><td>1060</td></tr>
<tr><td>Average Shops per 100 Meters</td><td></td><td></td><td>5.75</td></tr>
</table>
Therefore, according to the normalisation rules, the normalised value of the indicator C13-1 is 2 as its initial diagnosis is 5.75 (between 2 and 7).</td></tr>
<tr><td>C13-2</td><td>Types of Temporary Business</td><td>M</td><td>4 ticks</td><td>3</td><td>Total number of ticks below is 4
✓ Temporary pavement café & F&B;
❑ Temporary food station;
✓ Temporary show spot
✓ Temporary flower station;
✓ Mobility Street vendor (cigarettes, disc, girls’ accessory, clothes, portrait drawing, street show and etc.)
Therefore, according to the normalisation rules, the normalised value of the indicator C13-2 is 3 since it has 4 ticks (between 4 and 5) in the initial diagnosis).</td></tr>
<tr><td>C14-1</td><td>Employment Creation</td><td>D</td><td>Excellent Performance</td><td>3</td><td>According to the normalisation rules, the normalised value of indicator of C14-1 is 3 since it shows an Excellent Performance in terms of jobs creation (There are various jobs created in/along the street, and the employment creation is not only on the first floor but also in the whole sided buildings).</td></tr>
</table>

Indicators Code	Indicators Title	Acquisition Mode	Initial Diagnoses	Normalised Values	Details of initial diagnoses and normalisation
C14-2	***Types of Jobs***	M	7 ticks	3	Total number of ticks below is 7 ✓ *Salesperson* ✓ *Waitress* ✓ *Agent* ✓ *Craftsman* ✓ *Officers* ✓ *Parking Administrator;* ✓ *Mobile Street Vendor* Therefore, according to the normalisation rules, the normalised value of the indicator C14-2 is 3 since it has 7 ticks (between 6 and 7) in the initial diagnosis.
C15-1	***Added Value of Commercial Rents***	C	7.8%	2	Details of data calculation are shown in the table below: *Average Rental fee along Daxue Rd (RMB/㎡/Day)* — *10.02* *Average rental fee in Yangpu District (RMB/㎡/Day)* — *9.24* *Added Value of Commercial Rents (%)* $= \frac{(\textbf{Unit Price of Commercial Rent along the Street} - \textbf{Average Unit Price of Commercial Rent in this District})}{\textbf{Average Unit Price of Commercial Rent in this District}}$ — *7.8%* Therefore, according to the normalisation rules, the normalised value of the indicator C15-1 is 2 since the initial diagnosis is 7.8% (between 3% and 10%).
C15-2	***Added-Value of Housing Prices***	C	11.5%	3	Details of data calculation are shown in the table below: *Average housing price along Madang Rd (10,000RMB/㎡)* — *7.8* *Average housing price in Yangpu District (10,000RMB/㎡)* — *6.9* *Added Value of Housing Prices (%)* $\frac{(\textbf{Unit Housing Price along the Street} - \textbf{Average Unit Housing Price in this District})}{\textbf{Average Unit Housing Price in this District}}$ — *11.5%* Therefore, according to the normalisation rules, the normalised value of the indicator C15-2 is 3 since the initial diagnosis is 11.5% (above10%).

Table 8. 9: Table of Sustainability Evaluation Results of Daxue Rd

Evaluation Framework				**Weights**	**Evaluation Values**			
Target Layer	***Sub-Target Layer***	***Criteria Layer***	***Indicator Layer***		***Indicators***	***Criteria***	***Sub-Targets***	***Target***
SSI	***EnSI***	**C_1**	**C_{1-1}**	*0.0338*	2	0.101	4.69	6.95
			C_{1-2}	*0.0338*	1			
		C_2	**C_{2-1}**	*0.0317*	2	0.095		
			C_{2-2}	*0.0317*	1			
		C_3	**C_{3-1}**	*0.0337*	0	0.034		
			C_{3-2}	*0.0337*	1			
		C_4	**C_{4-1}**	*0.0332*	0	0.066		
			C_{4-2}	*0.0332*	2			
		C_5	**C_{5-1}**	*0.0345*	3	0.172		
			C_{5-2}	*0.0345*	2			
	SoSI	**C_6**	**C_{6-1}**	*0.0338*	3	0.169	8.98	
			C_{6-2}	*0.0338*	2			
		C_7	**C_{7-1}**	*0.0344*	3	0.172		
			C_{7-2}	*0.0344*	2			
		C_8	**C_{8-1}**	*0.0334*	3	0.167		
			C_{8-2}	*0.0334*	2			
		C_9	**C_{9-1}**	*0.0331*	3	0.198		
			C_{9-2}	*0.0331*	3			
		C_{10}	**C_{10-1}**	*0.0322*	3	0.193		
			C_{10-2}	*0.0322*	3			
	EcSI	**C_{11}**	**C_{11-1}**	*0.0346*	3	0.208	7.99	
			C_{11-2}	*0.0346*	3			
		C_{12}	**C_{12-1}**	*0.0335*	0	0.067		
			C_{12-2}	*0.0335*	2			
		C_{13}	**C_{13-1}**	*0.0351*	2	0.176		
			C_{13-2}	*0.0351*	3			
		C_{14}	**C_{14-1}**	*0.0313*	3	0.188		
			C_{14-2}	*0.0313*	3			
		C_{15}	**C_{15-1}**	*0.0323*	2	0.161		
			C_{15-2}	*0.0323*	3			

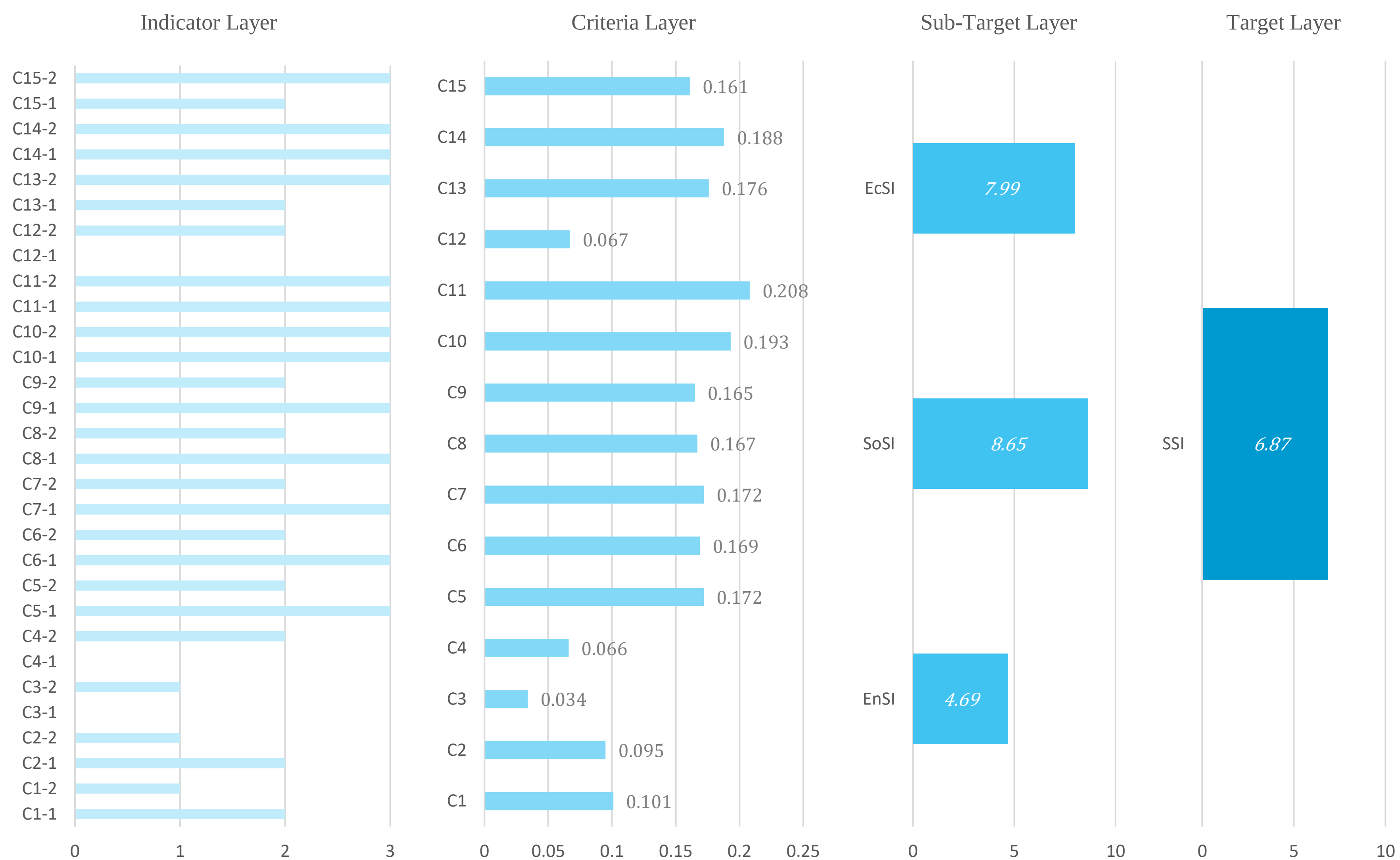
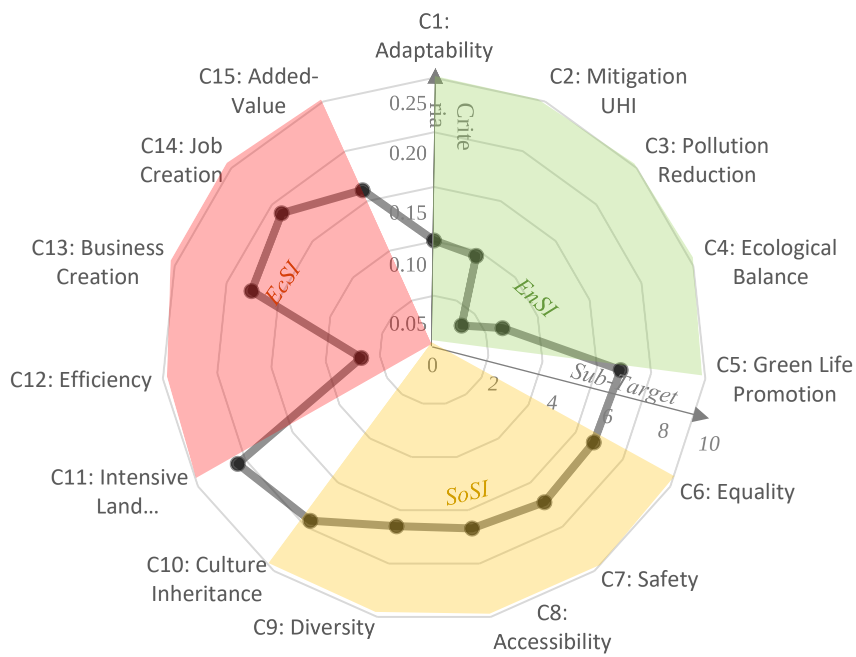
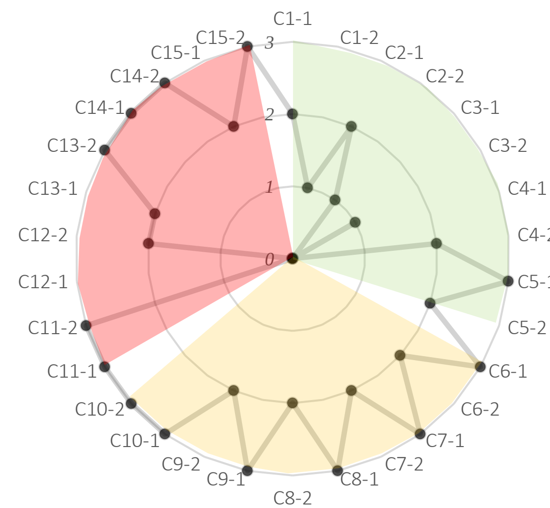


Figure 8. 8: Analysis Graphs of Sustainability Evaluation Results of Daxue Rd





C1-1	Adaptable Capacity to Local Climate	**C2-1**	Street Green Rate	**C3-1**	Average Emission of Noise	**C4-1**	Rainwater management	**C5-1**	Green Lifestyle Promotion
C1-2	Adaptable Capacity to Extreme Weather Events	**C2-2**	Air Temp. Difference	**C3-2**	Pollution Reduction	**C4-2**	Ecological Planting	**C5-2**	Green Travel Support
C6-1	Tactile pavement for the blind	**C7-1**	Coverage Proportion of Street Cameras	**C8-1**	The Variety of Arrival Ways	**C9-1**	Diversity of Street Activities	**C10-1**	Aesthetic Quality of Street Furniture
C6-2	Barrier-Free Facilities	**C7-2**	Coverage Safety Equipment	**C8-2**	Clear Sign and Guidance System	**C9-2**	Diversity of Street Functions	**C10-2**	Style Consistency with Surroundings
C11-1	Intensiveness of Street Space	**C12-1**	Intelligent Transportation System	**C13-1**	Density of Shops	**C14-1**	Employment Creation	**C15-1**	Added Value of Commercial Rents
C11-2	Mixed-Use of Street Land	**C12-2**	Traffic Performance Index	**C13-2**	Types of Temporary Business	**C14-2**	Types of Jobs	**C15-2**	Added-Value of Housing Prices

Figure 8. 9: Radar Graphs of Sustainability Evaluation Results of Daxue Rd

8.3.3 Evaluation Results of the Questionnaire Survey

The questionnaire surveys were issued on Daxue Rd on 27th Oct. 2017 and 28th Oct. 2017. A total of 54 questionnaires were completed, among which 50 were valid survey results. The whole process of questionnaire survey was smooth in general.

The on-site survey results were processed and organised into one spreadsheet in Microsoft Excel. Based on this, four questionnaires were invalid due to the issues of integrity and effectiveness. Therefore, a total of 50 questionnaires were deemed to be valid.

Once the data was cleaned and get prepared, they were analysed to confirm the validness of these selected data (See Table 8. 10). The average values of 50 questionnaires were filled in the column of "criteria" in the evaluation framework, and then the scores of the sub-target layer and the target layer were calculated accordingly based on the established aggregation methods.

Table 8. 11 shows the results of sustainability appraisal based on the questionnaire results of Daxue Rd. The EnSI, SoSI, and EcSI of Madang Rd were 6.11, 7.14, and 7.46 respectively, and the final SSI of Daxue Rd was 6.87. Regarding the criteria layer, C13 (Business Creation) got the highest score of 2.60, followed by 2.56 of C9 (Diversity), 2.44 of C14 (Job Creation), and 2.42 of C15 (Added-Value). Meanwhile, C3 (Pollution Reduction) got the lowest score of 1.66, followed by 1.68 of C2 (Mitigation UHI) and C6 (Equality). Figure 8. 11 illustrates the statistics and variation of the evaluation results at all layers. It can be found in the bar chart that the fluctuations of the criteria's values influenced the values in the sub-target layer as well as affects the value of the SSI.

Taken by the author

Figure 8. 10: Questionnaire Survey on Daxue Rd

Table 8. 10: Statistic Table of Questionnaire Results (Daxue Rd)

	Questionnaire NO.	Environmental Sustainability					Social Sustainability					Economic Sustainability				
		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
Raw data	*1*	1	2	0	1	1	2	2	2	3	1	1	1	3	3	2
	2	3	2	2	3	1	3	3	3	3	3	2	1	3	3	3
	3	2	1	2	1	1	1	3	2	3	2	2	2	3	3	2
	4	2	1	1	2	3	1	2	2	2	3	3	1	3	2	3
	5	1	2	2	3	3	2	3	3	3	3	3	2	3	3	3
	6	1	1	1	2	2	0	1	1	2	2	1	1	2	2	2
	7	2	2	2	3	1	1	2	2	3	2	2	2	2	2	3
	8	1	1	0	0	2	0	1	3	3	2	2	1	3	3	3
	9	1	1	2	1	2	2	2	1	2	2	2	1	1	1	2
	10	1	1	0	1	2	0	1	1	0	2	1	0	2	1	0
	11	2	1	1	1	2	1	2	2	2	3	1	1	3	3	2
	12	1	2	2	3	3	2	3	3	3	2	2	1	2	1	3
	13	2	1	3	2	2	2	1	3	3	1	1	1	3	2	3
	14	2	2	2	2	2	2	2	3	3	2	2	3	3	3	2
	15	1	1	2	2	2	2	2	3	3	3	2	3	3	2	1
	16	2	2	2	1	2	2	3	3	3	2	2	2	3	3	3
	17	2	0	1	1	2	3	2	3	3	3	1	3	3	3	3
	18	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3
	19	3	1	1	2	2	2	3	3	3	2	3	2	3	3	3
	20	2	1	0	1	0	0	1	1	2	3	2	2	3	3	3
	21	2	2	1	2	2	1	3	3	2	1	2	1	3	1	2
	22	2	2	1	1	1	1	2	2	2	3	1	1	2	3	2
	23	1	2	2	2	3	1	3	2	2	2	3	2	3	3	3
	24	2	3	3	3	2	3	3	1	3	1	2	2	3	3	2
	25	2	2	2	2	2	1	2	2	2	2	1	2	2	3	3
	26	2	1	1	1	1	1	2	3	3	2	1	2	3	2	2
	27	2	2	1	2	3	3	3	3	3	2	1	2	2	2	1
	28	2	3	3	3	3	2	3	3	3	3	2	2	3	2	3
	29	2	3	3	3	3	1	3	3	2	3	2	2	2	2	3

	Questionnaire NO.	Environmental Sustainability					Social Sustainability					Economic Sustainability				
		C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**	**C15**
Raw data	*30*	2	1	1	1	2	1	2	0	2	2	0	1	2	2	2
	31	2	2	2	2	2	1	1	2	1	2	2	2	1	2	2
	32	2	1	3	1	2	2	2	3	2	1	3	3	2	2	3
	33	1	2	2	2	2	2	2	3	3	2	2	3	3	3	3
	34	1	1	1	1	2	2	2	2	3	3	2	1	3	3	3
	35	1	2	2	2	2	1	1	1	2	1	2	2	2	2	1
	36	2	2	1	3	3	2	2	1	3	1	1	2	3	2	2
	37	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	38	2	2	2	2	2	2	2	2	3	1	2	2	3	2	3
	39	1	1	2	2	2	2	2	3	3	2	2	2	3	3	3
	40	2	2	1	1	3	1	2	2	3	2	2	2	3	3	2
	41	2	1	2	2	3	1	2	3	3	2	3	1	3	2	2
	42	1	2	2	2	1	0	3	1	3	1	3	2	1	2	1
	43	2	1	1	2	3	3	3	1	3	3	3	3	3	3	3
	44	2	2	2	1	3	2	2	1	2	1	2	3	2	2	2
	45	3	2	2	3	3	2	3	3	3	3	3	2	3	3	3
	46	3	3	2	2	2	2	2	2	3	1	2	1	3	3	2
	47	1	2	2	2	3	2	3	3	3	2	2	1	2	2	3
	48	2	1	1	2	2	3	3	2	2	1	1	1	3	3	3
	49	2	2	2	2	3	3	2	2	2	3	2	2	3	3	3
	50	1	2	2	2	2	2	1	2	2	1	2	2	2	2	2
Descriptive Analysis	**Average**	**1.78**	**1.64**	**1.64**	**1.84**	**2.13**	**1.60**	**2.22**	**2.22**	**2.58**	**2.11**	**1.96**	**1.84**	**2.60**	**2.42**	**2.40**
	Median	2	2	2	2	2	2	2	2	3	2	2	2	3	3	3
	Statistical Mode	2	2	2	2	2	2	2	3	3	2	2	2	3	3	3
	Standard Deviation	0.60	0.68	0.83	0.80	0.76	0.89	0.70	0.88	0.66	0.75	0.77	0.77	0.62	0.66	0.75
	Variance	0.35	0.45	0.67	0.62	0.56	0.77	0.48	0.75	0.42	0.54	0.58	0.58	0.37	0.42	0.55
	Kurtosis	-0.36	-0.25	-0.35	-0.82	0.02	-0.63	-0.89	-0.79	4.18	-1.14	-0.45	-0.61	0.71	-0.49	1.05
	Skewness	0.11	0.13	-0.23	0.01	-0.56	-0.11	-0.34	-0.67	-1.81	-0.18	-0.24	-0.04	-1.31	-0.71	-1.16
	Max.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Min.	1	0	0	0	0	0	1	0	0	1	0	0	1	1	0

Table 8. 11: Table of Sustainability Evaluation from Questionnaire results of Daxue Rd

Evaluation Framework				Questionnaire Results		
Criteria Code	Sub-Target Code	Target Code	Weights	Criteria[1]	Sub-target[2]	Target[2]
C_1	EnSI	SSI	0.0676	1.78	6.11	6.87
C_2			0.0633	1.68		
C_3			0.0673	1.66		
C_4			0.0663	1.86		
C_5			0.0689	2.16		
C_6	SoSI		0.0675	1.68	7.14	
C_7			0.0687	2.22		
C_8			0.0667	2.22		
C_9			0.0661	2.56		
C_{10}			0.0630	2.06		
C_{11}	EcSI		0.0692	1.94	7.46	
C_{12}			0.0669	1.80		
C_{13}			0.0702	2.60		
C_{14}			0.0625	2.44		
C_{15}			0.0645	2.42		

Note:

1: The values of criteria layer are the averages of the survey results of street questionnaires;

2: The values of sub-target layer and target layer are calculated based on the values of criteria layer and weights according to the aggregation methods of evaluation framework.

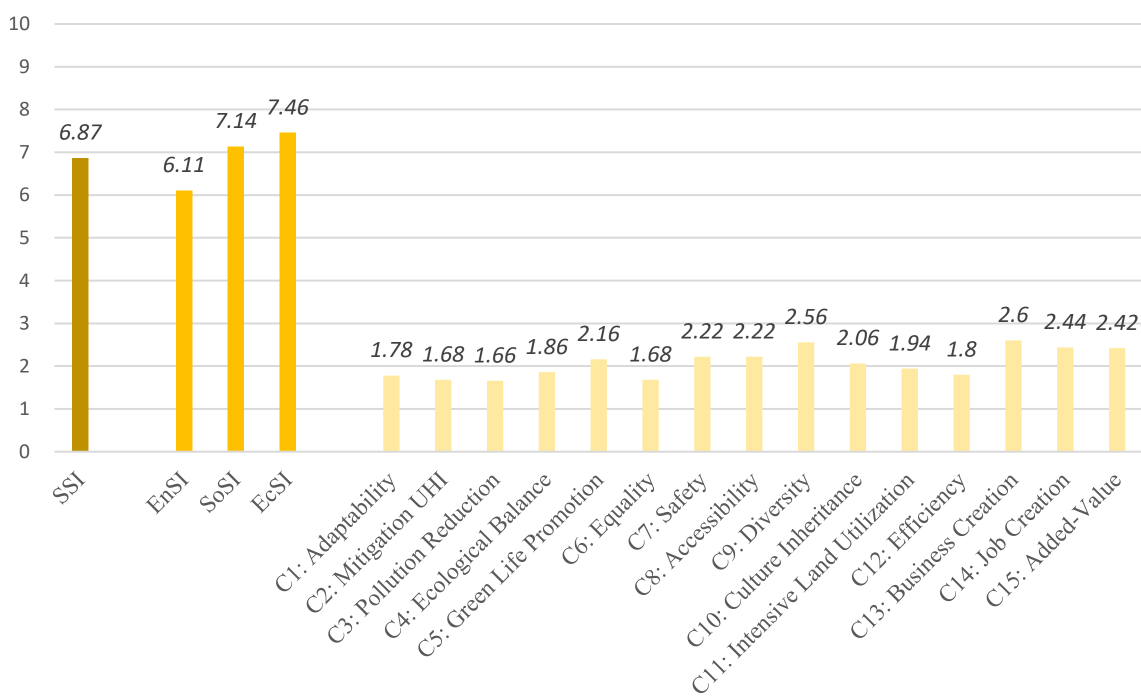


Figure 8. 11: Bar chart of sustainability evaluation from Questionnaire results of Daxue Rd

8.3.4 Comparison and Analysis

Concerning the sustainability evaluation of Daxue Rd, two sets of evaluation results were worked out based on the Indicator System and the Questionnaire Survey. Table 8. 12 presents the comparison of two sets of data, and Figure 8. 12 illustrates the similarities and differences of two sets of data through the bar chart and radar diagram.

First, from the perspective of the target layer, the SSI of Indicator System was the same as that of the questionnaire survey, and the score was 6.87.

The evaluation indexes calculated from the Questionnaire Survey of Madang Rd were very close at the sub-target layer, and the SoSI, EcSI, and EnSI were 6.93, 6.71, and 6.10 respectively. However, three indexes calculated from the Indicator System varied a lot, and the SoSI, EcSI, and EnSI were 9.67, 8.29, and 5.40 respectively. It can be found that the rankings of two sets of data were consistent regarding three aspects of sustainability: SoSI got the highest score, followed by EcSI, and the EnSI was the lowest one. Nevertheless, the differences between two sets of data were obvious: SoSI and EcSI calculated from questionnaire results were lower than those from the Indicator System, and the gaps were 19.2% and 28.3% respectively; while in contrary the EnSI from the Questionnaire Survey was 13.0% higher than that from Indicator System. Therefore, the gap between the two sets of data at the sub-target level was also relatively large.

Finally, regarding the comparison of two sets of data of the criteria layer, there were three main features:

1) Criteria's values from the questionnaires Survey were lower than those from Indicator System. Specifically speaking, the average of 15 criteria indexes from the Questionnaire Survey was 1.98, 18.1% lower than the average value of Indicator System (2.33).
2) The fluctuation of criteria's values from Indicator System was more evident than those from the Questionnaire Survey. All values of the fifteen criteria from questionnaires were close to 2 points and the difference between the highest score and the lowest score was only 0.56. However, the values of the 15 criteria calculated from the Indicator System ranged from 1 to 3 points. Also, their Standard Deviation was 0.81, which was 4.63 times the result from questionnaire data (0.17).
3) The trends in the two sets of evaluation criteria were consistent. It can be seen in Figure 8. 12 that the fluctuations from C1 to C15 were nearly the same, and the highest and lowest values of the two sets of data appeared at the same position in the graph.

From the overall perspective, ***the main characteristics of the two sets of data were generally consistent, and the scores of SSI were the same.*** The similarities lied in the same final scores of SSI and the variations and fluctuations at the indicator layer***. The differences were primarily embodied in the sub-target and the criteria layer.*** Also, the data variations in the Indicator System were obvious while assessment values from the questionnaire survey were relatively approximate.

Table 8. 12: Comparison between Sustainability Evaluation and questionnaire survey results (Madang Rd)

Evaluation Framework				**Evaluation values**				***Questionnaire Results***		
Target layer	**Sub-Target layer**	**Criteria layer**	**Indicator layer**	**Indicators**	**Criteria**	**Sub-Target**	**Target**	***Criteria***	***Sub-target***	***Target***
SSI	*EnSI*	C_1	C_{1-1}	2	*1.50*	4.69 ***	6.87	*1.78*	6.11 ***	*6.87*
			C_{1-2}	1						
		C_2	C_{2-1}	2	*1.50*			*1.68*		
			C_{2-2}	1						
		C_3	C_{3-1}	0	*0.50*			*1.66*		
			C_{3-2}	1						
		C_4	C_{4-1}	0	*1.00*			*1.86*		
			C_{4-2}	2						
		C_5	C_{5-1}	3	*2.50*			*2.16*		
			C_{5-2}	2						
	SoSI	C_6	C_{6-1}	3	*2.50*	8.65 *		*1.68*	7.14 **	
			C_{6-2}	2						
		C_7	C_{7-1}	3	*2.50*			*2.22*		
			C_{7-2}	2						
		C_8	C_{8-1}	3	*2.50*			*2.22*		
			C_{8-2}	2						
		C_9	C_{9-1}	3	*2.50*			*2.56*		
			C_{9-2}	2						
		C_{10}	C_{10-1}	3	*3.00*			*2.06*		
			C_{10-2}	3						
	EcSI	C_{11}	C_{11-1}	3	*3.00*	7.99 **		*1.94*	7.46 *	
			C_{11-2}	3						
		C_{12}	C_{12-1}	0	*1.00*			*1.8*		
			C_{12-2}	2						
		C_{13}	C_{13-1}	2	*2.50*			*2.6*		
			C_{13-2}	3						
		C_{14}	C_{14-1}	3	*3.00*			*2.44*		
			C_{14-2}	3						
		C_{15}	C_{15-1}	2	*2.50*			*2.42*		
			C_{15-2}	3						

*Note: *,**, and *** means the rank order*

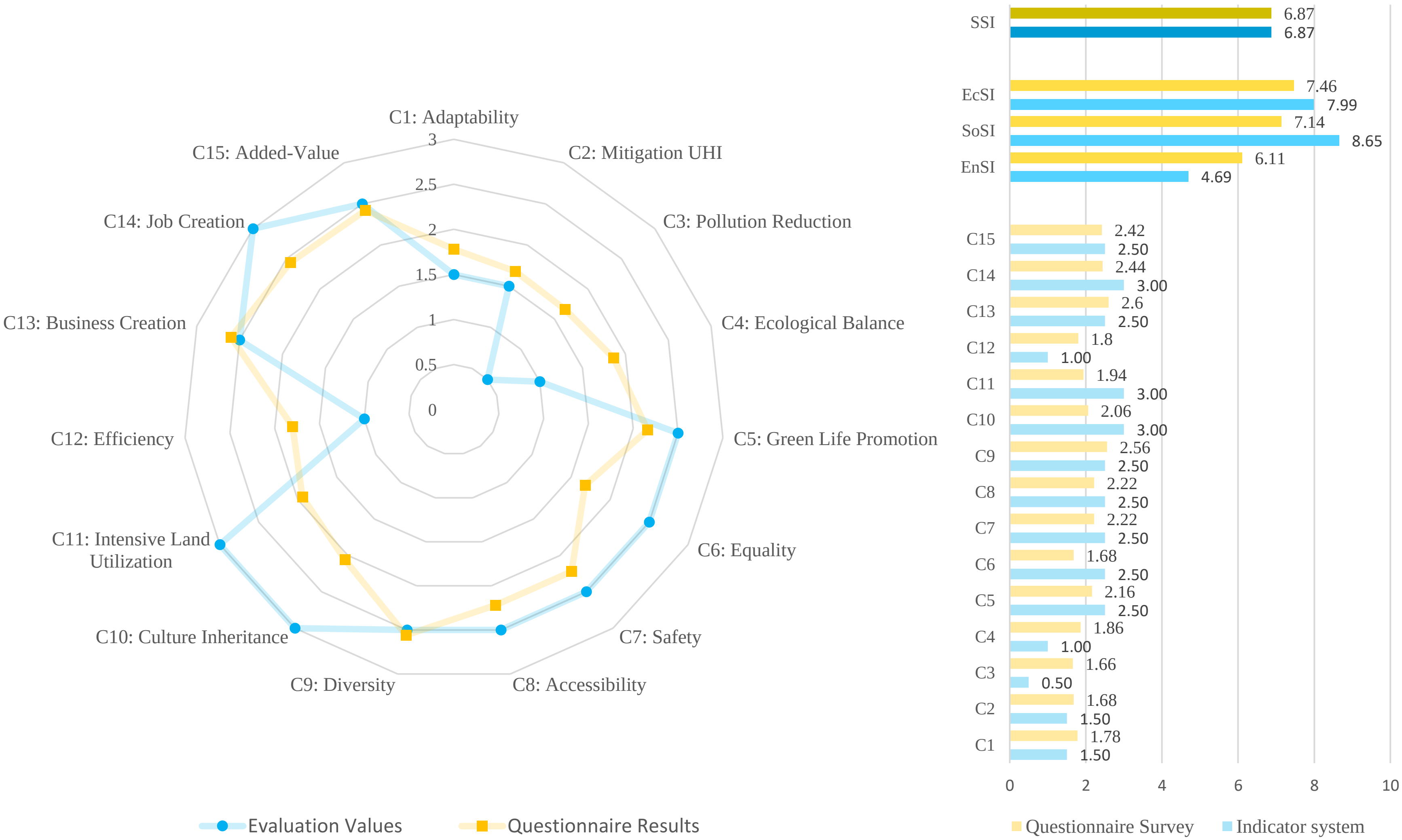


Figure 8. 12: Analysis Graphs of Comparison between Sustainability Evaluation and Street Questionnaire Results (Daxue Rd)

8.4 Case Three: Sujiatun Rd

8.4.1 Brief

Sujiatun Rd is a community street located in Anshan Village of Shanghai Yangpu District, and its total length is 380 meters. The street was built in the 1970s. Today, the trees and plants on its both sides are tall and pleasant. Various pocket gardens, mini-plazas, public seats, street sculptures, and red runways are organically distributed in Sujiatun Rd. There is neither bus station nor various stores along the street, so there is no bustle and rush atmosphere but quiet and peaceful feeling in the street. Whenever passing through Sujiatun Rd, various activities can be seen along it, like chatting with friends, jogging, kids' playing, having breakfast, sitting and watching and so on.

The background introduction of Sujiatun Rd cannot be explained without the reference to the influence of history and location factors on the street's construction and development.

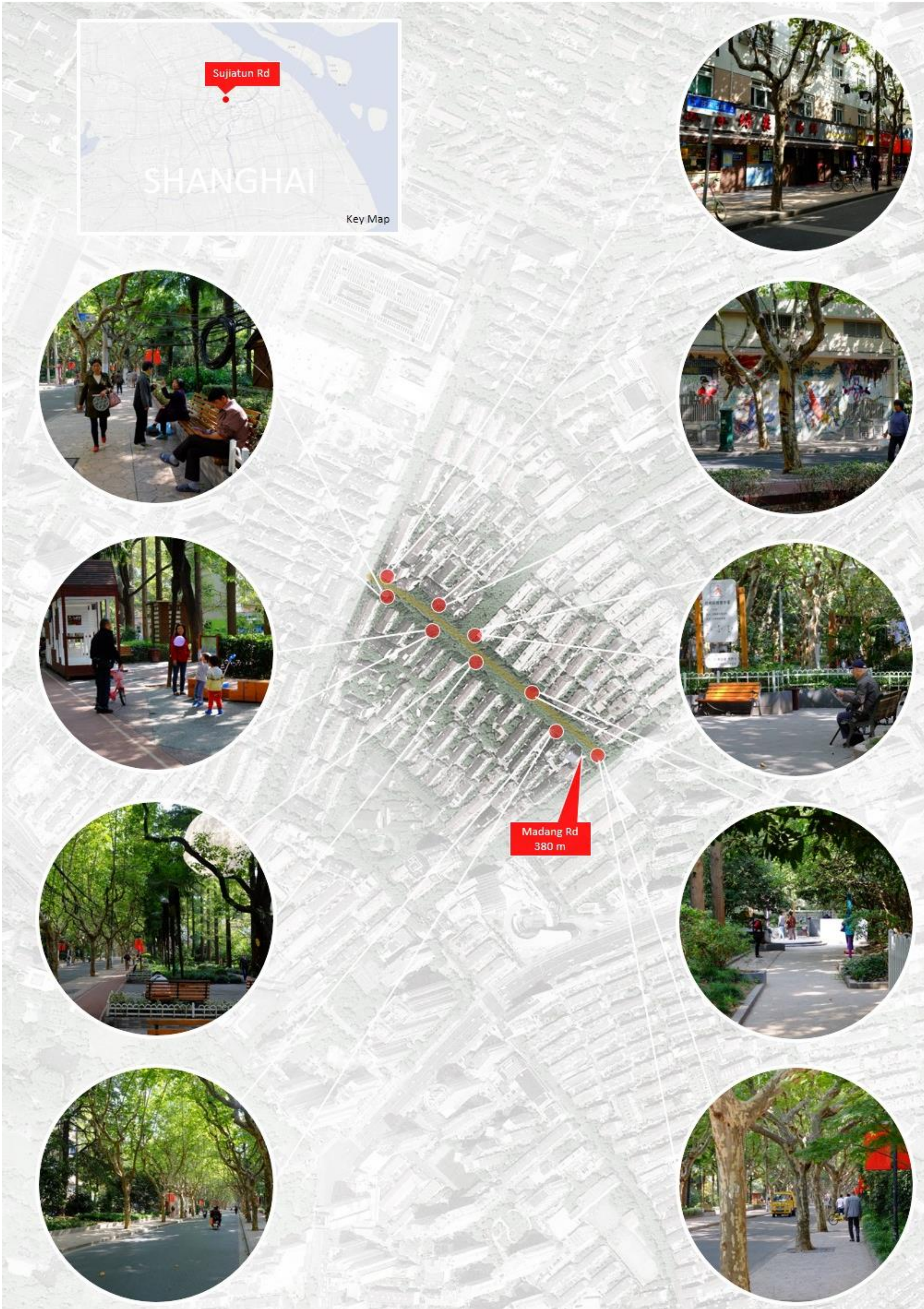
Firstly, Sujiatun Rd was built with the construction of Anshan Village after the establishment of New China (1949). Anshan Village, as one of the earliest workers villages in Shanghai, was built gradually from Anshan NO 1 village to Anshan NO. 8 Village from 1950 to 1990. Worker village is a typical residential form of Chinese characteristics. It is neither like the community blocks of modern style nor similar to the traditional Shikumen of Shanghai style. It is a big residential area in suburban areas which is dominated and built by the government as public housing in the socialist context (introduced in Chapter 5.3.3). The main feature of Worker Village is "Compact, Concentration, Commonality and Sharing". The residential buildings are mainly 3 to 5 floors, 4 or 5 households and one sharing kitchen and toilet in each floor, and about 10-15 m^2 for each household. Contrary to the tight and compact private space, a relatively spacious public garden is in the centre of villages and along the public streets to provide places for people's daily communication and activities. From a historical perspective, such compact and sharing layout not only met the political and social demand, "service for production and service for the workers", but also solved the conflicts between the slow economic development and growing demand in life quality. Therefore, Sujiatun Rd was built in such background with the features of high-density population spacious green space.

Secondly, Sujiatun Rd is close to Tongji University, so it is often selected as the site for the academic researches, design projects, or social survey of college students from Tongji University.

Also, the local government cooperated with Fab-Lab Shanghai, a design college of Tongji University. They joined together to push the retrofit and upgrade of Sujiatun Rd, including the improvement of the streetscape, increase the public facilities, and enhancement of public aesthetic. Moreover, many local festivals and road shows, like the lantern festival, have been happened in this street regularly. Therefore, Sujiatun Rd has been not only the main street for daily activities of local peoples but also an important place for their social life. With the gradual improvement of street quality, increasing people would like to come to visit. Just like one pedestrian participating in the Questionnaire Survey said, "*Whether you are the first time or have been here for several times, you will always want to stay a little bit longer when passing though Sujiatun Rd*".

Table 8. 13: Brief of Sujiatun Rd

Location	Workers' village in Shanghai suburbs
Total Length	380 meters
Built	In the 1970s
Type	Community branch
Feature	- A green and quiet community street with high green rate and nice street furniture; - Located in old Worker Village with high living density; - Local government cooperates with the university to retrofit the street and enhance the streetscape.



Photoed and made by the author. Source of satellite map: (Baidu, 2017)

Figure 8. 13: Analysis Graph of Sujiatun Rd

8.4.2 Evaluation Results of the Indicator System

Sujiatun Rd was investigated three times on 25th Jul., 2nd Nov., and 4th Nov. 2017 respectively. Table 8. 14 illustrates the results and details of the initial diagnosis and normalisation process of each indicator.

It can be seen from the score statistics that the average of 30 evaluated indicators was 2.00 (score range is from 0 to 3 points). Among them, the number of indicators getting the full score of 3 points was 11, accounting for 36.7%; the number of indicators getting 2 points was 11, accounting for 36.7%; the number of indicators getting 1 point was 5, accounting for 16.7%, and the indicators getting 0 point were C6-1 (Tactile pavement for the blind), the C12-1 (Intelligent Transportation System), and C13-2 (Types of Temporary Business) respectively, accounting for 10.0% of the total.

Based on the designed aggregation methods, the values of 15 evaluation criteria were calculated by the 30 indicators. The average score of fifteen criteria was 0.133 (range from 0 to 0.208). The criterion of C9 (Diversity) gained the highest score of 0.198, followed by C10 (Culture Inheritance) with a score of 0.193 and C2 (Mitigation UHI) with a score of 0.190. The lowest score was gotten by C13 (Business Creation) with a score of 0.035, and followed by 0.094 of C14 (Job Creation) and 0.097 of C15 (Added-Value).

Then, the values at the sub-target layer were calculated according to the aggregation formula. In the sub-target layer, the SoSI obtained the highest score of 7.63, EnSI got 7.31, and EcSI was the lowest at only 4.99.

At last, the Sustainable Street Index (SSI) of Sujiatun Rd was 6.53 according to the calculation.

Table 8. 15 shows the aggregation results and the detailed scores at all levels of the evaluation framework. Figure 8. 14 and Figure 8. 15 present the sustainable evaluation results of Sujiatun Rd and illustrate the scores in each evaluation layers as well as the relationships among four evaluation layers in the form of bar chart and radar graph respectively. It can be seen from the radar graph that the fluctuation of the indicators' scores was very significant.

In the aspect of environmental sustainability, the performance of Sujiatun Rd was relatively good. The average score of ten relevant evaluation indicators were 2.2. Four indicators got the full score of 3 points, namely C1-1 (Adaptable Capacity to Local Climate), C2-1 (Street Green Rate), and C2-2 (Air Temp. Difference), and C5-1 (Green Lifestyle Promotion). Four indicators got 2 points, namely C3-2(Pollution Reduction), C4-1(Rainwater management), C4-2(Ecological Planting), and

C5-2(Green Travel Support). Two indicators got only 1 point, namely C1-2(Adaptable Capacity to Extreme Weather Events), and C3-1(Average Emission of Noise) respectively. It can be seen from the radar chart of indicators' score, the ten scores (from C1-1 to C5-2) were fluctuated but generally stayed in the middle and high level. Therefore, the EnSI of Sujiatun Rd got 7.31, which was a pretty high score.

Concerning the social sustainability of Sujiatun Rd, five indicators got the full score of 3 points, four indicators got 2 points, and one indicator, namely C6-1 (Tactile pavement for the blind), got 0 point. The scores of the corresponding criteria were pretty high, and their average was 0.154. Therefore, the SoSI of Sujiatun Rd was 7.63 according to the calculations.

Regarding the economic sustainability of Sujiatun Rd, the overall performance was unsatisfactory. The average score of 10 indicators was only 1.5. Two indicators, namely C12-1(Intelligent Transportation System) and C13-2(Types of Temporary Business), got 0 point, and three indicators, namely C13-1(Density of Shops), C14-1(Employment Creation), and C15-1(Added Value of Commercial Rents) respectively, got 1 point. Therefore, the evaluation values of corresponding criteria were relatively low after aggregation. Also, the scores of C13 (Business Creation), C14 (Job Creation) and C15 (Added-Value) were the lowest three in total 15 criteria, namely 0.035, 0.094, and 0.097 respectively. Consequently, the score of EcSI was only 4.99 after the aggregation.

Table 8. 14: Detailed Calculation Process of Indicators of Sujiatun Rd

Indicators Code	Indicators Title	Acquisition Mode	Initial Diagnoses	Normalised Values	Details of initial diagnoses and normalisation
C1-1	***Adaptable Capacity to Local Climate***	D	3 ticks	3	Total number of ticks below is 3 ✓ *The choice of street trees and other plants suits Shanghai climate (hot summer and cold winter) and helps to maximise the time for comfortable activities in streets;* ✓ *Street furniture (including the bus station, street seats, & pavement shops) and facilities (like sharing/canopy) in frontage zone suits Shanghai climate (hot summer, cold winter and relatively rainy all year);* ✓ *A reasonable combination of plaza and green space in streets and proving flexibility for future.* Therefore, according to the normalisation rules, the normalised value of the indicator C1-1 is 3 since it has 3 ticks in the initial diagnosis.
C1-2	***Adaptable Capacity to Extreme Weather Events***	D	1 tick	1	Total number of ticks below is 1 ✓ *All street furniture and facilities are durable and secure;* ❑ *Smart alarm and notification for extreme weather events in the street;* ❑ *Emergency safety measurements for extreme weather situation, like windstorm and flooding.* Therefore, according to the normalisation rules, the normalised value of the indicator C1-2 is 1 since it has 1 tick in the initial diagnosis.
C2-1	***Street Green Rate***	M	43%	3	The street width is below 40 meters, and the street green rate is 43%. Hence according to the normalisation rules, the normalised value of the indicator C2-1 is 3.
C2-2	***Air Temp. Difference***	M	3.40℃	3	Details of temperature measurement and the calculation of temperature difference: *Measurement Date: 25th Jul. 2017; Weather: Sunny* *Measurement Time*: *10am* / *12am* / *2pm* *Regional Air Temp. (℃)*: 35 / 38 / 40 *Air Temp. of On-site Measurement (℃)*: 31.3 / 33.2 / 38.3 *Temp. Difference (℃)*: 3.7 / 4.8 / 1.7 *Average Temp. Difference (℃)*: *3.40* Therefore, according to normalisation rules, the normalised value of the indicator C2-2 is 3 as the Air Temp. Difference is 3.40 ℃ (above 2℃).

<table>
<tr><th>Indicators Code</th><th>Indicators Title</th><th>Acquisition Mode</th><th>Initial Diagnoses</th><th>Normalised Values</th><th>Details of initial diagnoses and normalisation</th></tr>
<tr><td>C3-1</td><td>Average Emission of Noise</td><td>M</td><td>63.40 Decibel</td><td>1</td><td>Details of on-site Measurement are shown in the table below:
<table>
<tr><td>Measurement Date (weather)</td><td colspan="2">2/11/2017 (Sunny)</td><td colspan="2">4/11/2017 (Cloudy)</td></tr>
<tr><td>Measurement Time</td><td>7-8am</td><td>1-2am</td><td>11-12am</td><td>2-3m</td></tr>
<tr><td>Noise (Decibel)</td><td>69.2</td><td>59.8</td><td>63.2</td><td>68.4</td></tr>
<tr><td colspan="4"><u>Average of Noise (Decibel)</u></td><td><u>65.15</u></td></tr>
</table>
Therefore, according to normalisation rules, the normalised value of the indicator C3-1 is <u>1</u> as the measured average noise is <u>65.15 Decibel (between 65 and 75 Decibel).</u></td></tr>
<tr><td>C3-2</td><td>Pollution Reduction</td><td>D</td><td>2 ticks</td><td>2</td><td>Total number of ticks below is <u>2</u>
✓ The usage of Environmentally friendly or recycled materials or construction technologies for pavement, curb and other street furniture to reduce pollution.
❑ The usage of the energy-efficient system or renewable energy for lighting;
✓ The provision of the bins with clear recycling category in the street.
Therefore, according to the normalisation rules, the normalised value of the indicator C3-2 is <u>2</u> since it has <u>2 ticks</u> in the initial diagnosis.</td></tr>
<tr><td>C4-1</td><td>Rainwater management</td><td>D</td><td>2 ticks</td><td>2</td><td>Total number of ticks below is <u>2</u>:
❑ Reasonable road vertical design and permeable pavement for rainwater drainage;
❑ The use of rain garden for rain management;
❑ Smart alarm and notification for the rainstorm in the street.
Therefore, according to the normalisation rules, the normalised value of the indicator C4-1 is <u>2</u> since it has <u>2 ticks</u> in the initial diagnosis.</td></tr>
<tr><td>C4-2</td><td>Ecological Planting</td><td>D</td><td>2 ticks</td><td>2</td><td>Total number of ticks below is <u>2</u>
✓ All streets' plants are local;
✓ Diversity of plants (the species of plants within one street are more than 5*)
❑ The usage of rainwater recovery or reused water for plant irrigation in the streets
Therefore, according to the normalisation rules, the normalised value of the indicator C4-2 is <u>2</u> since it has <u>2 ticks</u> in the initial diagnosis.</td></tr>
</table>

Indicators Code	Indicators Title	Acquisition Mode	Initial Diagnoses	Normalised Values	Details of initial diagnoses and normalisation
C5-1	***Green Lifestyle Promotion***	D	3 ticks	3	Total number of ticks below is <u>3</u> ✓ *Advertising and publicity of green lifestyle;* ✓ *Regular street show and activities for green life;* ✓ *Space to encourage green lifestyle, like jogging path, plaza and open space along the street* Therefore, according to the normalisation rules, the normalised value of the indicator C5-1 is <u>3</u> since it has <u>3 ticks</u> in the initial diagnosis.
C5-2	***Green Travel Support***	D	2 ticks	2	Total number of ticks below is <u>2</u> ✓ *Provision of a minimum-1.5m-width sidewalk with comfortable, reliable and pleasant facilities and atmosphere;* ✓ *Provision of a minimum-1.5m-width cycling lane, cycling parking space, and sharing bike station.* ❑ *Provision of the comfortable bus station and clear transit information.* Therefore, according to the normalisation rules, the normalised value of the indicator C5-2 is <u>2</u> since it has <u>2 ticks</u> in the initial diagnosis.
C6-1	***Tactile pavement for the blind***	D	Bad Performance	0	According to the normalisation rules, the normalised value of the indicator C6-1 is <u>0</u> since it shows “Bad Performance” (*there is no tactile pavement for the blind in the street*) in terms of tactile pavement for the blind.
C6-2	***Barrier-Free Facilities***	D	3 ticks	3	Total number of ticks below is <u>3</u> ✓ *Enough space in through zone for wheelchair and baby stroller;* ✓ *Barrier-free design in street intersection;* ✓ *Barrier-free facilities when there is a vertical difference within the sidewalk.* Therefore, according to the normalisation rules, the normalised value of the indicator C6-2 is <u>3</u> since it has <u>3 ticks</u> in the initial diagnosis.
C7-1	***Coverage Proportion of Street Cameras***	M	60%	2	According to the normalisation rules, the normalised value of the indicator C7-1 is <u>2</u> since the coverage proportion of street cameras is <u>60% (between 50% and 80%)</u>.

Indicators Code	Indicators Title	Acquisition Mode	Initial Diagnoses	Normalised Values	Details of initial diagnoses and normalisation
C7-2	***Coverage Safety Equipment***	D	6 ticks	2	Total number of ticks below is <u>6</u> ✓ *Anti-skidding pavement in the sidewalk;* ❑ *Coloured or marks pavement for cycling lanes;* ✓ *Sufficient lighting at night for street safety;* ❑ *Safe getting up/down in bus station;* ✓ *Bollards or planting to separate travel lanes and sidewalks;* ✓ *All street signs and signals are clear, tide-ordered and visible;* ✓ *Various ways to control car speed, including the clear sign of allowed car speed, speed hump or chicanes.* ✓ *In the intersection, featured and highlighted marks on the ground to remind of safety and protect cyclists and pedestrians;* ❑ *Various methods for a safety intersection, such as curb extension in the intersection to reduce crossing distance for pedestrian and decrease car speed, provision of medians for safety island if the street intersection is wide, sound reminder if the crossed traffic is large, skyway or underground passages for pedestrians if necessary* Therefore, according to the normalisation rules, the normalised value of the indicator C7-2 is <u>2</u> since it has <u>6 ticks (between 4 and 6 ticks)</u> in the initial diagnosis.
C8-1	***The Variety of Arrival Ways***	D	3 ticks	2	Total number of ticks below is <u>3</u> ✓ *Walking: provision of a minimum-1.5m-width sidewalk on both sides;* ✓ *Cycling: provision of separated or sharing cycling lanes on both sides, and cycling parking space;* ❑ *Public bus: there are bus station within 300m away from the street* ❑ *Taxi: provision of taxi ranks or taxi Boarding Area;* ❑ *Car: provision of parking lots within 300m from of the street;* ✓ *Special car accessibility: guaranteeing emergency cars, like the ambulance, fire-fighting truck, to access.* ıerefore, according to the normalisation rules, the normalised value of the indicator C8-1 is <u>2</u> since it has <u>3 ticks (3-4 ticks)</u> in the initial diagnosis.

Indicators Code	Indicators Title	Acquisition Mode	Initial Diagnoses	Normalised Values	Details of initial diagnoses and normalisation
C8-2	***Clear Sign and Guidance System***	D	2 ticks	2	Total number of ticks below is <u>2</u> ✓ *Provision of clear signs of basic street information, including street name, direction, and traffic regulation;* ✓ *Provision of extra information of surrounding situation;* ❑ *Provision of smart wayfinding system.* Therefore, according to the normalisation rules, the normalised value of the indicator C8-2 is <u>2</u> since it has <u>2 ticks</u> in the initial diagnosis.
C9-1	***Diversity of Street Activities***	M	10 pcs	3	Total number of activities observed on the street is <u>10</u> ✓ *Strolling* ✓ *Dog walking* ✓ *Sitting* ✓ *Meeting friends* ✓ *Kids playing* ✓ *Jogging & physical exercise* ✓ *Watching newspaper/reading books* ✓ *Playing chess/cards in groups* ✓ *Shopping* ✓ *Drinking & Eating* Therefore, according to the normalisation rules, the normalised value of the indicator C9-1 is <u>3</u> since the number of activity types observed in the street is <u>10 (between 7 and 10)</u> in the initial diagnosis.
C9-2	***Diversity of Street Functions***	D	4 ticks	3	Total number of ticks below is <u>4</u> ✓ *Traffic function* ✓ *Social function* ❑ *Commercial function* ✓ *Cultural function* ❑ *Political function* ✓ *Ecological function* Therefore, according to the normalisation rules, the normalised value of the indicator C9-2 is <u>3</u> since it has <u>4 ticks (between 3 and 4)</u> in the initial diagnosis.

Indicators Code	Indicators Title	Acquisition Mode	Initial Diagnoses	Normalised Values	Details of initial diagnoses and normalisation
C10-1	***Aesthetic Quality of Street Furniture***	D	Excellent Performance	3	According to the normalisation rules, the normalised value of the indicator C10-1 is 3 since it shows Excellent Performance in terms of aesthetic quality of street furniture. (*All street elements, including seats, Bollards, Pedestrian Guardrails, Bins, Public art, telephone boxes, parking control equipment, post and pouch boxes, smoke vents, bus station, pavement, lighting system, information station, cycling parks, and kerb, are designed dedicatedly and form as a whole and display high aesthetic quality)*
C10-2	***Style Consistency with Surroundings***	D	Excellent Performance	3	According to the normalisation rules, the normalised value of the indicator C10-2 is 3 since it shows Excellent Performance in terms of style consistency with surroundings (*Streetscape highlights and well displays local culture and historic heritage).*
C11-1	***Intensiveness of Street Space***	D	3 ticks	3	Total number of ticks below is 3 ✓ *The reasonable width of travel lanes, cycling lanes, and sidewalk.* ✓ *Reasonable and Intensive design of intersection land;* ✓ *Integration design of street furniture to save the street land* Therefore, according to the normalisation rules, the normalised value of the indicator C11-1 is 3 since it has 3 ticks in the initial diagnosis.
C11-2	***Mixed-Use of Street Land***	D	2 ticks	2	Total number of ticks below is 2 ✓ *To open building setback and design together between building line and the sidewalks inside the street red line* ✓ *Sharing street, such as tidal changeable lanes, travel & cycling sharing street;* ❑ *Multi-functional street space: changeable parking strip, temporary pavement cafe.* Therefore, according to the normalisation rules, the normalised value of the indicator C11-2 is 2 since it has 2 ticks in the initial diagnosis.
C12-1	***Intelligent Transportatio n System***	D	0 tick	0	Total number of ticks below is 0 ❑ *Intelligent public bus system to show real-time bus arrival time in bus station;* ❑ *Intelligent parking system to show real-time number of parking spaces;* ❑ *Intelligent traffic system to show real-time traffic condition.* Therefore, according to the normalisation rules, the normalised value of the indicator C12-1 is 0 since it has 0 tick in the initial diagnosis.

<table>
<thead>
<tr><th>Indicators Code</th><th>Indicators Title</th><th>Acquisition Mode</th><th>Initial Diagnoses</th><th>Normalised Values</th><th>Details of initial diagnoses and normalisation</th></tr>
</thead>
<tbody>
<tr><td>C12-2</td><td>Traffic Performance Index</td><td>N</td><td>Very Smooth</td><td>3</td><td>Based on the normalisation rules, the normalised value of the indicator C12-2 is 3 since its according to the official published data from Shanghai Urban and Rural Construction and Traffic Development Institute Year Average Traffic Performance of Daxue Rd is Very Smooth (The traffic is in good condition, the average traffic density of the road is small and the speed is high). .</td></tr>
<tr><td>C13-1</td><td>Density of Shops</td><td>M</td><td>0.53 shops/ 100meters</td><td>1</td><td>The detail information of shops number and the calculation process are shown in the table below:
<table>
<tr><th></th><th>South Side</th><th>North Side</th><th>Total</th></tr>
<tr><td>Number of Shops along Street</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td>Street Length (Meters)</td><td>380</td><td>380</td><td>760</td></tr>
<tr><td>Average Shops per 100 Meters</td><td></td><td></td><td>0.53</td></tr>
</table>
Therefore, according to the normalisation rules, the normalised value of the indicator C13-1 is 1 as its initial diagnosis is 0.53 shops/ 100meters (between 2 and 7).</td></tr>
<tr><td>C13-2</td><td>Types of Temporary Business</td><td>M</td><td>0 tick</td><td>0</td><td>Total number of ticks below is 0

❑ Temporary pavement café & F&B;
❑ Temporary food station;
❑ Temporary show spot
❑ Temporary flower station;
❑ Mobility Street vendor (cigarettes, disc, girls' accessory, clothes, portrait drawing, street show and etc.)

Therefore, according to the normalisation rules, the normalised value of the indicator C13-2 is 0 since it has 0 tick in the initial diagnosis).</td></tr>
<tr><td>C14-1</td><td>Employment Creation</td><td>D</td><td>Medium Performance</td><td>1</td><td>According to the normalisation rules, the normalised value of the indicator C14-1 is 1 since it shows Medium Performance in terms of jobs creation (There are some jobs in/along the street, like on-street parking assistants, security guards, convenient shops retailers.</td></tr>
</tbody>
</table>

Indicators Code	Indicators Title	Acquisition Mode	Initial Diagnoses	Normalised Values	Details of initial diagnoses and normalisation
C14-2	***Types of Jobs***	M	3 ticks	2	Total number of ticks below is 3 ✓ *Salesperson* ✓ *Waitress* ✓ *Agent* ❑ *Craftsman* ❑ *Officers* ❑ *Parking administrator;* ❑ *Mobile street vendor* Therefore, according to the normalisation rules, the normalised value of the indicator C14-2 is 3 since it has 3 ticks (between 3 and 5) in the initial diagnosis.
C15-1	***Added Value of Commercial Rents***	C	0.6%	1	Details of data calculation are shown in the table below: *Average Rental fee along Daxue Rd (RMB/㎡/Day)* — *9.30* *Average rental fee in Yangpu District (RMB/㎡/Day)* — *9.24* *Added Value of Commercial Rents (%) =* $= \frac{(\textbf{Unit Price of Commercial Rent along Street} - \textbf{Avg. Unit Price of Commercial Rent in the District})}{\textbf{Average Unit Price of Commercial Rent in this District}}$ — *0.6%* Therefore, according to the normalisation rules, the normalised value of the indicator C15-1 is 1 since the initial diagnosis is 0.6% (between 0% and 2%).
C15-2	***Added-Value of Housing Prices***	C	4.5%	2	Details of data calculation are shown in the table below: *Average housing price along Madang Rd (10,000RMB/㎡)* — *7.2* *Average housing price in Yangpu District (10,000RMB/㎡)* — *6.9* *Added Value of Housing Prices (%) =* $\frac{(\textbf{Unit Housing Price along the Street} - \textbf{Avg. Unit Housing Price in this District})}{\textbf{Average Unit Housing Price in this District}}$ — *4.5%* Therefore, according to the normalisation rules, the normalised value of the indicator C15-2 is 2 since the initial diagnosis is 4.5% (between 3% and 10%).

Table 8. 15: Table of Sustainability Evaluation Results of Sujiatun Rd

Evaluation Framework				Weights	Evaluation Values			
Target Layer	***Sub-Target Layer***	***Criteria Layer***	***Indicator Layer***		***Indicators***	***Criteria***	***Sub-Targets***	***Target***
SSI	***EnSI***	**C_1**	**C_{1-1}**	*0.0338*	3	0.135	7.31	6.53
			C_{1-2}	*0.0338*	1			
		C_2	**C_{2-1}**	*0.0317*	3	0.190		
			C_{2-2}	*0.0317*	3			
		C_3	**C_{3-1}**	*0.0337*	1	0.101		
			C_{3-2}	*0.0337*	2			
		C_4	**C_{4-1}**	*0.0332*	2	0.133		
			C_{4-2}	*0.0332*	2			
		C_5	**C_{5-1}**	*0.0345*	3	0.172		
			C_{5-2}	*0.0345*	2			
	SoSI	**C_6**	**C_{6-1}**	*0.0338*	0	0.101	7.63	
			C_{6-2}	*0.0338*	3			
		C_7	**C_{7-1}**	*0.0344*	2	0.137		
			C_{7-2}	*0.0344*	2			
		C_8	**C_{8-1}**	*0.0334*	2	0.133		
			C_{8-2}	*0.0334*	2			
		C_9	**C_{9-1}**	*0.0331*	3	0.198		
			C_{9-2}	*0.0331*	3			
		C_{10}	**C_{10-1}**	*0.0322*	3	0.193		
			C_{10-2}	*0.0322*	3			
	EcSI	**C_{11}**	**C_{11-1}**	*0.0346*	3	0.173	4.99	
			C_{11-2}	*0.0346*	2			
		C_{12}	**C_{12-1}**	*0.0335*	0	0.100		
			C_{12-2}	*0.0335*	3			
		C_{13}	**C_{13-1}**	*0.0351*	1	0.035		
			C_{13-2}	*0.0351*	0			
		C_{14}	**C_{14-1}**	*0.0313*	1	0.094		
			C_{14-2}	*0.0313*	2			
		C_{15}	**C_{15-1}**	*0.0323*	1	0.097		
			C_{15-2}	*0.0323*	2			

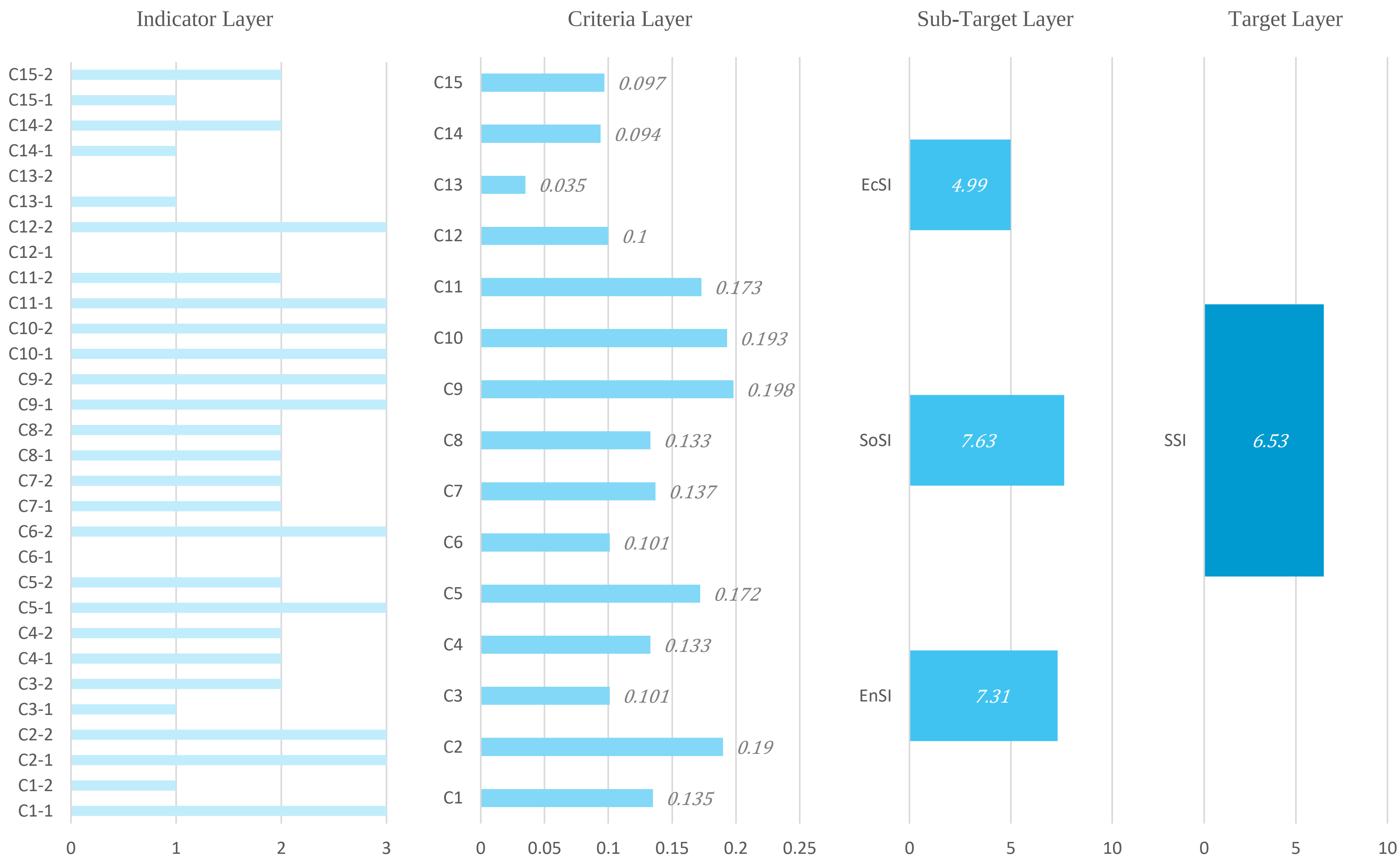
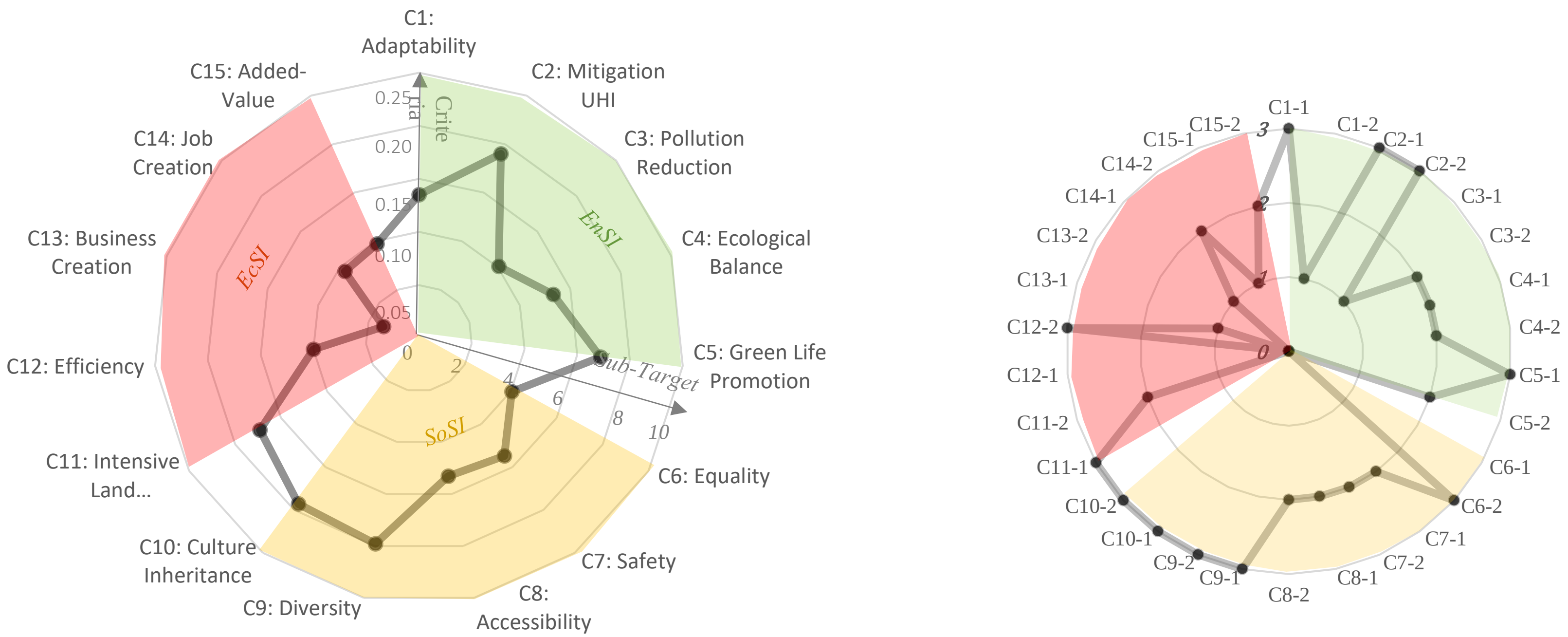


Figure 8. 14: Analysis Graphs of Sustainability Evaluation Results of Sujiatun Rd



C1-1	Adaptable Capacity to Local Climate	**C2-1**	Street Green Rate	**C3-1**	Average Emission of Noise	**C4-1**	Rainwater management	**C5-1**	Green Lifestyle Promotion
C1-2	Adaptable Capacity to Extreme Weather Events	**C2-2**	Air Temp. Difference	**C3-2**	Pollution Reduction	**C4-2**	Ecological Planting	**C5-2**	Green Travel Support
C6-1	Tactile pavement for the blind	**C7-1**	Coverage Proportion of Street Cameras	**C8-1**	The Variety of Arrival Ways	**C9-1**	Diversity of Street Activities	**C10-1**	Aesthetic Quality of Street Furniture
C6-2	Barrier-Free Facilities	**C7-2**	Coverage Safety Equipment	**C8-2**	Clear Sign and Guidance System	**C9-2**	Diversity of Street Functions	**C10-2**	Style Consistency with Surroundings
C11-1	Intensiveness of Street Space	**C12-1**	Intelligent Transportation System	**C13-1**	Density of Shops	**C14-1**	Employment Creation	**C15-1**	Added Value of Commercial Rents
C11-2	Mixed-Use of Street Land	**C12-2**	Traffic Performance Index	**C13-2**	Types of Temporary Business	**C14-2**	Types of Jobs	**C15-2**	Added-Value of Housing Prices

Figure 8. 15: Radar Graphs of Sustainability Evaluation Results of Sujiatun Rd

8.4.3 Evaluation Results of the Questionnaire Survey

The questionnaire surveys were issued on Sujiatun Rd on 2nd Nov., and 4th Nov. 2017.

A total of 51 questionnaires were handed out. After the on-site survey results were processed and organised, the integrity and effectiveness of the questionnaires were checked. One questionnaire was regarded as invalid due to the issues of integrity. Therefore, 50 questionnaires were deemed to be valid.

Once the data was cleaned and get prepared, they were analysed to confirm the validness of these obtained data (Table 8. 16). Then, the average values of 50 questionnaires were filled in the column of “criteria” in the evaluation framework, and the values of the sub-target layer as well as the target layer were calculated accordingly based on the established aggregation methods. Table 8. 17 shows the results of sustainability appraisal based on the questionnaire results of Sujiatun Rd, and Figure 8. 17 illustrates the comparison of the scores regarding the criteria, the sub-target, and the target layers.

The SoSI, EnSI, and EcSI of Madang Rd were 7.10, 6.97, and 5.50 respectively, and the SSI of Sujiatun Rd was 6.48. Concerning social and environmental sustainability, the scores of 10 evaluation criteria assessed by street users slightly fluctuated around 2.0. The highest score was C5 (Green Life Promotion) with a score of 2.26, followed by 2.22 of C8 (Accessibility) and 2.18 of C7 (Safety). Therefore, the SoSI and EnSI were 7.10 and 6.97 respectively, and the scores were approximate. In economic aspect, the street users gave the lowest four scores to C14 (Job Creation), C13 (Business Creation), C15 (Added-Value), and C12 (Efficiency), namely 1.26, 1.28, 1.80, and 1.86 respectively. Consequently, the final score of EcSI was 5.50 according to the data aggregation.

Taken by the author

Figure 8. 16: Questionnaire Survey on Sujiatun Rd

Table 8. 16: Statistic Table of Questionnaire results (Sujiatun Rd)

Questionnaire NO.		Environmental Sustainability					Social Sustainability					Economic Sustainability				
		C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**	**C15**
Raw data	*1*	3	3	3	3	3	3	2	2	1	1	1	2	0	0	1
	2	2	3	3	3	3	3	3	2	2	3	2	2	1	1	2
	3	3	3	3	3	3	3	3	3	3	3	3	3	1	1	1
	4	2	2	3	3	2	2	2	1	3	3	2	3	2	2	2
	5	2	2	1	2	2	2	2	2	2	1	2	2	1	1	3
	6	1	2	2	2	3	1	1	2	2	3	3	1	1	1	2
	7	2	2	2	2	3	2	2	2	3	2	2	2	1	1	2
	8	2	2	2	2	3	3	3	3	2	3	2	2	2	2	2
	9	3	2	3	3	3	3	3	2	3	1	2	1	1	0	1
	10	2	2	2	2	3	2	3	3	2	3	2	3	2	2	2
	11	2	2	2	2	2	3	3	3	2	2	2	2	2	2	2
	12	1	1	1	2	2	2	2	1	1	1	1	1	1	1	1
	13	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2
	14	2	2	3	2	2	2	2	2	2	1	1	1	0	0	2
	15	2	2	2	1	3	2	3	3	1	1	1	1	1	1	1
	16	3	3	3	3	3	3	3	3	3	3	3	2	1	1	1
	17	3	3	3	3	3	3	3	2	3	1	3	3	2	2	3
	18	3	2	2	2	3	1	2	2	2	3	2	2	1	2	2
	19	3	2	2	3	3	3	2	1	2	2	1	1	1	2	1
	20	2	2	2	3	2	3	2	3	3	3	2	2	1	1	1
	21	2	3	1	2	2	2	2	2	1	1	2	2	0	0	1
	22	3	3	2	3	3	2	3	3	2	3	3	3	1	1	3
	23	1	2	0	3	3	3	3	3	3	3	2	1	1	0	0
	24	3	3	2	3	3	2	3	3	2	1	3	3	1	1	1
	25	2	3	2	3	3	2	3	3	2	2	2	1	1	1	1
	26	2	2	2	1	1	2	2	2	3	2	1	1	1	0	2
	27	2	1	2	2	2	1	2	1	3	1	2	1	1	1	1
	28	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	29	1	3	3	2	2	0	1	0	1	1	1	0	1	1	1
	30	2	2	2	2	1	2	2	3	3	3	3	3	2	2	3

Questionnaire NO.		Environmental Sustainability					Social Sustainability					Economic Sustainability				
		C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**	**C15**
Raw data	*31*	2	1	2	1	1	1	1	3	1	2	3	3	2	2	2
	32	2	2	2	3	2	3	2	2	1	1	2	2	2	2	3
	33	2	1	1	2	1	1	1	1	1	2	2	3	1	1	2
	34	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2
	35	1	1	1	1	1	1	2	3	2	3	3	3	2	2	2
	36	1	1	1	1	1	1	1	2	1	1	2	1	2	2	3
	37	2	2	2	2	1	2	2	2	1	1	1	1	2	2	2
	38	1	1	2	1	1	3	2	3	3	3	3	3	2	2	3
	39	2	1	2	3	2	3	2	2	3	3	3	2	1	1	2
	40	1	1	1	1	1	2	2	2	2	2	2	2	1	1	2
	41	2	1	1	1	1	1	3	3	3	2	3	3	1	1	3
	42	1	1	2	1	2	1	2	2	1	2	1	1	1	1	2
	43	1	1	2	1	2	2	1	2	3	2	2	2	2	2	2
	44	3	2	2	2	2	3	1	3	3	2	3	3	1	1	3
	45	3	3	3	3	3	3	3	2	2	3	2	1	1	1	1
	46	2	2	3	3	2	2	2	2	3	3	2	1	1	2	1
	47	1	2	2	2	3	1	1	2	2	3	1	1	1	1	1
	48	2	2	2	2	3	2	2	2	3	2	2	2	1	1	2
	49	3	2	3	3	3	3	3	2	3	1	2	1	1	0	1
	50	2	2	2	1	3	2	3	3	1	1	1	1	1	1	1
Descriptive Analysis	**Average**	**2.02**	**1.98**	**2.04**	**2.14**	**2.26**	**2.10**	**2.18**	**2.22**	**2.14**	**2.04**	**2.04**	**1.86**	**1.28**	**1.26**	**1.80**
	Median	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2
	Statistical Mode	2	2	2	3	3	2	2	2	3	3	2	1	1	1	2
	Standard Deviation	0.71	0.71	0.73	0.78	0.80	0.81	0.72	0.74	0.81	0.86	0.73	0.86	0.61	0.72	0.78
	Variance	0.50	0.50	0.52	0.60	0.63	0.65	0.51	0.53	0.64	0.72	0.52	0.72	0.36	0.51	0.60
	Kurtosis	-0.98	-0.98	0.01	-1.31	-1.25	-0.71	-0.99	0.31	-1.42	-1.65	-1.06	-1.23	0.37	-0.47	-0.81
	Skewness	-0.03	0.03	-0.39	-0.25	-0.51	-0.43	-0.28	-0.70	-0.27	-0.08	-0.06	0.08	0.35	-0.10	0.11
	Max.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Min.	1	1	0	1	1	0	1	0	1	1	1	0	0	0	0

Table 8. 17: Table of Sustainability Evaluation from Questionnaire results of Sujiatun Rd

Evaluation Framework				Questionnaire Results		
Criteria Code	**Sub-Target Code**	**Target Code**	**Weights**	**Criteria[1]**	**Sub-target[2]**	**Target[2]**
C_1	**EnSI**	**SSI**	0.0676	2.02	6.97	6.48
C_2			0.0633	1.98		
C_3			0.0673	2.04		
C_4			0.0663	2.14		
C_5			0.0689	2.26		
C_6	**SoSI**		0.0675	2.10	7.10	
C_7			0.0687	2.18		
C_8			0.0667	2.22		
C_9			0.0661	2.14		
C_{10}			0.0630	2.04		
C_{11}	**EcSI**		0.0692	2.04	5.50	
C_{12}			0.0669	1.86		
C_{13}			0.0702	1.28		
C_{14}			0.0625	1.26		
C_{15}			0.0645	1.80		

Note:

1: The values of criteria layer are the averages of the survey results of street questionnaires;

2: The values of sub-target layer and target layer are calculated based on the values of criteria layer and weights according to the aggregation methods of evaluation framework.

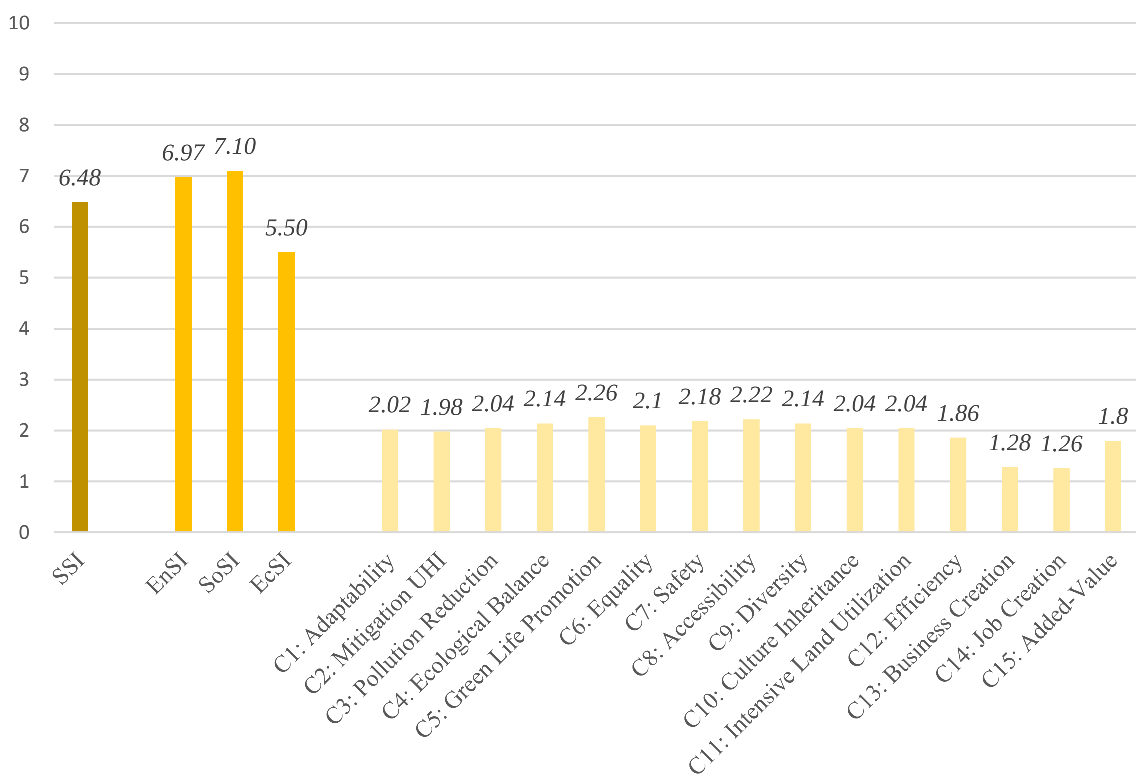


Figure 8. 17: Bar Chart of Sustainability Evaluation from Questionnaire Results of SujiatunRd

8.4.4 Comparison and Analysis

Two sets of sustainable evaluation of Sujiatun Rd were worked out based on the Indicator System and the Questionnaire Survey of street users. Table 8. 18 presents the comparison of two sets of data, and Figure 8. 18 illustrates the similarities and differences of two sets of data through the bar chart and radar diagram.

First, from the perspective of the target layer, the SSI of the Indicator System was 6.53, which was 0.05 higher than that of the Questionnaire Survey (6.48). It can be seen that the two results were very close, and the difference is within 1%.

At the sub-target layer, the SoSI, EnSI, and EcSI based on the Indicator System were 7.63, 7.31, and 4.90 respectively, and the three indexes calculated by questionnaire results were 7.10, 6.97, and 5.50. It can be found that the ranking of two sets of data was consistent regarding three aspects of sustainability: SoSI got the highest score, closely followed by EnSI, and the EcSI was the lowest one. Furthermore, the differences between them were also relatively small. The EcSI from the Questionnaire Survey was 0.6 (10.9%) higher than that from the Indicator System, and the gaps of EnSI and SoSI were 4.9% and 7.5% respectively. The arithmetic averages of Indicator System and that of questionnaire results were also close (the former was 6.61, and the latter was 6.52), however the Variation of the former data was 2.23 while that of the latter was only 0.79, which meant the fluctuations of evaluation results from the Indicator System were much larger than that from questionnaires.

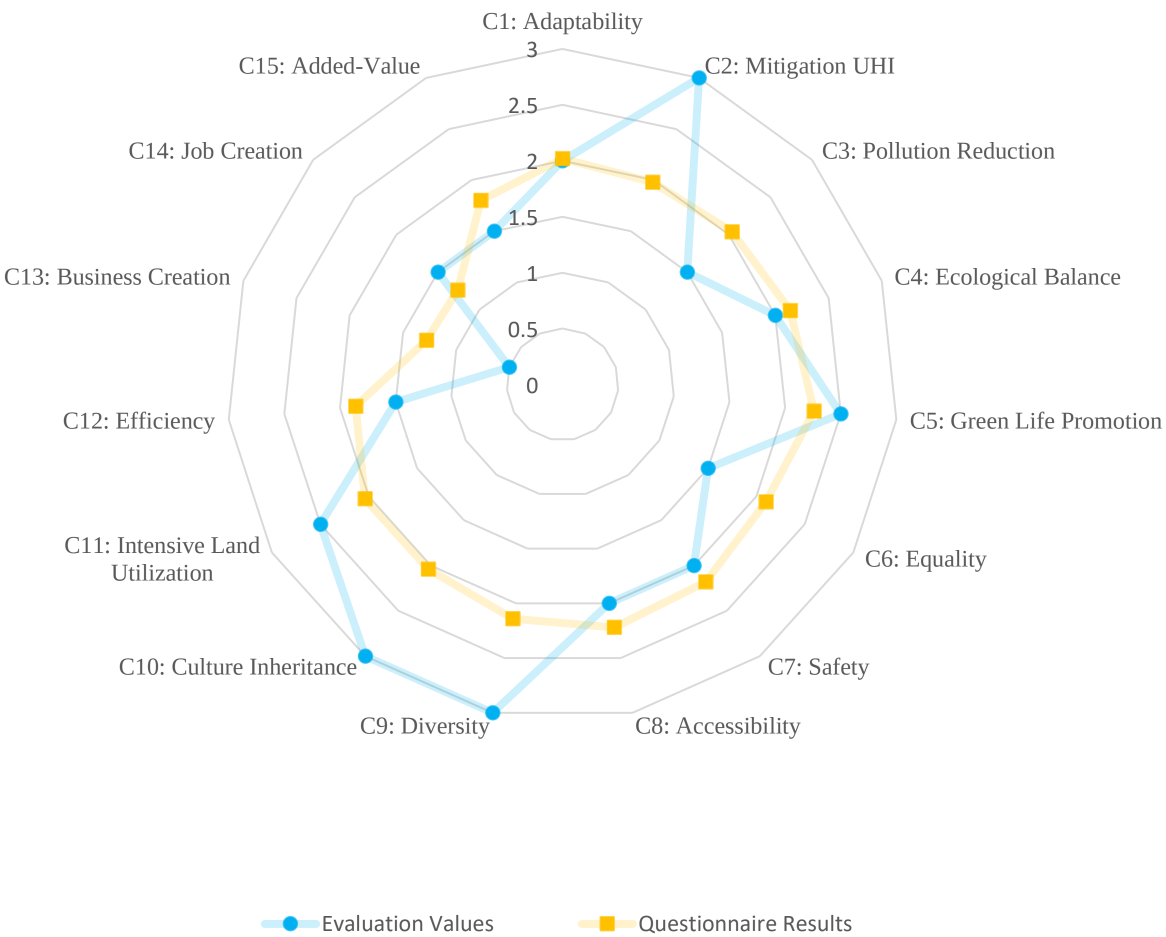
Finally, regarding two sets of data at the criteria layer, the main similarities and differences were similar to those in the sub-target layer identified above. The arithmetic averages of 15 criteria of two sets of data were very close: 2.00 of the Indicator System and 1.96 of the Questionnaires Survey. Moreover, the trends of the two sets of data were consistent, and the changes from C1 to C15 were nearly the same. Meanwhile, the key differences lying in the two sets of data were that the fluctuations of the criteria’s values from the Indicator System were much more evident than those from the Questionnaire Survey. When it came to the lowest score of C13 (Business Creation), the score from the Indicator System was 0.5 while that from the Questionnaire Survey was 1.28. The highest score of 15 criteria from the Indicator System was 3.0, while that from questionnaire results was 2.26. Moreover, the top three scores from the Indicator System were C2 (Mitigation UHI), C9 (Diversity) and C10 (Culture Inheritance) with the same score of 3.0. However, the top three scores from the Questionnaire Survey were C5 (Green life promotion), C8 (Accessibility) and C7 (Safety) with a score of 2.26, 2.22, and 2.18 respectively.

In summary, ***the data variations from the Indicator System were more noticeable than those from the Questionnaire Survey, but the two sets of data were consistent on the whole regarding to their rank order and the scores of SSIs***.

Table 8. 18: Comparison Table between Sustainability Evaluation and Questionnaire Survey Results (Sujiatun Rd)

Evaluation Framework				**Evaluation values**				***Questionnaire Results***		
Target layer	**Sub-Target layer**	**Criteria layer**	**Indicator layer**	**Indicators**	**Criteria**	**Sub-Target**	**Target**	***Criteria***	***Sub-target***	***Target***
SSI	*EnSI*	C_1	C_{1-1}	*3*	*2.00*	7.31 **	6.53	*2.02*	6.97 **	*6.48*
			C_{1-2}	*1*						
		C_2	C_{2-1}	*3*	*3.00*			*1.98*		
			C_{2-2}	*3*						
		C_3	C_{3-1}	*1*	*1.50*			*2.04*		
			C_{3-2}	*2*						
		C_4	C_{4-1}	*2*	*2.00*			*2.14*		
			C_{4-2}	*2*						
		C_5	C_{5-1}	*3*	*2.50*			*2.26*		
			C_{5-2}	*2*						
	SoSI	C_6	C_{6-1}	*0*	*1.50*	7.63 *		*2.10*	7.10 *	
			C_{6-2}	*3*						
		C_7	C_{7-1}	*2*	*2.00*			*2.18*		
			C_{7-2}	*2*						
		C_8	C_{8-1}	*2*	*2.00*			*2.22*		
			C_{8-2}	*2*						
		C_9	C_{9-1}	*3*	*3.00*			*2.14*		
			C_{9-2}	*3*						
		C_{10}	C_{10-1}	*3*	*3.00*			*2.04*		
			C_{10-2}	*3*						
	EcSI	C_{11}	C_{11-1}	*3*	*2.50*	4.90 ***		*2.04*	5.50 ***	
			C_{11-2}	*2*						
		C_{12}	C_{12-1}	*0*	*1.50*			*1.86*		
			C_{12-2}	*3*						
		C_{13}	C_{13-1}	*1*	*0.50*			*1.28*		
			C_{13-2}	*0*						
		C_{14}	C_{14-1}	*1*	*1.50*			*1.26*		
			C_{14-2}	*2*						
		C_{15}	C_{15-1}	*1*	*1.50*			*1.80*		
			C_{15-2}	*2*						

*Note: *,**, and *** means the rank order*



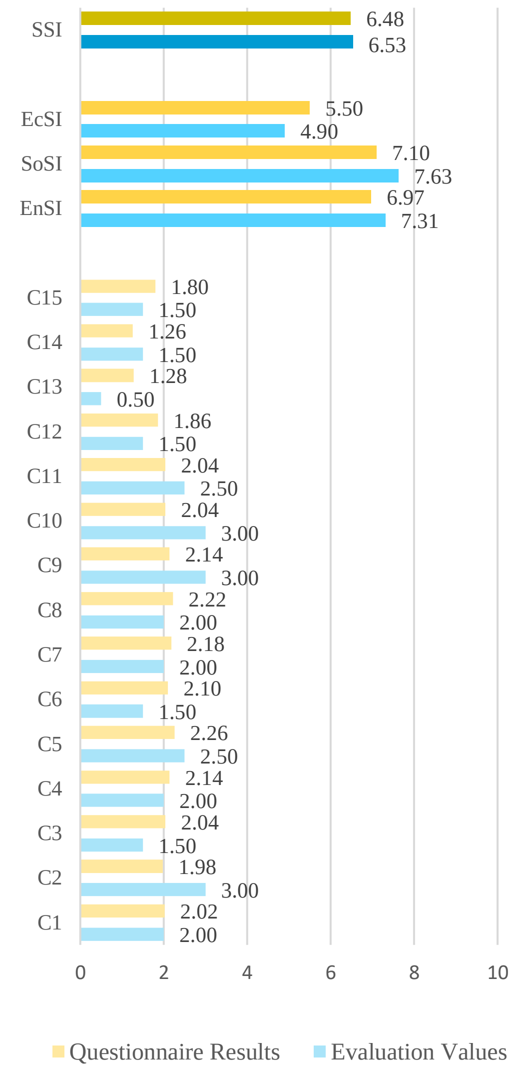


Figure 8. 18: Analysis Graphs of Comparison between Sustainability Evaluation and Street Questionnaire Results (Sujiatun Rd)

8.5 Potential System Improvements

8.5.1 Cross-comparison

In order to have a comprehensive comparison, the cross-comparisons included the analysis of three aspects:

1) The comparison of the evaluation results of the Indicator System of three streets;
2) The comparison of the evaluation results of the Questionnaires Survey of three streets;
3) The comparison of the differences and similarities between the evaluation results of the Indicator System and that of the questionnaire survey of three streets.

The following parts are the analysis of three-aspect comparison.

Cross-comparison of evaluation results of the Indicator System:

Table 8. 19 shows the data statistics of the three streets that calculated based on the Indicator System of sustainability evaluation. Figure 8. 19 illustrates the comparison of the scores of each layer of three streets that calculated by the Indicator System.

According to the evaluation results of the Indicator System, the SSI scores of Madang Rd, Daxue Rd, and Sujiatun Rd were 7.56, 6.87, and 6.53 respectively. The ranking sequence was the same as the preliminary assessment in the 1st Field Survey. Concerning the SSI of three streets, the scores were not high though they got the top three streets in the preliminary assessment of the 1st Field Survey. The SSI was a 10-point-system (0-2 is Very Poor; 2-4 is Poor, 4-6 is Medium, 6-8 is good, and 8-10 is Excellent) which was introduced in Chapter 7.5.2, hence, none of the three streets could be described as “Excellent”.

When comparing the EnSI, the SoSI, and the EcSI of three streets, it can be seen that the scores of SoSI were the highest and most steady one among three sustainable aspects, and the relationship between EnSI and EcSI was inversely proportional. Specifically speaking, the SoSI scores of Madang Rd, Daxue Rd, and Sujiatun Rd were all the highest score in the sub-target layer, and they were 9.67, 8.65, and 7.63 respectively. However, the evaluation results of EcSI and EnSI were different. When the EcSI of Madang Rd and Daxue Rd got relatively high scores, namely 8.29 and 7.99 respectively, the scores of EnSI were only 5.40 and 4.69 respectively. Similarly, the EnSI of Sujiatun Rd got 7.31, while its EcSI was only 4.90. Moreover, the Variance of EcSIs of three streets was 3.52, which showed the EcSIs of three street fluctuates a lot.

Regarding the comparison of the criteria’s scores of three streets, there were three main features shown in the analysis graphs. Firstly, all three streets got full scores regarding C10 (Culture

Inheritance). Secondly, the criteria that all three evaluated streets got relatively high scores were C9 (Diversity) and C11 (Intensive Land Utilisation), and their arithmetic averages were both 2.83 (with two full scores of 3 points and one 2.5 points). Thirdly, the criteria that all three streets got relatively low scores were C3 (Pollution Reduction) and C4 (Ecological Balance), and their arithmetic averages were 1.00 and 1.50 respectively. Fourthly, the criterion that the scores of three streets showed biggest fluctuation was C2 (Mitigation UHI), and the Variation of the C2 scores of three streets was 1.58, the most significant in the statistics of criteria layer. Fifthly, the criteria that all three streets got the same scores were C5 (Green Life Promotion) and C10 (Culture Inheritance).

Finally, comparing the values of the three evaluated streets at the indicator layer, several features can be summarised. Firstly, all three streets got the full score of three points in the indicators of C9-1 (Diversity of Street Activities), C10-1 (Aesthetic Quality of Street Furniture), C10-2 (Style Consistency with Surroundings), and C11-1 (Intensiveness of Street Space). Secondly, all three streets got relatively low scores in the indicators of C3-1 (Average Emission of Noise) and C12-1 (Intelligent Transportation System). The scores of C3-1 (Average Emission of Noise) of Madang Rd, Daxue Rd, and Sujiatun Rd were 0, 0, and 1 respectively. The C12-1 (Intelligent Transportation System) of Madang Rd, Daxue Rd, and Sujiatun Rd were 2, 0, and 0. Thirdly, the evaluation results of three streets were the same in the criteria of C8-2 (Clear Sign and Guidance System), C9-1 (Diversity of Street Functions), C10-1 (Aesthetic Quality of Street Furniture), C10-2 (Style Consistency with Surroundings), and C11-1 (Intensiveness of Street Space).

In overall, the evaluation results of Indicator System could objectively reflect the actual performance of three streets. Also, the results clearly showed the different performance in environmental, social, and economic aspects of one street, and embodied the advantages and disadvantages of different streets as well.

Table 8. 19: Cross-comparison Table of Evaluation Results of Indicator System

Evaluation Framework				Madang Rd				Daxue Rd				Sujiatun Rd				Cross-comparison							
Target	Sub-Target	Criteria	Indicator	Target	Sub-Target	Criteria	Indicators	Target	Sub-Target	Criteria	Indicators	Target	Sub-Target	Criteria	Indicators	Target		Sub-Target		Criteria		Indicators	
																AVG.	Var.	AVG.	Var.	AVG.	Var.	AVG.	Var.
SSI	EnSI	C_1	C_{1-1}	7.56	5.40 ***	2.50	3	6.87	4.69 ***	1.50	2	6.53	7.31 **	2.00	3	6.99	0.28	5.80	1.84	2.00	0.25	2.67	0.33
			C_{1-2}				2				1				1							1.33	0.33
		C_2	C_{2-1}			0.50	1			1.50	2			3.00	3					1.67	1.58	2.00	1.00
			C_{2-2}				0				1				3							1.33	2.33
		C_3 (min)	C_{3-1}			1.00	0			0.50	0			1.50	1					1.00	0.25	0.33	0.33
			C_{3-2}				2				1				2							1.67	0.33
		C_4	C_{4-1}			1.50	1			1.00	0			2.00	2					1.50	0.25	1.00	1.00
			C_{4-2}				2				2				2							2.00	0.00
		C_5	C_{5-1}			2.50	2			2.50	3			2.50	3					2.50	0.00	2.67	0.33
			C_{5-2}				3				2				2							2.33	0.33
	SoSI	C_6	C_{6-1}		9.67 *	3.00	3		8.65 *	2.50	3		7.63 *	1.50	0			8.65	1.03	2.33	0.58	2.00	3.00
			C_{6-2}				3				2				3							2.67	0.33
		C_7	C_{7-1}			3.00	3			2.50	3			2.00	2					2.50	0.25	2.67	0.33
			C_{7-2}				3				2				2							2.33	0.33
		C_8	C_{8-1}			2.50	3			2.50	3			2.00	2					2.33	0.08	2.67	0.33
			C_{8-2}				2				2				2							2.00	0.00
		C_9	C_{9-1}			3.00	3			2.50	3			3.00	3					2.83	0.08	3.00	0.00
			C_{9-2}				3				2				3							2.67	0.33
		C_{10} (max)	C_{10-1}			3.00	3			3.00	3			3.00	3					3.00	0.00	3.00	0.00
			C_{10-2}				3				3				3							3.00	0.00
	EcSI	C_{11}	C_{11-1}		8.29 **	3.00	3		7.99 **	3.00	3		4.90 ***	2.50	3			7.06	3.53	2.83	0.08	3.00	0.00
			C_{11-2}				3				3				2							2.67	0.33
		C_{12}	C_{12-1}			1.50	2			1.00	0			1.50	0					1.33	0.08	0.67	1.33
			C_{12-2}				1				2				3							2.00	1.00
		C_{13}	C_{13-1}			2.00	2			2.50	2			0.50	1					1.67	1.08	1.67	0.33
			C_{13-2}				2				3				0							1.67	2.33
		C_{14}	C_{14-1}			3.00	3			3.00	3			1.50	1					2.50	0.75	2.33	1.33
			C_{14-2}				3				3				2							2.67	0.33
		C_{15}	C_{15-1}			3.00	3			2.50	2			1.50	1					2.33	0.58	2.00	1.00
			C_{15-2}				3				3				2							2.67	0.33

*Note: *,**, and *** means the rank order*

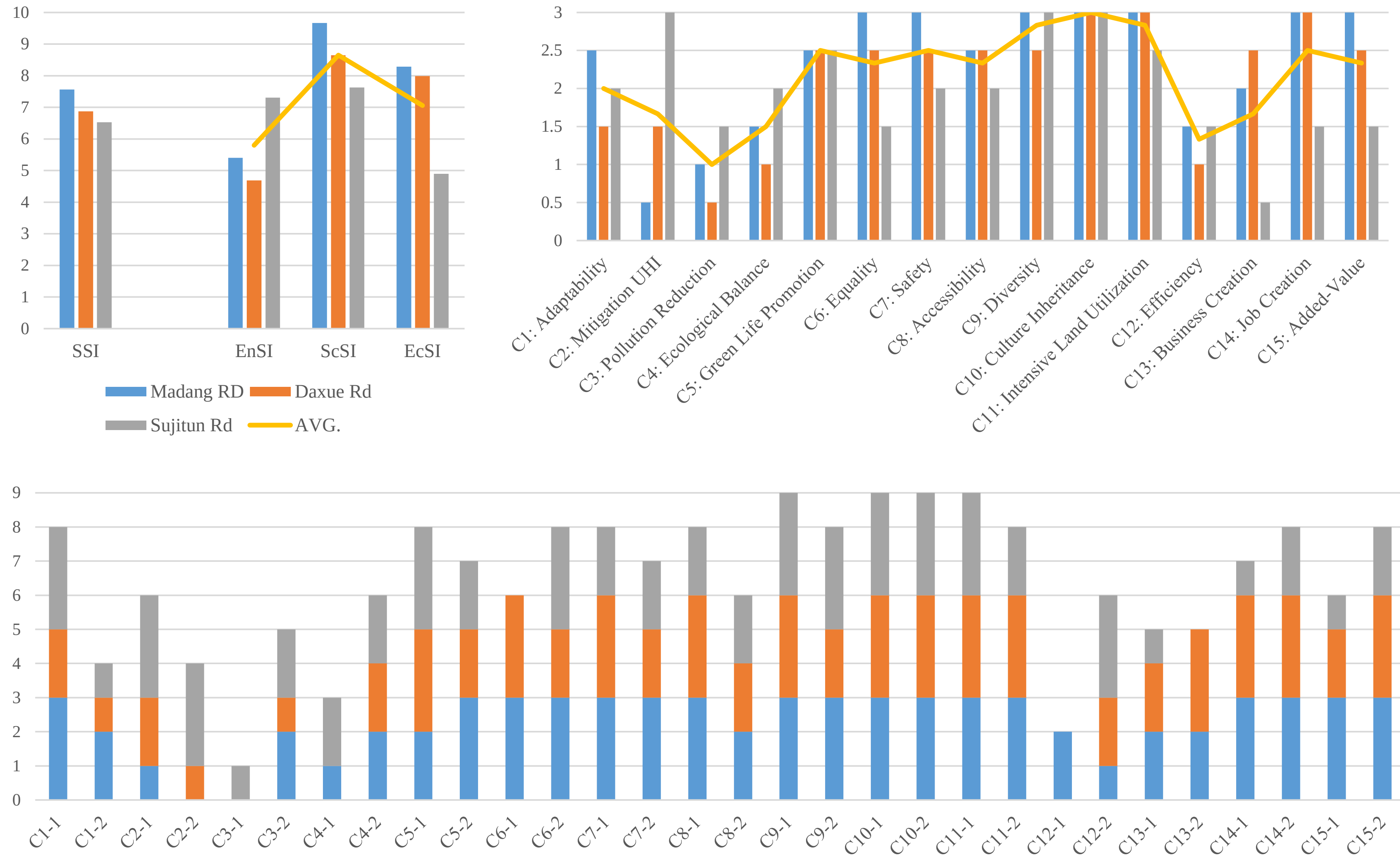


Figure 8. 19: Comparison of Indicator, Criteria, Sub-Target, and Target Layers of Three Evaluated Streets

Cross-comparison of evaluation results of questionnaires survey of street users:

Table 8. 20 shows the data statistics of the sustainability evaluation of the three streets that calculated based on the Questionnaire Survey. Figure 8. 20 illustrates the comparison of the scores of each layer of three streets that calculated by the Questionnaire Survey.

The scores of the SSIs of Madang Rd, Daxue Rd, and Sujiatun Rd calculated based on the Questionnaire Survey were 6.57, 6.87, and 6.48 respectively. The evaluation scores were not high. As a scoring system of 10 points, the evaluation results of three streets were just above the medium. Furthermore, the three evaluation results were very close, and their Variance was only 0.04.

At the sub-target layer, it can be found from the comparison of EnSIs, SoSIs, and EcSIs of three streets that the SoSIs got the highest and the scores of three streets were very close. The SoSIs of Madang Rd, Daxue Rd, and Sujiatun Rd were 6.93, 7.14, and 7.10, and the average of three streets was 7.06. The SoSIs of three streets were very close, and their Variance was only 0.01. Moreover, the EnSIs of Madang Rd, Daxue Rd and Sujiatun Rd were 6.10, 6.11 and 6.97 respectively, and the average of EnSIs of three streets was 6.39. The differences of EcSIs among three streets were considerable comparing with the other two indexes. The EcSI of Daxue Rd got the highest score of 7.46, while that of Sujiatun Rd was the lowest score of 5.50. When merely comparing the nine indexes of the three streets at the sub-target layer, Daxue Rd gained the highest and second highest scores of 7.46 and 7.14 of EcSI and SoSI respectively, and the SoSI of Sujiatun Rd was the third with a score of 7.10. The lowest score at the sub-target layer went to EcSI of Sujiatun Rd with a score of 5.50, followed by EnSI of Madang Rd and Daxue Rd with a score of 6.10 and 6.11 respectively.

Concerning the comparison of 15 criteria's scores of three streets, three features can be summarised. Firstly, the scores were very similar, which was reflected both by the scores of 15 criteria of one street and by the scores of the same criterion of three streets. The Variance of each criterion of three streets was between 0 and 0.05. For example, the scores of C12 (Efficiency) of Madang Rd, Daxue Rd, and Sujiatun Rd were 1.78, 1.80, and 1.86 respectively, and their Variance was only 0.002. Besides, the scores of C10 (Culture Inheritance), C11 (Intensive Land Utilisation), and C15 (Added-Value) of three streets were also very close. The scores that given by the street users from the questionnaires were often among the average scores, so it can be said that the judgements from street users tended to score in the middle.

Secondly, the scores of C9 (Diversity), C8 (Accessibility), and C5 (Green Life Promotion) were relatively high, while the scores of C2 (Mitigation UHI), C12 (Efficiency), and C3 (Pollution Reduction) were relatively low. C9 (Diversity) got the highest average score of three streets, and the average was 2.30. C8 (Accessibility) and C5 (Green Life Promotion) got the second and third position with the scores of 2.17 and 2.15 respectively. On the contrary, the average of C2 (Mitigation UHI) was the lowest with a score of 1.78, and the second and third lowest scores were 1.81 of C12 (Efficiency) and 1.83 of C3 (Pollution Reduction) respectively.

Thirdly, Sujiatun Rd got more low scores while Daxue Rd obtained more high scores at criteria layer. When comparing all scores of criteria assessments of three streets, C13 (Business Creation) and C14 (Job Creation) of Sujiatun Rd were the lowest two scores, namely 1.26 and 1.28 respectively, and C13 (Business Creation) and C9 (Diversity) of Daxue Rd were the highest two scores, namely 2.60 and 2.56 respectively.

From an overall perspective, the evaluation results of the three streets calculated by the questionnaire data were similar, and the SSIs of three streets were relatively low.

Table 8. 20: Cross-comparison Table of Evaluation Results of Questionnaire Results

Evaluation Framework			Madang Rd			Daxue Rd			Sujiatun Rd			Cross-comparison					
Target	Sub-Target	Criteria	Target	Sub-target	Criteria	Target	Sub-target	Criteria	Target	Sub-target	Criteria	Target		Sub-Target		Criteria	
												AVG.	Var.	AVG.	Var.	AVG.	Var.
SSI	*EnSI*	C1	6.57	6.10	1.74	6.87	6.11	1.78	6.48	6.97	2.02	6.64	0.04	6.39	0.25	1.85	0.02
		C2			1.68			1.68			1.98					1.78	0.03
		C3			1.78			1.66			2.04					1.83	0.04
		C4			1.90			1.86			2.14					1.97	0.02
		C5			2.04			2.16			2.26					2.15	0.01
	SoSI	C6		6.93	1.96		7.14	1.68		7.10	2.10			7.06	0.01	1.91	0.05
		C7			1.96			2.22			2.18					2.12	0.02
		C8			2.08			2.22			2.22					2.17	0.01
		C9			2.20			2.56			2.14					2.30	0.05
		C10			2.24			2.06			2.04					2.11	0.01
	EcSI	C11		6.70	1,86		7.46	1.94		5.50	2.04			6.55	0.97	1.95	0.01
		C12			1.78			1.80			1.86					1.81	0.002
		C13			2.18			2.60			1.28					2.02	0.45
		C14			2.12			2.44			1.26					1.94	0.37
		C15			2.12			2.42			1.80					2.11	0.10

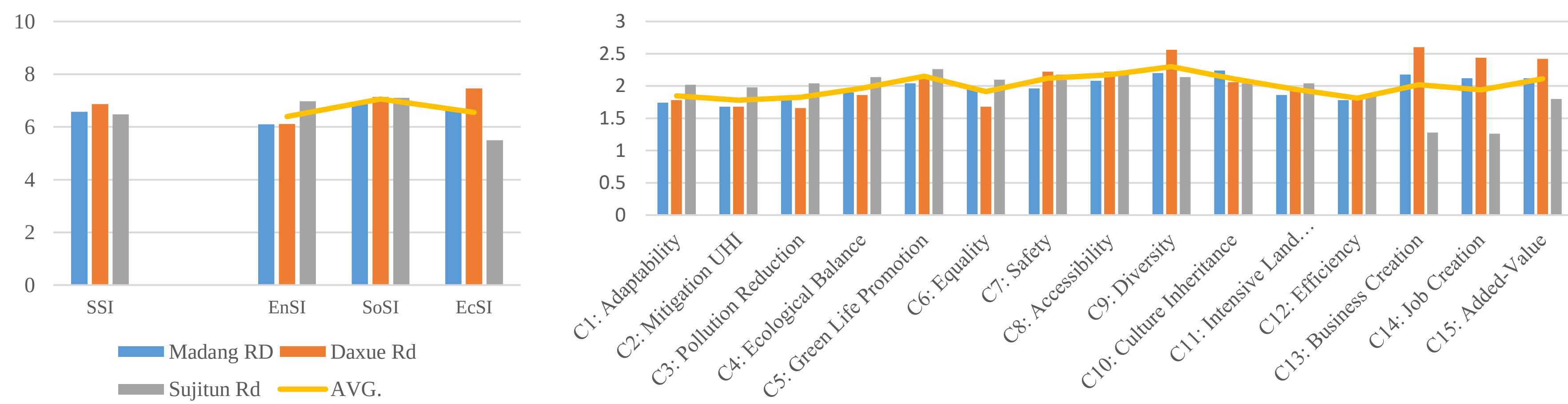


Figure 8. 20: Bar Charts of Sustainability Evaluation of Questionnaire Results of Three Evaluated Streets

Cross-comparison between the evaluation results of the Indicator System and that of the Questionnaire Survey:

Table 8. 21 shows the two sets of results of sustainability evaluation that are calculated from the Indicator System and Questionnaire Survey of three evaluated streets. Table 8. 22 further illustrates the differences of evaluation results between the Indicator System and the Questionnaire Survey.

Firstly, it can be seen from the comparison of SSIs of three streets that the scores of two sets of data were consistent. The evaluation results from the Indicator System were very close to that from the Questionnaire Survey. To Daxue Rd, the SSI calculated from the Indicator System was the same as that from questionnaire data, namely 6.87. The difference of SSIs of Sujiatun Rd was only 0.5%. The differences of SSIs between the Indicator System and the Questionnaire Survey of Madang Rd were the biggest among the three streets, but the difference percentage was only 9.9%.

Secondly, when comparing the values of the sub-target layer of three streets, there were three main findings.

1) On the whole, the numerical differences of the EnSIs, SoSIs, and EcSIs of three streets were relatively small, and the average difference was 11.1%. The most significant difference of the evaluation results between the Indicator System and the Questionnaire Survey lied in the SoSIs of Madang Rd with a difference of 27.4%, while the smallest difference was the EnSIs of Sujiatun Rd, namely 3.4%.
2) When comparing the values of the sub-target layer of three streets horizontally, it could be found that the SoSIs of three streets calculated by the Indicator System were higher than those calculated by the Questionnaire Survey, while the EnSIs of three streets calculated by the Indicator System were mostly smaller than those by the Questionnaire Survey. The SoSIs of Madang Rd, Daxue Rd, and Sujiatun Rd from the Indicator System were higher than those from the Questionnaire Survey by 27.4%, 15.1%, and 5.3% respectively. On the contrary, the EnSIs from the Indicator System were lower than that from the Questionnaire.
3) From the perspective of longitudinal comparison of the values of the sub-target layer of three streets, it could be found that the differences of Madang Rd were the most obvious with an average difference of 16.8%, and the evaluation results of Sujiatun Rd at sub-target layer were the closest with an average difference percentage of 4.9%.

Thirdly, when comparing the evaluation results of criteria layer of three streets, four key features were:

1) In overall, the numerical differences of the criteria' values of the three evaluated streets were not significant. The most significant difference lied in the C2 (Mitigation of UHI) of Madang Rd with a difference of 39.3%, and the smallest difference was the C1 (Adaptability) of Sujiatun Rd with a difference of 0.7%.
2) The street showing the most significant differences between the two sets of data was Madang Rd, and the average percentage of differences of 15 criteria reached 24.4%. Sujiatun Rd showed the smallest difference.
3) The values of C3 (Pollution Reduction), C4 (Ecological Balance), C12 (Efficiency), and C13 (Business Creation) of three streets calculated based on the Indicator System were lower than those based on the Questionnaire Survey. Especially to C3 (Pollution Reduction), the average difference of three streets was 27.6%, and the Difference Percentages of Madang Rd, Daxue Rd, and Sujiatun Rd were 26.0%, 38.7%, and 18% respectively.
4) The values of C5 (Green Life Promotion), C10 (Culture Inheritance), C11 (Intensive Land Utilisation), C14 (Job Creation) of three streets calculated by the Indicator System were higher than those by the Questionnaire Survey. To the criteria of C10 (Culture Inheritance) and C11 (Intensive Land Utilisation), the average differences of three streets were both 29.6%.

From an overall perspective, two points could be summarised based on the cross-comparison of evaluation results of three streets from an overall perspective. 1) ***The overall evaluation results from the Indicator System were nearly the same as those from the Questionnaire Survey***. Though there were some relatively noticeable gaps in the values of criteria layer, the final SSI values were very close after data aggregation. 2) ***The evaluation values of the sub-target and criteria layer calculated by the Indicator System showed bigger different, while the evaluation results calculated from the Questionnaire Survey were even and similar***.

Table 8. 21： Table of Cross-comparison of the Two Sets of Data of Three Evaluated Streets from Indicator System and Questionnaire Results

Evaluation Framework			Madang Rd						Daxue Rd						Sujiatun Rd					
Target	Sub-Target	Criteria	Indicator System			Questionnaire results			Indicator System			Questionnaire results			Indicator System			Questionnaire results		
SSI	EnSI	C1	7.56	5.40	2.5	6.57	6.10	1.74	6.87	4.69	1.5	6.87	6.11	1.78	6.53	7.31	2.0	6.48	6.97	2.02
		C2			0.5			1.68			1.5			1.68			3.0			1.98
		C3			1.0			1.78			0.5			1.66			1.5			2.04
		C4			1.5			1.90			1.0			1.86			2.0			2.14
		C5			2.5			2.04			2.5			2.16			2.5			2.26
	SoSI	C6		9.67	3.0		6.93	1.96		8.65	2.5		7.14	1.68		7.63	1.5		7.10	2.1
		C7			3.0			1.96			2.5			2.22			2.0			2.18
		C8			2.5			2.08			2.5			2.22			2.0			2.22
		C9			3.0			2.20			2.5			2.56			3.0			2.14
		C10			3.0			2.24			3.0			2.06			3.0			2.04
	EcSI	C11		8.29	3.0		6.70	1.86		7.99	3.0		7.46	1.94		4.9	2.5		5.50	2.04
		C12			1.5			1.78			1.0			1.80			1.5			1.86
		C13			2.0			2.18			2.5			2.6			0.5			1.28
		C14			3.0			2.12			3.0			2.44			1.5			1.26
		C15			3.0			2.12			2.5			2.42			1.5			1.80

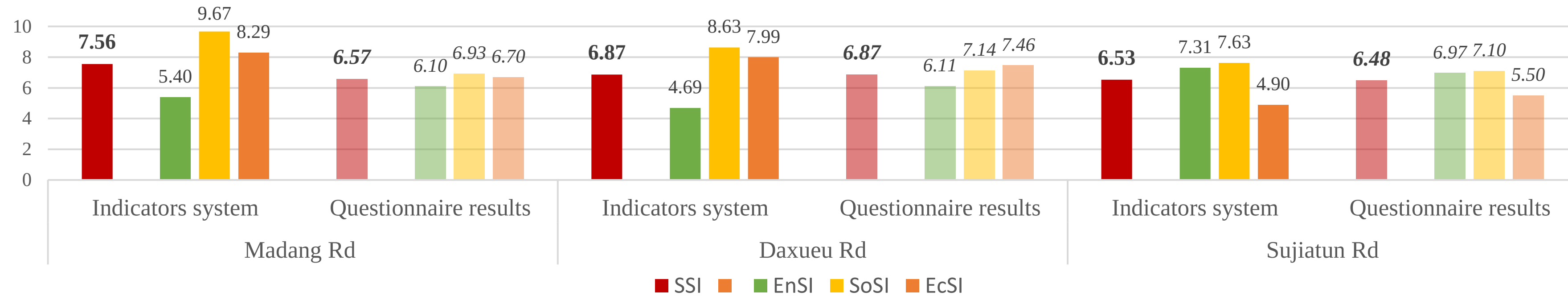


Figure 8. 21: Bar chart of cross-comparison of the SSI, EnSI, SoSI, and EcSI of three evaluated streets from Indicator System and questionnaire results

Table 8. 22： Table of Differences between the Evaluation Results from Indicator System and that from Questionnaire Results

Evaluation Framework			Madang Rd						Daxue Rd						Sujiatun Rd					
Target	**Sub-Target**	**Criteria**	**Val.**	**Pct.**	**Val.**	**Pct.**	**Val.**	**Pct.**	**Val.**	**Pct.**	**Val.**	**Pct.**	**Val.**	**Pct.**	**Val.**	**Pct.**	**Val.**	**Pct.**	**Val.**	**Pct.**
		C1					0.76	25.3%					-0.28	-9.3%					-0.02	-0.7%
		C2					-1.18	-39.3%					-0.18	-6.0%					1.02	34.0%
	EnSI	**C3**			-0.70	-7.0%	-0.78	-26.0%			-1.42	-14.2%	-1.16	-38.7%			0.34	3.4%	-0.54	-18.0%
		C4					-0.40	-13.3%					-0.86	-28.7%					-0.14	-4.7%
		C5					0.46	15.3%					0.34	11.3%					0.24	8.0%
		C6					1.04	34.7%					0.82	27.3%					-0.60	-20.0%
		C7					1.04	34.7%					0.28	9.3%					-0.18	-6.0%
SSI	***SoSI***	**C8**	0.99	9.90%	2.74	27.4%	0.42	14.0%	*0*	*0.0%*	1.51	15.1%	0.28	9.3%	0.05	*0.5%*	0.53	5.3%	-0.22	-7.3%
		C9					0.80	26.7%					-0.06	-2.0%					0.86	28.7%
		C10					0.76	25.3%					0.94	31.3%					0.96	32.0%
		C11					1.14	38.0%					1.06	35.3%					0.46	15.3%
		C12					-0.28	-9.3%					-0.80	-26.7%					-0.36	-12.0%
	EcSI	**C13**			1.59	15.9%	-0.18	-6.0%			0.53	5.3%	-0.10	-3.3%			-0.60	-6.0%	-0.78	-26.0%
		C14					0.88	29.3%					0.56	18.7%					0.24	8.0%
		C15					0.88	29.3%					0.08	2.7%					-0.30	-10.0%

Note:

1. *Val. (Value) = Indicator System – Questionnaire Results;*
2. *Pct. (Percentage) of differences at Target and Sub-Target layer = (Indicator System – Questionnaire Results) / 10*100%*
3. *Pct. (Percentage) of differences at criteria layer = (Indicator System – Questionnaire Results) / 3*100%*

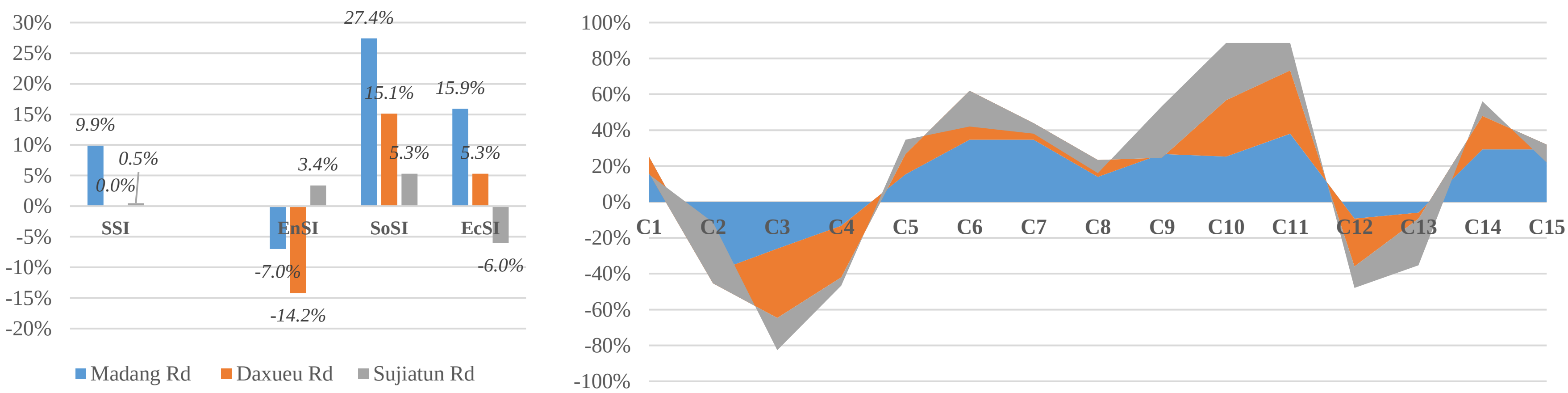


Figure 8. 22: Comparison of Difference Percentage between the Evaluation Results from Indicator System and that from Questionnaire Results

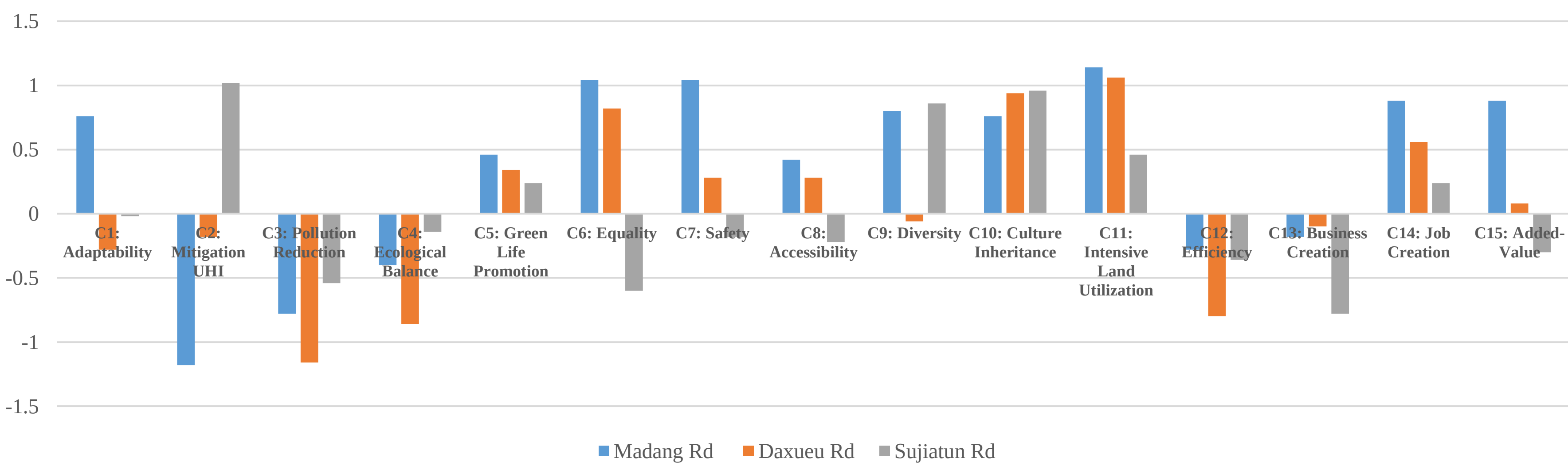


Figure 8. 23： Comparison of Difference Values between the Evaluation Results from Indicator System and that from Questionnaire Results

Summary of Cross-comparison

The primary findings above are summarised in Table 8. 23.

Table 8. 23: Summary of the Key Findings in Cross-comparison

Cross-comparison of evaluation results of Indicator System of three streets:	
Target Layer	- *The evaluation results of SSIs are not high regarding the scoring system of 10 points;* - *The ranking sequence of SSIs is Madang Rd, Daxue Rd, and Sujiatun Rd that is the same as the preliminary assessment in the 1st filed survey.*
Sub-Target Layer	- *The scores of the ScSI are the highest and most steady one among three sustainable aspects to one street;* - *The relationships between the EnSIs and the EcSIs are inversely proportional.*
Criteria Layer	- *All three streets get full scores in terms of C10 (culture Inheritance);* - *The criteria that all three evaluated streets get relatively high scores are C9 (Diversity) and C11 (Intensive Land Utilisation);* - *The criteria that all three street get low scores are C3 (Pollution Reduction) and C4 (Ecological Balance);* - *The criterion that the scores of three streets show the most significant fluctuation is C2 (Mitigation UHI);* - *The criteria that all three streets get the same scores are C5 (Green Life Promotion) and C10 (Culture Inheritance).*
Indicator Layer	- *All three streets get the full score of three points in the indicators of C9-1 (Diversity of Street Activities), C10-1 (Aesthetic Quality of Street Furniture), C10-2 (Style Consistency with Surroundings), and C11-1 (Intensiveness of Street Space);* - *All three streets get relatively low scores in the indicators of C3-1 (Average Emission of Noise) and C12-1 (Intelligent Transportation System);* - *The evaluation results of three streets are the same in the criterion of C8-2 (Clear Sign and Guidance System), C9-1 (Diversity of Street Functions), C10-1 (Aesthetic Quality of Street Furniture), C10-2 (Style Consistency with Surroundings), and C11-1 (Intensiveness of Street Space).*
Overall	- *The evaluation results of the Indicator System can objectively reflect the actual performance of three evaluated streets.* - *The evaluation results can clearly show the different performance in environmental, social, and economic aspects of one street, and embody the advantages and disadvantages of different streets as well.*
Cross-comparison of evaluation results of questionnaires survey of street users of three streets:	
Target Layer	- *The evaluation results of the SSIs of three streets are similar;* - *The scores of the SSIs of three streets are not high regarding the scoring system of 10 points.*
Sub-Target Layer	- *The scores of the SoSIs are the highest, and the scores of the three streets are very close;* - *The differences in the EcSIs of three street are the biggest;* - *Daxue Rd gains the highest and second highest scores of 7.46 and 7.14 concerning EcSIs and SoSIs respectively;* - *The lowest score at the sub-target layer goes to the EcSI of Sujiatun Rd with a score of 5.50, followed by the EnSI of Madang Rd and Daxue Rd with a score of 6.10 and 6.11 respectively.*
Criteria Layer	- *The scores that were given by the respondents are close in general;* - *The street users generally give relatively high scores to three streets regarding C9 (Diversity), C8 (Accessibility), and C5 (Green Life Promotion), while giving low scores in terms of C2 (Mitigation UHI), C12 (Efficiency), and C3 (Pollution Reduction).* - *More respondents give low scores to the Sujiatun Rd and high scores to Daxue Rd.*
Overall	- *The assessment's results from street users gotten via a random questionnaire survey are relatively moderate, and the scores of 15 evaluation criteria given by street users are similar in all the streets' surveys.* - *The evaluation results of the three streets calculated based on the data from the Questionnaire Survey are also similar, and the evaluation results cannot clearly show the differences in the three streets.*

Cross-comparison between the evaluation results of Indicator System and that of questionnaire survey:	
Target Layer	- *The evaluation results of SSI of three streets are basically consistent.*
Sub-Target Layer	- *On the whole, the numerical differences of EnSI, SoSI, and EcSI of the three streets are relatively small;* - *From the perspective of horizontal comparison of sustainable sub-targets, the SoSIs from Indicator System are all larger than the results from questionnaire results, while the EnSIs calculated from the Indicator System are mostly smaller than those from questionnaire survey;* - *From the perspective of longitudinal comparison of the sub-target data of three evaluated streets, it can be found that the differences of Madang Rd are the most obvious with an average difference percentage of 16.8% and the evaluation results of Sujiatun Rd at sub-target layer are the closest with an average difference percentage of 4.9%.*
Criteria Layer	- *In general, the numerical differences of the criteria' values of the three evaluated streets are not significant;* - *The street showing the most significant difference between the two sets of data is Madang Rd, and Sujiatun Rd shows the smallest difference;* - *The values of C3 (Pollution Reduction), C4 (Ecological Balance), C12 (Efficiency), and C13 (Business Creation) calculated based on Indicator System are lower than those based on the assessment of street users to all three streets;* - *The values of C5 (Green Life Promotion), C10 (Culture Inheritance), C11 (Intensive Land Utilisation), C14 (Job Creation) from Indicator System are higher than those from questionnaire results to all three evaluated streets.*
Overall	- *The overall evaluation results from Indicator System are nearly the same as those from street questionnaire;* - *The evaluation values of the Indicator System show more noticeable different at sub-target and criteria layer while the assessment from street users is even and similar.*

8.5.2 Improvement points of Indicator System

The possible improvement points in terms of the Indicator System were analysed from three aspects:

1) *To summarise the application experiences of the Indicator System in three Shanghai cases.*
2) *To analyse the sustainability evaluation results of three Shanghai cases that using the Indicator System.*
3) *To study the cross-comparison of two sets of evaluation results among three sample streets.*

Analysis of the application experiences of the Indicator System in three Shanghai streets:

When reviewing the practices procedure and implementation experiences of the Indicator System in the sustainability evaluation of three Shanghai streets, the three principles, namely Utilisation convenience, Data Accessibility, Evaluation Objectivity, are analysed accordingly.

Conveniences: The utilisation of the Indicator System is convenient. The field work only involves observation and some simple measurements. The necessary tools, including a pencil, a checklist, the Noise Monitor (can be replaced by iPhone or other smart cell phones with the App of noise monitor), tapeline, and Temperature Detector, are all very compact and easy to carry. The user is not required to have strong professional knowledge, and the whole implementation process is straightforward and user-friendly. Furthermore, the data processing and results calculation are also simple. As soon as the raw data obtained from fieldwork or relevant calculation are input into a well-prepared data sheet of Microsoft Excel, the evaluation results are worked out accordingly.

Accessibility: The data accessibility of the evaluation process is relatively high in general. Twenty-four of total thirty evaluation indicators can be rated according to the comparison between the scoring criteria and actual street performance by on-site observation. The acquaintance of the other six evaluation indicators is required on-site measurement, data searching and related calculation, but the whole process is still simple. The simplicity of data acquisition and processing is important, which makes the Indicator System more accessible to non-professionals. However, the raw data C2-2 (Temp. Difference) need to be measured in summer, which causes limitation to the time of street evaluation. Hence the discussion of the system improvement should be focused on how to decrease the limitation of the evaluation time of C2-2.

Objectivity: the evaluation procedure is objective since the rating relies on the comparison between the street performance and scoring criteria without the subjective description and value judgments of the evaluator. However, it is important to note that the correct rating of evaluation indicators requires a comprehensive observation of the whole street. If the observation only covers part of the street rather than the whole street, or the observation process is quick and careless, it is easy to miss out on the details and fail to make right judgments.

Table 8. 24 presents a summary of the analysis above, and the possible improvements of the Indicator System of sustainable street evaluation can be extracted that ***the discussion on how to decrease the limitation of the evaluation time of C2-2 (Temp. Difference)***. The potential solutions might be to search officially published data or the better replacement indicator of C2-2.

Table 8. 24: Summary of the Application Experiences of the Indicator System in Shanghai cases

Analysis Principles	Analysis Results	Issues	Potential Improvements
Conveniences	*Very convenient*	-	-
Accessibility	*Relatively high*	*The raw data C2-2 (Temp. Difference) need to be measured in summer, which causes limitation to the time of street evaluation.*	*The discussion on how to decrease the limitation of the evaluation time of C2-2 (Temp. Difference).*
Objectivity	*Objective*	-	-

Analysis of Evaluation results of three Shanghai by the Indicator System:

The evaluation results of three Shanghai streets calculated by the Indicator System are analysed in detail from the principle of Veracity, Integrity, and Comparability. Also, based on the analysis, some corresponding suggestions on the system improvements are proposed.

***Veracity**:* The evaluation results and their cross-comparison shows that the Indicator System can objectively and genuinely assess the actual performance of the streets. Firstly, the SSIs of the three evaluated streets are generally consistent with their actual performance. The scores of three sustainable aspects, namely the EnSIs, the SoSIs, and the EcSIs, can embody the features of different streets. Secondly, the ranking sequences of the SSIs of the three sample streets calculated by the Indicator System are the same as the preliminary assessment in the 1st Field Survey, which indicates the continuity of the work and results of the evaluation system. Though the scores of some criteria of the Indicator System are not the same as those of the preliminary assessment, the results of SSIs and their ranking are consistent, which demonstrates the accuracy of the evaluation results to some extent. Finally, the cross-comparison of the scores of indicators' and criteria' layers of three streets (see Table 8. 23) indicates that most of the evaluation results, including similarity and differences of these scores, the highest and lowest score, can be explained by the actual performance of the streets. However, two points need to be put into further discussion. The first point is that the scores of three streets in C3-1 (Average Emission of Noise) were all relatively low. Even to Sujiatun Rd that is well-known as its quiet and peaceful atmosphere, its score of C3-1 (Average Emission of Noise) was only 1 point, and the scores of Madang Rd and Daxue Rd were both 0 point. Therefore, the scoring criteria or measurement methods of C3-1 should be reviewed so as to enhance the sensitivity of this indicator. The other point is that the scores of C4 (Ecological Balance) were unable to reflect the actual performance and characteristic of the streets comprehensively. The scores of C4 (Ecological Balance) of three evaluated streets were relatively similar (1.0 of Daxue Rd, 1.5 of Madang Rd, and 2.0 of Sujiatun Rd) through the actual performance of the three streets were different according to the site survey. Therefore, the sensitivity and expressiveness of C4-1 (Rainwater management) and C4-2 (Ecological Planting) should be reinforced.

Integrity: The cross-comparison results show that the evaluation results of the Indicator System can comprehensively reflect the actual situation and features of the evaluated streets. The evaluation results are coherent to the actual performance of each street observed by the research during the field survey. For example, all the evaluated streets, Madang Rd, Daxue Rd, and Sujiatun Rd, have high social acceptance. Both Madang Rd and Daxue Rd are very successful commercial streets, but Madang Rd is more artificial and less environmental-friendly. Sujiatun Rd is a green and pleasant community street, but it is less vibrant regarding economics. All these features can be reflected by the scores of EnSIs, SoSIs, and EcSIs. Compared with the evaluation results of the Questionnaire Survey, the Indicator System can show a stereoscopic result. Also, the stereoscopic evaluation results can not only fully reflect the actual situation of the street, but also indicates the potential methods of street improvement and retrofit.

Comparability: The whole system has very strong comparability, which has been fully demonstrated and highlighted by the cross-comparison of the evaluation results. The evaluation framework is built on four different layers, namely the target layer, sub-target layer, criteria layer, and indicator layer respectively, and with a strong mutual relationship. So, the scores of each layer can be compared horizontally and vertically. Moreover, it is an open and transparent system. The evaluation process can be traced back, and the data in all layers can be compared in multiple dimensions.

Based on the analysis above, Table 8. 25 presents a summary. There are two possible improvements for the Indicator System:

1) ***The sensitivity of C3-1 (Average Emission of Noise) should be enhanced***, such as modification of scoring criteria or measurement methods;
2) ***The sensitivity and expressiveness of the indicators that represent C4 (Ecological Balance) should be reinforced***, the potential solutions might be the modification of the scoring criteria of C4-1 (Rainwater management) and C4-2 (Ecological Planting), or searching better indicators for C4 (Ecological Balance).

Table 8. 25: Summary of Sustainability Evaluation Results of Three Shanghai Cases

Analysis Principles	**Analysis Results**	**Issues**	**Potential Improvements**
Veracity	*Relatively High*	*The evaluation results of three streets in C3-1 (Average Emission of Noise) are all low, which does not reflect the difference in performance.*	*To enhance the sensitivity of C3-1 (Average Emission of Noise) so as to raise the evaluation results, such as modification of scoring criteria or measurement methods;*
		The scores of C4 (Ecological Balance) is unable to reflect the actual performance and characteristic of the streets comprehensively.	*To reinforce the sensitivity and expressiveness of the indicators that represent C4 (Ecological Balance)*
Integrity	*High*	-	-
Comparability	*Very High*		-

Analysis of cross-comparison of two sets of evaluation results among three sample streets:

It must be acknowledged that the evaluation results of the Indicator System are not necessarily the same as those calculated by the data from the Questionnaire Survey. There are many reasons which might cause the situation, such as limited understanding of the sustainability of the public, the moderate rating habit of local people, and personal subjectivity. However, considering that one of the main features and advantages of sustainability evaluation is for popular publicity and public promotion. If the evaluation results of Indicator System can be consistent with that from the judgments of street users, the evaluation system tends to get more recognition and acceptance. As the concept of sustainable streets is accepted and acknowledged by more people, more public forces are to be joined together to promote the sustainable shift. Therefore, the fundamental principles of the analysis in this part are “Overall Consistency” and “Details No Confliction” to discuss the potential improvements of the Indicator System but without influence the veracity, integrity, and comparability of the evaluation system.

Overall Consistency: Overall Consistency means the two sets of evaluation results are consistent not only in the final SSIs but also in the general features of values in each layer. So, it can be seen from the comparison’s summary (Table 8. 23) that the evaluation results of SSI of three streets are basically consistent, the numerical differences of EnSIs, SoSIs, and EcSIs of three evaluated streets are relatively small, and the numerical differences of the criteria’ values of the three streets are also not significant. Therefore, it can be said on overall the evaluation results from the Indicator System are consistent to those from the Questionnaire Survey.

Details No Confliction**:** The review includes the check whether there are conflict details between two sets of evaluation results. The conflicts include considerable gaps and opposite evaluation outcomes. According to the summary of cross-comparison (Table 8. 23), the evaluation results of C3 (Pollution Reduction) and C4 (Ecological Balance) from Indicator System were considerably lower than those from questionnaire survey, while the results of C10 (Culture Inheritance) and C11 (Intensive Land Utilisation) from Indicator System were much higher than those from questionnaire survey. These gaps might be caused by a limited understanding of the meanings of the evaluated criteria, and might also be due to there are disadvantages in the Indicator System. Therefore, the discussions about the system improvement can be focused on whether the indicators representing C3 (Pollution Reduction) and C4 (Ecological Balance) can be modified, so as to increase the corresponding evaluation results, and whether the indicators representing C10 (Culture Inheritance) and C11 (Intensive Land Utilisation) can be modified as to decrease the evaluation results accordingly. The potential modification options include the revise of the scoring criteria of the indicator and finding the indicator replacements.

Finally, Table 8. 26 presents a summary, and it shows that the discussion of possible improvements should focus on the indicators of C3 (Pollution Reduction), C4 (Ecological Balance), C10 (Culture Inheritance), and C11 (Intensive Land Utilisation).

Table 8. 26: Summary of Comparison Results

Analysis Principles	Analysis Results	Issues	Potential Improvements
Overall Consistency	*High*		-
Details No Confliction	*Relatively High*	*The evaluation results of C3 (Pollution Reduction) and C4 (Ecological Balance) are considerably lower than those from questionnaire survey*	*Discussion on whether the indicators representing C3 (Pollution Reduction) and C4 (Ecological Balance) can be modified so as to increase the corresponding evaluation results;*
		The results of C10 (Culture Inheritance) and C11 (Intensive Land Utilisation) from Indicator System are much higher than those from questionnaire survey	*Discussion on whether the indicators representing C10 (Culture Inheritance) and C11 (Intensive Land Utilisation) can be modified as to decrease the evaluation results accordingly.*

Summary of improvement points of the Indicator System

Based on the analysis of the three aspects above, Table 8. 27 summarises all possible improvement and potential solutions concerning the Indicator System. There were five points in total. As the starting points and analysis perspectives were different, the importance of the five improvement points was not the same. Specifically speaking, the first three points of improvements were proposed because of their influences of the accessibility of necessary data and the accuracy of the Indicator System. Therefore, these three points were important. The fourth and fifth points came from the aim of reducing the gaps between the Indicator System and the judgments of street users rather than eliminate the gap, so these two points were rated as medium concerning importance.

Table 8. 27: Summary of System Improvements

No.	Improvement Points	Potential Solutions	Importance
1	To decrease the limitation of the evaluation time of C2-2 (Temp. Difference) to the evaluation time.	To search published data or the better replacement indicator of C2-2.	Strong
2	To enhance the sensitivity of C3-1 (Average Emission of Noise) so as to raise the evaluation results	To review the scoring criteria or measurement methods;	Strong

No.	Improvement Points	Potential Solutions	Importance
3	To reinforce the sensitivity and expressiveness of the indicators that represent C4 (Ecological Balance)	To modify the scoring criteria of C4-1 (Rainwater management) and C4-2 (Ecological Planting), or searching better indicators for C4 (Ecological Balance).	Strong
4	To discuss whether the indicators representing C3 (Pollution Reduction) and C4 (Ecological Balance) can be modified so as to increase the corresponding evaluation results;	To revise of the scoring criteria of the indicator or to search the indicator replacements.	Medium
5	To discuss whether the indicators representing C10 (Culture Inheritance) and C11 (Intensive Land Utilisation) can be modified as to decrease the evaluation results accordingly.	To revise the scoring criteria of the indicator or to search the indicator replacements.	Medium

8.6 Summary

Chapter 8 elaborated on the implementation of established Indicator System of Sustainability Evaluation in three Shanghai streets and compared the evaluation results in detail, thereby proposing a series of suggestions on the improvements of the Indicator System.

Through the application of the indicator system in the practice of three sample streets, it can be found that the evaluation system was easy to apply and the evaluation results could reflect the actual performance of the three streets comprehensively and accurately.

From the perspective of application, the on-field evaluation work only needs to observe and simply measure the current situation of the streets, collate the checklists, and record the data. The measurement tools needed on site were user-friendly for normal researchers or designers. 4 out of 30 indicators need online data, but they are highly accessible. However, the biggest limitation of the system lies in the C2-2 (Temp. Difference) as it is highly sensitive to seasons.

From the perspective of evaluation results, the SSI scores of Madang Rd, Daxue Rd, and Sujiatun Rd were 7.56, 6.87, and 6.53, which were in line with the preliminary assessment in the 1st field survey. Secondly, the evaluation results could reflect the streets' characteristics. Compared with the preliminary assessment, the scores in the criteria layer of the indicator system fluctuated more and were more sensitive to the street performance. Madang Rd got the high scores regarding SoSI and EcSI (9.67 and 8.29 respectively). Daxue Rd had outstanding performance in social and economic sustainability, but poor from environmental perspective (EnSI=4.69). The EnSI of Sujiatun Rd was the highest (7.31) while its EcSI was only 4.90 for. These scores could provide useful suggestions for the future design of their renovation. Also, statistical comparisons of evaluation results helped to find the indicators flaws, like C3-1 (Average Emission of Noise), C4-1 (Rainwater Management) and C4-2 (Ecological Planting).

The evaluation outcomes of the indicator system were basically consistent with the results of the questionnaires, and it was more sensitive to the actual street situation. The main differences between them helped for further optimization of indicator system. The SSIs from the Indicator System were very close to those from the Questionnaires. The final SSIs from the indicator system and questionnaires were the same in Daxue Rd, and the differences of Sujiatun Rd was only 0.5%. The most significant difference lied in Madang Rd with 9.9%. In addition, the two sets of data for the three streets showed the same overall characteristics regarding three pillars of sustainability. When comparing the criteria layer of two sets of data, the scores of indicator system fluctuated much more than those of questionnaires. The variance of former was 1.86, while the later one was only 0.23, which showed the indicator system were more sensitive to the actual street situation. Some indicators for C3(pollution reduction), C4(ecological balance), C10(cultural inheritance), and C11(land intensive use) were quite different in the two sets of data, which provided a basis for further optimization of index evaluation system.

Based on the 8 principles of 3 aspects, the research discussed the possible improvements of the indicator system and puts forward 5 aspects modification involving 9 indicators.

Specifically speaking, the analysis included 1) the application experiences of the Indicator System in three Shanghai streets from the principles of Utilisation Convenience, Data Accessibility, and Evaluation Objectivity, 2) the analysis of evaluation results of the Indicator System from the principles of Veracity, Integrity, and Comparability; and 3) the analysis of cross-comparison of two sets of evaluation results from the principles of “Overall Consistency” and “Details No Confliction”. Given this, a series of system optimisation were proposed which related to the modification of 9 indicators (See Table 8.27), including the Indicator C3-1 (Average Emission of Noise), and indicators representing C4 (Ecological Balance), C10 (Culture Inheritance), and C11 (Intensive Land Utilisation).

Chapter 9. Optimisation and further discussion of Indicator System of sustainable street evaluation

9.1 Introduction

Chapter 9 aims to propose an optimised scheme on the Indicator System of Sustainability Evaluation for Shanghai streets by systematic analysis of results of Expert Interviews and application experiences.

Firstly, Chapter 9.2 introduces the main results of the Expert Interviews and discusses the feasibility and methods of these possible modifications to the Indicator System. Based on this, Chapter 9.3 presents the optimised scheme of the evaluation system, including the modifications of indicator selection, revisions of normalisation methods, adjustments of weight coefficients, and the update of the aggregation formula. Finally, Chapter 9.4 further discusses some issues that influence the delivery of sustainable streets in Shanghai.

9.2 Summary of Expert Interview

The research conducted a total of four semi-structured interviews with four experts regarding the improvements of the Indicator System. Chapter 4.3.4.1 has elaborated on the methods and techniques of the Expert Interview, including participants, procedure, and duration. Appendix F shows the prepared questions for the interviews.

The four interviews were smooth and fruitful. The following part summarises the key findings of the Expert Interview.

1. ***All experts agreed that the exploration and research on the Sustainable Streets are significant and valuable***. Meanwhile, experts pointed out in the interview that except for the theoretical development, the significance of practical exploration of sustainable streets is more crucial. Shanghai released “Shanghai Street Design Guide” in 2016, which is the first street design manual in China. Dr. Jin mentioned in the interview that the editorial board had thought of adding a related study and evaluation template for street evaluation in “Shanghai Street Design Guide”. However, the idea failed to be realised at that time due to

the limitation of time and resources. Therefore, this study is of great significance for the formation of the evaluation system of Shanghai streets and the promotion of sustainable development of urban streets in Shanghai.

2. ***Four experts all spoke highly of the established Indicator System of Sustainable Streets.*** The experts believe that it is innovative and meaningful to include the development of urban streets into the sustainability framework and evaluate the streets from three dimensions of sustainability. The experts also expressed their agreement concerning the evaluation structure, normalisation methods, weighting system, and aggregation model of the established Indicator System. Moreover, when reviewing the evaluation results of three sample streets, namely Madang Rd, Sujiatun Rd, and Daxue Rd, all experts indicated that the results were similar to their expectation and could reflect the actual performance of these streets comprehensively and objectively. Hence, the evaluation system of Shanghai sustainable streets established in this study is reasonable and feasible.

3. ***Table 9. 1 summarises the experts' suggestions on the possible improvements of the selected indicators.*** There was a total of eight aspects of improvements, among which five aspects were obtained from the previous study and interviewed one by one as questions in the semi-structured interview, and other three aspects were new questions raised in the open discussion during the interviews. The following part is to elaborate them respectively.

    1) Regarding ***the limitation of C2-2 (Temp. Difference) and its alternative indicators***, Dr. Ge, Dr. Jin and Mr. Zhao raised that the measurement of C2-2(Temp. Difference) might not be accurate due to the measurement time and location, and there were also noticeable uncertainties in the process of indicator calculation and data normalisation. Meanwhile, Dr. Jin suggested some alternative indicators to represent C2 (UHI Mitigation), like Street Shading Percentage, Green Looking Ratio, and Vertical Green Rate. Through in-depth discussion and analysis of these suggested indicators, Street Shading Percentage is a proper indicator because the street shading has a significant effect on alleviating the street temperature in summer for Shanghai 's climate condition. Street shading has been proved to be proportional to the degree to which UHI are mitigated. According to the relevant survey of Shanghai (SGUAB, 2013), fully shaded or partially shaded streets are on average 0.5-1.5 degrees Celsius cooler in summer than unshaded streets, and the difference can be as high as 3.6 degrees Celsius. As for the

other suggested alternative indicators, the Green Looking Ratio is difficult to quantify for one street, while The Vertical Greening Rate can help to mitigate UHI for a street, but there is no existing evidence on to what extent its effectiveness is Mitigation. Therefore, ***the Street Shading Rate was selected as the alternative indicator of C2-2 (Temp. Difference) for the evaluation system***.

2) Concerning ***the sensitivity of indicator C3-1 (Average Emission of Noise)***, the interview discussions focused on its rating system. Dr. Ge mentioned a technical specification for environmental noise monitoring (MEP, 2013), which can be referenced for the modification of the rating system. The issue of how to measure the street noise caused many discussions during interviews. Dr. Cao suggested using the indicator of Vehicle Speed to reflect the street noise because relevant studies showed that the noise level is mostly related to the speed of transit vehicles. Dr. Jin believed that the noise level of the streets should be measured in the residential or office blocks along the street rather than measured on the street, because the immediate victims of street noise were residents living on both sides, while the pedestrians in the streets were usually not very sensitive to the street noise. Moreover, one expert mentioned one research about Sujiatun Rd he was involved. Sujiatun Rd looks quiet and peaceful street because of pleasant green space and low traffic volume. However, many complaints were about noise according to their interviews with residents. The complaints said many people would like to play music or chat loudly while exercising or playing in Sujiatun Rd during the evening, which caused considerable noise and affected their rest.

In order to explore these identified issues more comprehensively, the author conducted an in-depth relevant research after the interview. Ma's study (2010) showed that the factors that affect street noise are the Road Characteristics, Running Status of Vehicles, Vehicles Speed, Traffic Flows, and the Vehicle Types. The dominant factors are the Road Characteristics, including road types, height changes, and surface material. Also, the driving status and speed of vehicles are also important factors. Therefore, the street noise cannot be reflected by one or two data. Secondly, the suggestion that the pollution level of street noise should be measured in the residential block along the street is not practical due to considerable uncertainties of results and location of the measurements. There might be several neighbourhoods on both side of the sample street, and the building layout and landscape situation are different. Then, the noise level measured in various neighbourhood would definitely different. However, this suggestion reminded that some measures can mitigate the impact of noise pollution on the sided buildings. Furthermore, Dr. Jin's findings of the survey on Sujiatun Rd revealed the noise pollution of the streets should be measured both during day-time and night-time respectively, thereby providing an average assessment.

In summary, followed the expert suggestion and relevant study, the indicator of ***C3-1 (Average Emission of Noise) was broken into two sub-indicators, namely Average Emission of Day-Time Noise and Average Emission of Night-Time Noise***. Also, ***the rating systems were to be optimised accordingly***.

3) The discussion about ***the sensitivity and expressiveness of the indicators that represent C4 (Ecological Balance)*** focus on the indicators of C4-1 (Rainwater Management) and C4-2 (Ecological Planting). In general, all experts agreed that rainwater management and greening are two critical elements of ecological balance at the scale of urban streets in the built environment. The two selected indicators are reasonable and representative. Concerning the rating system, Dr. Jin mentioned some of the sustainable technologies of C4-1 (Rainwater Management), such as rain garden and permeable pavements, were not efficient in Shanghai. Rain gardens, implemented in some Shanghai streets, were complained by residents because these rain gardens caused massive mosquitos in summer. Also, the practices of rain gardens in Shanghai were not effective due to the high level of underground water, poor water quality of surface runoff, and low permeability of the local soil. Moreover, the permeable pavements have also been implemented in some Shanghai streets, but they are always blocking due to the poor quality and impurity contents of surface runoff in Shanghai. Regarding C4-2 (Ecological Planting), Dr. Jin and Dr. Ge mentioned that there had been some studies on evaluation of ecological planting in urban streets, so these existing indicators or evaluation methods could be referenced for the rating system of C4-2 (Ecological Planting).

   Based on the interview discussion, the author conducted a further study on the Shanghai implementation of Rain Gardens and the Permeable Pavement. Many researchers (Wang & Li, 2013; Zang, et al., 2015; Yang, 2016; Zhu & Zhai, 2016; Chen, et al., 2015; Zang, 2016) have noticed the implementation limitations of rain garden in Shanghai and also proposed a series of technological innovation and practical design guide on rain garden according to Shanghai hydrological, climatic, and geological conditions. Furthermore, the application of permeable pavements in Shanghai is also continuously explored and improved, including the prefiltration of rainwater and the optimisation of material mix (Kong, 2017; Meng, et al., 2009; Zai, 2018). Therefore, the applications of these sustainable technologies in Shanghai are still on exploration and experiments, but they can still be used to evaluate the performance concerning ecological balance. Furthermore, concerning ecological planting, Fang (2006) put forward the comprehensive evaluation system of plant community of Shanghai green space. Also, Fang's study indicated that "Naturalness" is an indicator to assess the degree of nature and interference, which is generally reflected by the proportion of local species in the community, the degree of combination of arbors and shrubs, and the degree of species richness in the community (Han, et al., 2005; Bradley, 2001; Fang, 2006) .

Therefore, in short, the Indicator System ***kept C4-1 (Rainwater Management) and C4-2 (Ecological Planting) as the indicators evaluation criterion for C4 (Ecological Balance) and optimised their rating systems according to the interview findings.***

4) Regarding the ***optimisation of indicators representing C3 (Pollution Reduction) and C4 (Ecological Balance)***, the discussion of the previous two points had covered the critical issues of this point. Therefore, the ***modification schemes concluded from the two points above also applied to this point***.

5) ***The optimisation scheme of indicators representing C10 (Culture Inheritance) and C11 (Intensive Land Utilisation***) also sparked widespread discussion during interviews.

   Two indicators, namely C10-1 (Aesthetic Quality of Street Furniture) and C10-2 (Style Consistency with Surroundings), represented the evaluation criterion of C10 (Culture Inheritance) in the evaluation system. Dr. Cao and Mr. Zhao pointed out that these two indicators were similar. Both evaluate the degree of cultural inheritance from the perspective of streetscapes. However, culture inheritance consists of not only historic preservation and streetscapes but also the cultivation and activation of contemporary and local cultural, which has been explained in Chapter 3.2.2. Therefore, urban streets, as one of the most critical public space, should function the cultural interface to promote more cultural activities there. However, the selected indicators failed to reflect it. Given this, ***the optimisation scheme was to combine C10-1 (Aesthetic Quality of***

Street Furniture) into C10-2 (Style Consistency with Surroundings) firstly, and then design a new indicator called "Culture Promotion" to assess the ability of the street as a cultural medium to foster and activate local cultures.

Concerning the criterion of C11 (Intensive Land Utilisation), two indicators, namely C11-1 (Intensiveness of Street Land) and C11-2 (Mixed-Use of Street Space) represented it in the evaluation system. All experts agreed on the indicator selection and their rating systems in general. Furthermore, Dr. Cao analysed the root cause of the waste phenomenon of street land lied in the planning mechanism. In the regulatory detailed planning of China, the Red Lines of plots and the street often overlap. But the buildings within the plots have to be built behind the "Building Setback Lines". Given this, there must be a piece of open land between street and buildings that are connected to the streets and belongs to the owners of each plot. Mostly, these lands are often separated from the street by walls or form the functions that are not harmonious to the street space, which not only causes massive land waste but also drives the streetscape rigid. However, the problem cannot be solved by an evaluation system of urban streets because the regulatory detailed planning is the legal planning. The Red Line of urban streets and the Building Setback Lines have legal effects once they are drawn up in the planning. Dr. Jin said in the interviews, Shanghai was exploring innovations from the planning system to break the constraints of traditional "Building Setback Lines", but it may take long and more collaborative efforts by different departments. Therefore, ***the indicators for the criterion of C11 (Intensive Land Utilisation) was kept the same for the evaluation system.***

6) Regarding ***C6-1(Tactile pavement for the blind), one indicator to represent the criterion of C6 (Equality)***, it was identified as flawed during the interviews. Dr. Jin mentioned one symposium that was organised by the Shanghai Government and Shanghai Association for the Disabled in order to improve "Shanghai Street Design Guide". The symposium revealed that the blind people generally do not use the tactile pavement for the blind but walk along the curbs between cycling land and sidewalks according to the findings from the symposium on the street use with the disabled people. There are tactile pavements for the blind in most of Shanghai streets, but few of them are reliable and maintained in good condition. The street survey of this research found that many tactile pavements for the blind were broken or occupied. Consequently, instead of providing convenience to the blind, these tactile pavements even create huge

difficulties for the people with luggage or baby carriage to walk in many narrow sidewalks. The researcher had also noticed this phenomenon during the street investigation. Many scholars also identified the issue and advocated a complete barrier-free system for urban streets rather than just the tactile pavements for sidewalks (Fan & Bian, 2018; Wang, et al., 2017; Yin, 2009). Therefore, ***C6-1 (tactile pavement for the blind) was integrated into the indicator of C6-2 (Barrier-free facilities).*** Also, the rating system would be enriched and modified according to the national “Codes of Barrier-free Design” (MOHURD, 2012) .

7) Both Mr. Zhao and Dr. Jin pointed out that ***the indicators, namely C7-1 (Coverage Proportion of Street Camera) and C7-2 (Coverage Safety Equipment), for the criterion of C7 (Safety)*** were not representative enough. There had been a series of indicators listed in the potential pool (Table 3. 12), including Crashes and injuries for motorists, pedestrians, and cyclists, Traffic fatality, Number of street crimes. These indicators, like annual traffic accidents and street crimes, are much more directly for the evaluation of street safety. However, these data are not public in China. The researcher tried to call the relevant authorities to ask if part of these data could be available for this research, but the application was declined. Therefore, the Indicator System kept the indicator selection for ***the criterion of C7 (Safety)*** in this study. The other possible indicators could be for further study.

8) When discussing ***the criterion of C12 (Efficiency),*** Mr. Zhao raised that the selected two indicators, namely C12-1(Intelligent Transportation System) and C12-2 (Traffic performance Index), highlighted the efficient mobility of auto vehicles but neglected the efficiency of pedestrians and cyclists. Some streets in Shanghai compressed the space of sidewalks and cycling lanes to increase the motor lanes and ease the congestion of vehicles, which consequently led to the low efficiency for pedestrians and cyclists. Such streets are indeed not efficient streets. Therefore, ***relevant indicators evaluating the level of service of sidewalks and cycling lanes would be added into the Indicator System*** to provide a comprehensive evaluation of the street efficiency.

Table 9. 1： Optimisation Summary of the Indicator System Obtained from the Expert Interviews

NO.	Prepared Issues for the Interviews	Expert Suggestions	Optimisation Schemes
1)	The limitation of C2-2 (Temp. Difference) and its alternative indicators	*- There are noticeable uncertainties in calculation and normalisation of C2-2; - The alternative indicators could be Street Shading Percentage, Green Looking Ratio, and Vertical Green Situation.*	*- To use Street Shading Rate as the alternative indicator of C2-2 (Temp. Difference)*
2)	The sensitivity of indicator C3-1 (Average Emission of Noise)	*- A technical specification for noise monitoring can be referenced. (MEP, 2013) - The location of the measurements of noise level; - The noise level is mostly related to Vehicle Speed. - Residents complain Sujiatun Rd of its noise in the evening.*	*- To break the indicator of C3-1 (Average Emission of Noise) into two indicators, namely Average Emission of Noise during Daytime and Average Emission of Noise during Night-time; - To optimise the rating systems according to the technical specification.*
3)	The sensitivity and expressiveness of the indicators that represent C4 (Ecological Balance)	*- The selected indicators are reasonable and representative. - Shanghai practices of Rain Gardens and Permeable Pavements are not successful. - Some existing evaluation methods could be referenced for the rating system of C4-2.*	*- To keep C4-1 (Rainwater Management) and C4-2 (Ecological Planting) as two indicators representing C4 (Ecological Balance); - To modify the rating systems accordingly*
4)	Optimisation of indicators for C3 (Pollution Reduction) and C4 (Ecological Balance),	- Similar as the above 2 points	*- To review after completing the modification schemes in the previous two points.*
5)	The optimisation scheme of indicators representing C10 (Culture Inheritance) and C11 (Intensive Land Utilisation)	*- The selected indicators for C10 (Culture Inheritance) are similar; - Urban streets are the cultural interface to promote more cultural activities; - The indicators selected for C11 and their rating systems are reasonable and appropriate.*	*- To integrated C10-1 (Aesthetic Quality of Street Furniture) into C10-2 (Style Consistency with Surroundings), and to design a new indicator called "Culture Promotion" to assess the ability of the street to activate local culture; - To keep the selected indicators for C11 (Intensive Land Utilisation),*
NO.	**New Issues Raised in the Interviews**	**Expert Suggestions**	**Optimisation schemes**
6)	C6-1 (Blind Pavement) for the criterion of C6 (Equality)	- C6-1 (Blind Pavement) has flawed; - A complete barrier-free system for urban streets is significant.	*- To integrate C6-1 (tactile pavement for the blind) into C6-2 (Barrier-free facilities)*
7)	The indicators for C7 (Safety)	- C7-1 (Coverage Proportion of Street Camera) and C7-2 (Coverage Safety Equipment) are not representative enough to the criterion of C7 (Safety).	*- To keep the available indicators for this study; - To list other possible indicators for further study.*
8)	The indicators for C12 (Efficiency).	- The selected indicators, namely C12-1(Intelligent Transportation System) and C12-2 (Traffic performance Index), focus on the efficient mobility of auto vehicles but neglect the efficiency of pedestrians and cyclists.	*- To add relevant indicators evaluating the level of service of sidewalks and cycling lanes.*

9.3 System Optimisation

Table 9. 1 summarises the main results of the expert interviews and the optimisations of the Indicator System. The main modifications lied in the two parts of indicator Selection and Normalisation methods, but the other two parts, the weight coefficient in the Weighting System and calculation formulas in the Aggregation Model also need to adjust accordingly. Therefore, the following parts present the optimisation scheme of the Indicator System.

9.3.1 Indicator selection

Table 9.2 summarises the main modifications of indicator selection, and Table 9. 3 shows a list of optimised indicators. Specifically speaking, the key changes are:

1) To replace C2-2 (Temperature Difference) by C2-2(Street Shading Rate);
2) To break the indicator of C3-1 (Average Emission of Noise) into two indicators, namely C3-1 (Average Emission of Noise -Daytime) and C3-2 (Average Emission of Noise -Night-time);
3) To integrate the indicator of C10-1 “Aesthetic Quality of Street Furniture” into the indicator of C10-2 “Style Consistency with Surroundings”, and then to add one indicator, called C10-1 (Cultural Promotion);
4) To add two indicators, namely C12-3 (Level of service of the sidewalk) and C12-4 (Level of service of cycling Lane) for the evaluation criterion of C12 (Efficiency);
5) To integrate C6-1(Tactile pavement for the blind) into C6-2 (Barrier-free facilities) and code it as C6-1 (Barrier-free facilities).

Table 9. 2: Main Modifications of Indicator Selection

Original Indicators	Modification Methods	Optimised Indicators
C2-2 (Temperature Difference)	Replaced by	C2-2 (Street Shading Rate)
C3-1 (Average Emission of Noise)	Broken into two	C3-1 (Average Emission of Noise - Daytime) C3-2 (Average Emission of Noise - Night-time)
C6-1 (Tactile pavement for the blind) C6-2 (Barrier-free Facilities)	Integrated into	C6-1 (Barrier-free Facilities)
C10-1 (Aesthetic Quality of Street Furniture)	Replaced by	C10-1 (Culture Promotion)
-	Newly increasing	C12-3 (Level of service of the sidewalk); C12-4 (Level of service of cycling Lane)

Table 9. 3: Table of the Selected Indicators for Evaluation System

	Criteria		Indicators					
	Code	**Title**	**Code**	**Title**	**Definition**	**Calculation Methods**	Measurement Unit	Acquisition Mode
Environmental Sustainability	*C1*	Adaptability	*C1-1*	Adaptable Capacity to Local Climate	The ability of the street to adapt to local climatic conditions	Total number of ticks (√) in the evaluation checklist	Pcs	D
			C1-2	Adaptable Capacity to Extreme Weather Events	The ability of the street to adapt to extreme weather events, such as windstorm, rainstorm, and extreme hot/cold weathers	Total number of ticks (√) in the evaluation checklist	Pcs	D
	C2	Mitigation UHI	*C2-1*	Street Green Rate	Percentage of the width of green bands in the street	$\text{C2 1 (Street Green Rate)} = \frac{\text{Total width of green bands}}{\text{Total width of the street}}$	%	M
			C2-2	***Street Shading Rate***	The percentage of the total shadow area of the vertical projection shelter such as tree canopy and sunshade facilities	$\text{C2 1 (Street Shading Rate)} = \frac{\text{Total Shadow Area}}{\text{Street Total Area}}$	%	M
	C3	Pollution Reduction	***C3-1***	**Average Emission of Noise -Daytime**	Average noise emitted in the street of daytime	Meter reading	Decibel	M
			C3-2	**Average Emission of Noise -Night-time**	Average noise emitted in the street of night-time	Meter reading	Decibel	M
			C3-3	Pollution Reduction	Measures to reduce pollution during streets' construction and operation	Total number of ticks (√) in the evaluation checklist	Pcs	D
	C4	Ecological Balance	*C4-1*	Rainwater management	Management ability for rainfall	Total number of ticks (√) in the evaluation checklist	Pcs	D
			C4-2	Ecological Planting	Ecological planting in the street	Total number of ticks (√) in the evaluation checklist	Pcs	D
	C5	Green Life Promotion	*C5-1*	Green Lifestyle Promotion	The promotion and propaganda of green life and environmental preservation in the street	Total number of ticks (√) in the evaluation checklist	Pcs	D
			C5-2	Green Travel Support	Support and promotion of Green Travel	Total number of ticks (√) in the evaluation checklist	Pcs	D

	Criteria		Indicators					
	Code	Title	Code	Title	Definition	Calculation Methods	Measurement Unit	Acquisition Mode
Social Sustainability	*C6*	Equality	***C6-1***	**Barrier-Free Facilities**	Provision of reliable and convenient barrier-free facilities for all kinds of people in the street	Total number of ticks (√) in the evaluation checklist	Pcs	D
	C7	Safety	*C7-1*	Coverage Proportion of Street Cameras	The coverage proportion of CCTV cameras within the street	C7 1 (Coverage Proportion of Street Camera) $= \frac{\text{Length covered by the street camera}}{\text{Total length of the street}}$	%	M
			C7-2	Coverage Safety Equipment	The coverage of relevant equipment and facilities for street safety	Total number of ticks (√) in the evaluation checklist	Pcs	D
	C8	Accessibility	*C8-1*	The Variety of Arrival Ways	Provision of various arrival ways	Total number of ticks (√) in the evaluation checklist	Pcs	D
			C8-2	Clear Sign and Guidance System	Provision of clear sign and guidance system for easy street accessibility	Total number of ticks (√) in the evaluation checklist	Pcs	D
	C9	Diversity	*C9-1*	Diversity of Street Activities	Diversity of activities within the street	Total number of ticks (√) in the evaluation checklist	Pcs	M
			C9-2	Diversity of Street Functions	The various functions that the street serves in the urban life	Total number of ticks (√) in the evaluation checklist	Pcs	D
	C10	Culture Inheritance	***C10-1***	**Culture promotion**	The ability of the street as a cultural medium to foster and activate local cultures.	Rating the street performance accordingly	-	D
			C10-2	Style Consistency with Surroundings	Style consistency of streetscape with the surrounding landscape and local history	Rating the street performance accordingly	-	D
Economic Sustainability	*C11*	Intensive Land Utilisation	*C11-1*	Intensiveness of Street Space	Economical and efficient use of street land	Total number of ticks (√) in the evaluation checklist	Pcs	D
			C11-2	Mixed-Use of Street Land	Mixed-usage and multi-function of street space	Total number of ticks (√) in the evaluation checklist	Pcs	D
	C12	Efficiency	*C12-1*	Intelligent Transportation System	Usage and coverage of intelligent transportation system	Total number of ticks (√) in the evaluation checklist	Pcs	D
			C12-2	Traffic Performance Index	Year average vehicles capacity	Total number of ticks (√) in the evaluation checklist	-	N

	Criteria		Indicators					
	Code	**Title**	**Code**	**Title**	**Definition**	**Calculation Methods**	**Measurement Unit**	**Acquisition Mode**
Economic Sustainability	*C12*	Efficiency	***C12-3***	**Level of service of the Sidewalk**	Average level of service and traffic efficiency of sidewalks	Rating the street performance accordingly	-	D
			C12-4	**Level of service of Cycling Lane**	Average level of service and traffic efficiency of cycling lanes	Rating the street performance accordingly	-	D
	C13	Business Creation	*C13-1*	Density of Shops	The density of shops along the street	$\text{C13 1 (Density of shops)} = \frac{\text{Number of shops}}{\text{Total length of the street}} * 100$	shops /100m	M
			C13-2	Types of Temporary Business	Total types of temporary business	Total number of ticks (√) in the evaluation checklist	Pcs	M
	C14	Job Creation	*C14-1*	Employment Creation	Ability of the street to create employment positions	Rating the street performance accordingly	-	D
			C14-2	Types of Jobs	The types of job opportunities in the street	Total number of ticks (√) in the evaluation checklist	Pcs	M
	C15	Added-Value	*C15-1*	Added Value of Commercial Rents	Value-added rate of commercial rents along the street	See Note 1	%	C
			C15-2	Added-Value of Housing Prices	Value-added rate of Housing Price along the street	See Note 2	%	C

Note:

1. The optimised indicators are underlined
2. The formula to calculate C15-1: $\text{Added Value of Commerical Rents} = \frac{(\text{Unit Price of Commercial Rent along the Street} - \text{Average Unit Price of Commercial Rent in this District})}{\text{Average Unit Price of Commercial Rent in this District}}$
3. The formula to calculate C15-2: $\text{Added Value of Housing Price} = \frac{(\text{Unit Housing Price along the Street} - \text{Average Unit Housing Price in this District})}{\text{Average Unit Housing Price in this District}}$
4. The four types of acquisition modes of indicators are:
   Mode M: indicators linked to on-site measurements;
   Mode D: indicators linked to the completion of design requirements:
   Mode N: indicators linked to official published indexes;
   Mode C: indicators linked to the calculation of some officially published indexes.

9.3.2 Normalisation methods

Table 9. 4 illustrates the main changes of normalisation methods. The following parts present the revised datasheets of these ten indicators.

Table 9. 4: Main Changes of Normalisation Methods

No.	Indicator	New/Modification	Notes
1	C2-2: Street Shading Rate	New	To reference the *Shanghai Avenue Evaluation Methods"* (SGUAB, 2012)
2	C3-1: Average Emission of Noise – Daytime	Modification	To reference *"Road Traffic Noise Intensity Classification"* (MEP, 2012)
3	C3-2: Average Emission of Noise – Night-time	Modification	*To reference "Road Traffic Noise Intensity Classification"* (MEP, 2012)
4	C4-1: Rainwater Management	Modification	To enrich the rating system
5	C4-2: Ecological Planting	Modification	To revise the rating system by academic studies;
6	C6-1: Barrier-Free Facilities	Modification	To reference "Codes for barrier-free design" (MOHURD, 2012)
7	C10-1: Culture Promotion	New	To assess the ability of the street as a cultural medium to foster and activate local cultures.
8	C10-2: Style Consistency with the Surroundings and Local History	Modification	To combine the assessment of "Aesthetic Quality of Street Furniture"
9	C12-3: Level of service of the Sidewalk	New	*To reference "Code for Design of Urban Road Engineering" (See the table below)* (MOHURD, 2016)
10	C12-4: Level of service of Cycling Lane	New	*To reference "Code for Design of Urban Road Engineering" (See the table below)* (MOHURD, 2016)

1) C2-2: STREET SHADING RATE

Table 9. 5: Datasheet- Indicator C2-2

Indicator	**Code & Name**	C2-2: **Street Shading Rate**
	Definition	The percentage of the total shadow area of the vertical projection shelter such as tree canopy and sunshade facilities
Initial Diagnosis	**Calculation Method**	$\text{C2 1 (Street Shading Rate)} = \frac{\text{Total Shadow Area}}{\text{Street Total Area}}$
	Measurement Unit	%
Normalisation rules		0: <30% 1: >=30%, <60% 2: >=60%, <90% 3: >=90%

Note:

1. *The normalisation rules were designed based on the relevant standards and the investigation findings of 236 Shanghai streets.*
2. *"Shanghai Avenue Evaluation Methods"* (SGUAB, 2012) *indicates: The basic condition is "the greening shading rate of sidewalks and cycling lanes should be above 90%, that of vehicle way (under 4 lanes) should be above 50% and above 30% for the vehicle way (above 4 lanes) ".*
3. *The table below shows the sample normalisation rules, shading rate, and examples of corresponding streets*

Normalised value	***Street Shading Rate***	***Examples***
3	>=90%	 
2	>=60%, <90%	 
1	>=30%, <60%	 
0	<30%	 

Some of the photos are from Baidu Streetscape (Baidu, 2017)

2) C3-1: AVERAGE EMISSION OF NOISE – DAYTIME

Table 9. 6: Datasheet- indicator C3-1

Indicator	**Code & Name**	C3-1: **Average Emission of Noise – Daytime**
	Definition	Average noise emitted in the street of daytime
Initial Diagnosis	**Calculation Method**	Meter reading
	Measurement Unit	Decibel
Normalisation rules		0: > 74 decibel 1: >71 decibel, <= 74 decibel 2: >68 decibel, <71= decibel 3: <=68

Note:

1. *Daytime is between 6am and 10pm;*
2. *The measurement requirements:*
   1) *The measuring spot should be more than 50 meters away from the intersections and be located on the sidewalk. The monitoring point should be 1.2 ~ 6.0 meters away from the ground in height. In addition, the measurement should avoid the interference of non-street traffic sources.*

2) *The measurement time should cover one working day and one weekend, rush hour (7am~10am/4pm ~7pm) and normal time. Each measurement period is 20 minutes. The final value for normalisation is the average of all measured values.*
3. *The normalisation rules were designed based on "Road Traffic Noise Intensity Classification"* (MEP, 2012) *in the table below:*

Unit: dB (A)

Level	One	Two	Three	Four	Five
Average daytime equivalent sound level	<=68	68.1 ~70.0	70.1~72.0	72.1 ~74.0	>74

Source: (MEP, 2012)

3) C3-2: AVERAGE EMISSION OF NOISE – NIGHTTIME

Table 9. 7: Datasheet- indicator C3-1

Indicator	**Code & Name**	C3-1: **Average Emission of Noise – Night-time**
	Definition	Average noise emitted in the street of night-time
Initial Diagnosis	**Calculation Method**	Meter reading
	Measurement Unit	Decibel
Normalisation rules		0: > 64 decibel 1: >61 decibel, <= 64 decibel 2: >58 decibel, <61= decibel 3: <=58

Note:

1. *Night-time is between 10pm and 6am;*
2. *The measurement requirements:*
   1) *The measuring spot should be more than 50 meters away from the intersections and be located on the sidewalk. The monitoring point should be 1.2 ~ 6.0 meters away from the ground in height. In addition, the measurement should avoid the interference of non-street traffic sources.*
   2) *The measurement time should cover one working day and one weekend. Each measurement period is 20 minutes. The final value for normalisation is the average of all measured values.*
3. *The normalisation rules were designed based on "Road Traffic Noise Intensity Classification"* (MEP, 2012) *in the table below:*

Unit: dB (A)

Level	One	Two	Three	Four	Five
Average night-time equivalent sound level	<=58	58.1 ~60.0	60.1~62.0	62.1 ~64.0	>64

Source: (MEP, 2012)

4) C4-1: RAINWATER MANAGEMENT

Table 9. 8: Datasheet- indicator C4-1

Indicator	**Code & Name**	C4-1: **Rainwater Management**
	Definition	Management ability for rainfall.
Initial Diagnosis	**Calculation Method**	Total number of ticks below ___ *Tick the items that fit:* ❑ *Reasonable and effective rainwater inlets and drainage facilities;* ❑ *Properly maintenance of rainwater facilities;* ❑ *Different types of natural surface to storage and permeate rainwater, including planting troughs, tree pits, the median, and green space along the streets;* ❑ *Permeable pavements to allow rainwater to seep back into the soil;* ❑ *Rain garden to absorb and recycle rainwater for landscape irrigation;* ❑ *Bio-swale to filter and purify rainwater*
	Measurement Unit	Pcs
Normalisation Rules		***3:*** *5-6 ticks;* ***2****: 3-4 ticks;* ***1:*** *1-2 ticks;* ***0:*** *0 tick.*

5) C4-2: ECOLOGICAL PLANTING

Table 9. 9: Datasheet- indicator C4-2

Indicator	**Code & Name**	C4-2: Ecological Planting
	Definition	Ecological planting in the street
Initial Diagnosis	**Calculation Method**	Total number of ticks below ___ *Tick the items that fit:* ***Excellent:*** *The hierarchical structure of the plant community is complete, showing the complex structure of the tree-shrub-herb. Shrub coverage reaches 30-50%, and the proportion of native species is above 50%.* ***Good:*** *The arrangement of the tree-shrub-herb structure is reasonable, and the proportion of native species is 30-50%. Shrub coverage is about 30%;* ***Medium:*** *the tree-shrub-herb structure is incomplete, and the proportion of native species is between 10% and 30%;* ***Bad:*** *there is only one layer in the tree-shrub-herb structure and only one or two types of plant species. The proportion of native species is less than 10%.*
	Measurement Unit	Pcs
Normalisation rules		***3:*** *3 ticks;* ***2****: 2 ticks;* ***1:*** *1 tick;* ***0:*** *no tick.*

6) C6-1: BARRIER-FREE FACILITIES

Table 9. 10: Datasheet- Indicator C6-1

Indicator	**Code & Name**	C6-1: **Barrier-free Facilities**
	Definition	Provision of reliable and convenient barrier-free facilities for all kinds of people in the street
Initial Diagnosis	**Calculation Method**	Total number of ticks below ___ *Tick the items that fit:* ❑ *The width of the footpath should meet the needs of wheelchairs, baby strollers, and people with luggage;* ❑ *Barrier-free facilities (reasonable slope or accessible elevator) for vertical differences (stairs/overpass/underpass) in the sidewalk.* ❑ *Safe and reliable tactile pavements on sidewalks, and braille tips in bus stations and street signs.* ❑ *Audible pedestrian signals for street crossing to remind vulnerable groups;* ❑ *Bus stations provide screen sign language and subtitle information service to people with hearing impairment;* ❑ *The form of safety island should be accessible to wheelchair users.*
	Measurement Unit	Pcs
Normalisation rules		***3:*** *5-6 ticks;* ***2****: 3-4 ticks;* ***1:*** *1-2 tick;* ***0:*** *no tick.*

7) C10-1: CULTURE PROMOTION

Table 9. 11: Datasheet- Indicator C10-2

Indicator	**Code & Name**	C10-2: **Culture promotion**
	Definition	The ability of the street as a cultural medium to foster and activate local cultures.
Initial Diagnosis	**Calculation Method**	*Tick one description that mostly fits the actual condition of the street:* ❑ ***Excellent:*** *the street is a cultural hub in the district to promote the formation and dissemination of local culture actively. There are many types of public facilities, like public seats, open stages, and small plazas, in the street. Various cultural and religious activities, like public speech, lantern shows, festival parade, and religious pray often happened here.* ❑ ***Good:*** *the street can promote local culture. There are some facilities, like public seats and open plaza, in the street. Also, some civic cultural activities, like singing and dancing, community activities, and road show, happened in this street;* ❑ ***Medium:*** *the street sometimes can be a place for some basic civic activities, but is unable to promote local culture.* ❑ ***Bad:*** *no cultural activity happens in the street. Few people would like to carry out activities in this street.*
	Measurement Unit	-
Normalisation rules		**3**: *Excellent Performance;* **2:** *Good Performance;* **1**: *Medium Performance;* **0:** *Bad Performance*

8) C10-2: STYLE CONSISTENCY WITH THE SURROUNDINGS AND LOCAL HISTORY

Table 9. 12: Datasheet- Indicator C10-1

Indicator	**Code & Name**	C10-1: **Style consistency with the surrounding and local history**
	Definition	The overall aesthetic quality of street furniture
Initial Diagnosis	**Calculation Method**	*Tick one description that mostly fits the actual condition of the street:* ❑ ***Excellent:*** *The overall streetscape fully displays local culture and historical identity. Also, the street furniture form as a whole and reflect high aesthetic quality;* ❑ ***Good:*** *The overall streetscape is coherent to the surroundings and looks in harmony. The street furniture looks harmonious in general;* ❑ ***Medium:*** *Streetscape does not match with the surrounding landscape, but it looks tidy and ordered. The street furniture is not designed delicately, but tidy in general;* ❑ ***Bad:*** *The overall streetscape and street furniture destroy the local culture or historical features.*
	Measurement Unit	-
Normalisation rules		**3**: *Excellent Performance;* **2:** *Good Performance;* **1**: *Medium Performance;* **0:** *Bad Performance*

9) C12-3: LEVEL OF SERVICE OF THE SIDEWALK

Table 9. 13: Datasheet- Indicator C12-3

Indicator	**Code & Name**	C12-3: **Level of service of the Sidewalk**
	Definition	Average level of service and traffic efficiency of sidewalks
Initial Diagnosis	**Calculation Method**	*Tick one description that mostly fits the actual condition of the street:* ❑ ***Free Walking****: Walking is in a free state. It is comfortable and without interference. The pedestrians can choose the walking speed and overtake freely. Also, there is no conflict between different pedestrians.* ❑ ***Steady Walking****: Walking is in a relatively free state. There is little interference between pedestrians, but the walking is still comfortable in general. The pedestrians can choose walking speed, but there is a little constraint. Overtaking space is relatively large, and there are some overtaking phenomena;* ❑ ***Obstacle Walking:*** *The traffic flow is stable. There is always interference among pedestrians, and walking speed is limited. There are obstacles for overtaking. The walking experiences are not comfortable;* ❑ ***Intermittent Walking:*** *Walking is unstable and congested. The traffic flow is dense, the interference among pedestrians is considerable. Many pedestrians seek for overtaking. The footway is very crowded, and the walking speed is minimal.*
	Measurement Unit	-
Normalisation rules		**3**: *Free Walking;* **2:** *Steady Walking;* **1**: *Obstacle Walking;* **0:** *Intermittent Walking*

Note:

1. *This indicator should reflect the average level of service. Hence the level of service of rush hour (7am~10am and 4pm~7pm during the working day) and that of normal time should be evaluated respectively, thereby providing an average value.*
2. *The design of normalisation rules referenced the definition and classification of Level of Service of sidewalks in "Code for Design of Urban Road Engineering" (See the table below)* (MOHURD, 2016)

Level of Service	Walking speed (m/s)	Qualitative Description
A	>1.1	**Free Walking:** Walking is in a free state. It is comfortable and without interference. The pedestrians can choose the walking speed and overtake freely. Also, there is no conflict between different pedestrians.
B	1.0~1.1	**Steady Walking:** Walking is in a relatively free state. There is little interference between pedestrians, but the walking is still comfortable in general. The pedestrians can choose walking speed, but there is a little constraint. Overtaking space is relatively large, and there are some overtaking phenomena.
C	0.8~15	**Obstacle Walking:** The traffic flow is stable. There is always interference among pedestrians, and walking speed is limited. There are obstacles for overtaking. The walking experiences are not comfortable.
D	5~10	**Intermittent Walking:** Walking is unstable and congested. The traffic flow is dense, the interference among pedestrians is considerable. Many pedestrians seek for overtaking. The footway is very crowded, and the walking speed is minimal.

Adapted from (MOHURD, 2016)

10) C12-4: LEVEL OF SERVICE OF CYCLING LANE

Table 9. 14: Datasheet- Indicator C12-4

Indicator	**Code & Name**	C12-4: **Level of service of Cycling Lane**
	Definition	Average level of service and traffic efficiency of cycling lanes
Initial Diagnosis	**Calculation Method**	*Tick one description that mostly fits the actual condition of the street:* ❑ ***Free Riding**: The riding is in a free state. It is comfortable and without interference. The rider can choose the riding speed and overtake freely. Also, there is no conflict between different modes.* ❑ ***Steady Riding**: The riding is in a relatively free state. There is little interference between bikes, but the riding is still comfortable. The rider can choose riding speed, but there is a little constraint. Overtaking space is relatively large, and there are some overtaking phenomena.* ❑ ***Obstacle Riding:** the traffic flow is stable. There is always interference among bikes, and riding speed is limited. There are obstacles for overtaking.* ❑ ***Intermittent Riding:** the riding is unstable and congested. The traffic flow is dense, the interference among bikes is considerable. Riders often seek for overtaking. The cycling lane is very crowded, and the riding speed is minimal.*
	Measurement Unit	-
Normalisation rules		**3**: *Free Walking;* **2:** *Steady Walking;* **1**: *Obstacle Walking;* **0:** *Intermittent Walking*

Note:

1. *This indicator should reflect the average level of service. Hence the level of service of rush hour (7am~10am and 4pm~7pm during the working day) and that of normal time should be evaluated respectively, thereby providing an average value.*
2. *The design of normalisation rules referenced the definition and classification of Level of Service of sidewalks in "Code for Design of Urban Road Engineering" (See the table below)* (MOHURD, 2016).

Level of Service	Riding speed (km/h)	Qualitative Description
A	>20	**Free riding:** the riding is in a free state. It is comfortable and without interference. The rider can choose the riding speed and overtake freely. Also, there is no conflict between different modes.
B	20~15	**Steady Riding:** the riding is in a relatively free state. There is little interference between bikes, but the riding is still comfortable. The rider can choose riding speed, but there is a little constraint. Overtaking space is relatively large, and there are some overtaking phenomena.
C	10~15	**Obstacle riding:** the traffic flow is stable. There is always interference among bikes, and riding speed is limited. There are obstacles for overtaking.
D	5~10	**Intermittent riding:** the riding is unstable and congested. The traffic flow is dense, the interference among bikes is considerable. Riders often seek for overtaking. The cycling lane is very crowded, and the riding speed is minimal.

Adapted from (MOHURD, 2016)

9.3.3 Weighting System

The weighting system retained the original structure and structural logic that had been elaborated in Chapter 7.4.1. Therefore, the main change was the response adjustment after the optimisation of some indicators. Table 9. 16 shows the revised weighting system.

Table 9. 15 lists the main modifications to the Weighting System.

1) C2-2 (Street Shading Rate) and C10-1 (Culture promotion), as the replaced indicators, used the weights of their original indicators;
2) The original indicator of C3-1 (Average Emission of Noise) was divided into two indicators, namely C3-1 (Average Emission of Noise -Daytime) and C3-2 (Average Emission of Noise -Night-time), so the two new indicators shared the original weight coefficient (0.03365/2=0.016825);
3) The original C6-1 (Tactile pavement for the blind) had been integrated into the indicator of C6-2(Barrier-Free Facilities), so there was only one indicator representing the evaluation criterion of C6 (Equality). Consequently, the weight coefficient of the indicator layer [C6-1(Barrier-Free Facilities)] was equal to that of the criteria layer [C6 (Equality)];

4) For the evaluation criterion of C12 (Efficiency), there were two new indicators for the system, namely C12-3(Level of service of the Sidewalk) and C12-4 (Level of service of Cycling Lane). Given this, four indicators represented C12 (Efficiency) in the optimised Indicator System, and they were relatively independent and of equal importance. Therefore, these four indicators shared equally the weight coefficient of C12 (Efficiency) (0.0669/4=0.016725).

Table 9. 15: Modification list of weighting system

NO.	Indicator	Weight Ecoefficiency
1	C2-2 (Street Shading Rate)	0.03165
2	C3-1 (Average Emission of Noise -Daytime)	0.016825
3	C3-2 (Average Emission of Noise -Night-time)	0.016825
4	C6-1(Barrier-Free Facilities)	0.0675
5	C10-1 (Culture promotion)	0.03215
6	C12-3(Level of service of the Sidewalk)	0.016725
7	C12-4 (Level of service of Cycling Lane)	0.016725

Table 9. 16: Weighting system of the sustainability evaluation framework

Evaluation Framework				Weighing System			
Target Layer	*Sub-Target Layer*	*Criteria Layer*	*Indicator Layer*	*Weight Coefficient*			
Sustainability	**Environmental Sustainability**	C1: Adaptability	C1-1: Adaptable Capacity to Local Climate	1.0	0.333	0.0676	0.03380
			C1-2 Adaptable Capacity to Extreme Weather Events				0.03380
		C2: Mitigation UHI	C2-1: Street Green Rate			0.0633	0.03165
			C2-2: Street Shading Rate				0.03165
		C3: Pollution reduction	C3-1: Average Emission of Noise -Daytime			0.0673	0.016825
			C3-2: Average Emission of Noise -Night-time				0.016825
			C3-3: Pollution Reduction				0.03365
		C4: Ecological balance	C4-1: Rainwater management			0.0663	0.03315
			C4-2: Ecological Planting				0.03315
		C5: Green life promotion	C5-1: Green Lifestyle Promotion			0.0689	0.03445
			C5-2: Green Travel Support				0.03445

Evaluation Framework				Weighing System			
Target Layer	***Sub-Target Layer***	***Criteria Layer***	***Indicator Layer***	***Weight Coefficient***			
Sustainability	**Social Sustainability**	C6: Equality	C6-1: Barrier-Free Facilities	1.0	0.333	0.0675	0.0675
		C7: Safety	C7-1: Coverage Proportion of Street Cameras			0.0687	0.03435
			C7-2: Coverage Safety Equipment				0.03435
		C8: Accessibility	C8-1: The Variety of Arrival Ways			0.0667	0.03335
			C8-2: Clear Sign and Guidance System				0.03335
		C9: Diversity	C9-1: Diversity of Street Activities			0.0661	0.03305
			C9-2: Diversity of Street Functions				0.03305
		C10: Culture Inheritance	C10-1: Culture promotion			0.0633	0.03215
			C10-2: Style Consistency with Surroundings				0.03215
	Economic Sustainability	C11: Intensive Land Utilisation	C11-1: Intensiveness of Street Space		0.333	0.0692	0.03460
			C11-2: Mixed-Use of Street Land				0.03460
		C12: Efficiency	C12-1: Intelligent Transportation System			0.0669	0.016725
			C12-2: Traffic Performance Index				0.016725
			C12-3: Level of service of the Sidewalk				0.016725
			C12-4: Level of service of Cycling Lane				0.016725
		C13: Business Creation	C13-1: Density of Shops			0.0702	0.03510
			C13-2: Types of Temporary Business				0.03510
		C14: Job Creation	C14-1: Employment Creation			0.0625	0.03125
			C14-2: Types of Jobs				0.03125
		C15: Added-Value	C15-1: Added Value of Commercial Rents			0.0645	0.03225
			C15-2: Added-Value of Housing Prices				0.03225

9.3.4 Aggregation Methods

The aggregation models and calculation methods remained the same as before. The modification was the necessary response to the change of numbers of indicators. Therefore, the change of aggregation methods lied in the formula for the first step of the aggregation process. Table 9. 17 shows the aggregation model.

Table 9. 17: Optimised Aggregation Model

AGGREGATION STEP ONE							
Basic Data		*Calculation formula*	*Result*				
			AGGREGATION STEP TWO				
			Basic Data	*Calculation formula*	*Result*		
					AGGREGATION STEP THREE		
					Basic Data	*Calculation formula*	*Result*
Indicator Code	**Weight Code**		Criteria Code		Sub-Target		Target
$C_{1\text{-}1}$	$W_{1\text{-}1}$	$\boldsymbol{C_n = C_{n\text{-}1} W_{n\text{-}1} + C_{n\text{-}2} W_{n\text{-}2} + \ldots C_{n\text{-}4} W_{n\text{-}4}}$ $n \in (1,2,3,\ldots,15)$	C_1	***EnSI* = (C₁+C₂+C₃ +C₄+C₅) *10**	*EnSI*	**SSI = (EnSI*SoSI*EcSI)$^{1/3}$**	SSI
$C_{1\text{-}2}$	$W_{1\text{-}2}$						
$C_{2\text{-}1}$	$W_{2\text{-}1}$		C_2				
$C_{2\text{-}2}$	$W_{2\text{-}2}$						
$C_{3\text{-}1}$	$W_{3\text{-}1}$		C_3				
$C_{3\text{-}2}$	$W_{3\text{-}2}$						
$C_{3\text{-}3}$	$W_{3\text{-}3}$						
$C_{4\text{-}1}$	$W_{4\text{-}1}$		C_4				
$C_{4\text{-}2}$	$W_{4\text{-}2}$						
$C_{5\text{-}1}$	$W_{5\text{-}1}$		C_5				
$C_{5\text{-}2}$	$W_{5\text{-}2}$						
$C_{6\text{-}1}$	$W_{6\text{-}1}$		C_6	***SoSI* = (C₆+C₇+C₈ +C₉+C₁₀) *10**	*SoSI*		
$C_{7\text{-}1}$	$W_{7\text{-}1}$		C_7				
$C_{7\text{-}2}$	$W_{7\text{-}2}$						
$C_{8\text{-}1}$	$W_{8\text{-}1}$		C_8				
$C_{8\text{-}2}$	$W_{8\text{-}2}$						
$C_{9\text{-}1}$	$W_{9\text{-}1}$		C_9				
$C_{9\text{-}2}$	$W_{9\text{-}2}$						
$C_{10\text{-}1}$	$W_{10\text{-}1}$		C_{10}				
$C_{10\text{-}2}$	$W_{10\text{-}2}$						
$C_{11\text{-}1}$	$W_{11\text{-}1}$		C_{11}	***EcSI* = (C₁₁ +C₁₂+C₁₃ +C₁₄+C₁₅) *10**	*EcSI*		
$C_{11\text{-}2}$	$W_{11\text{-}2}$						
$C_{12\text{-}1}$	$W_{12\text{-}1}$		C_{12}				
$C_{12\text{-}2}$	$W_{12\text{-}2}$						
$C_{12\text{-}3}$	$W_{12\text{-}3}$						
$C_{12\text{-}4}$	$W_{12\text{-}4}$						
$C_{13\text{-}1}$	$W_{13\text{-}1}$		C_{13}				
$C_{13\text{-}2}$	$W_{13\text{-}2}$						
$C_{14\text{-}1}$	$W_{14\text{-}1}$		C_{14}				
$C_{14\text{-}2}$	$W_{14\text{-}2}$						
$C_{15\text{-}1}$	$W_{15\text{-}1}$		C_{15}				
$C_{15\text{-}2}$	$W_{15\text{-}2}$						

9.4 Further Discussion

Through a series of street investigations, questionnaires surveys, and expert interviews, most of the findings have been reflected in the theoretical study of sustainable streets and the optimisation of the Indicator System of sustainable streets. Some findings have an impact on the delivery of sustainable streets and its Shanghai practices, but they are beyond the scope of this research. Therefore, the following part summarises these findings into four points and discusses briefly.

1. ***How to use the evaluation results?***

   Some discussions might lie in that whether there is the perfect street, whether the street with a higher score in the evaluation is necessarily better than the other, and how to evaluate different streets by one system due to the variety of their characteristics. These are the issues raised in the expert interview, as well as the question the researcher thinks in this research.

   How to compare a neighbourhood street, like Sujiatun Rd which is quiet and peaceful and full of green trees, with a commercial street, like Madang Rd which is a famous tourist attraction located in the city centre? This is related to the evaluation purpose and usage methods of the evaluation results. The evaluations of different types of streets were discussed in Chapter 6, and it was concluded that all types of streets can achieve high scores in sustainability evaluation, and no type of street is inherently superior to others. It is important to notice that the purpose of sustainability evaluation for the streets is to push the sustainable development of urban streets. In other words, the evaluation is not simply for comparison but to find the problems and renovation strategies. Therefore, if a neighbourhood street is compared with a commercial street, the comparative analysis should focus on how to help various types of streets to be more sustainable and develop in a more holistic way, which had been mentioned in Chatper 6.4.

   Firstly, the evaluation process provides an opportunity to observe and analyse the street in depth. Secondly, the evaluation results, including the numerical scores of four layers, reflect the performance of the street objectively and comprehensively. Thirdly, the analysis of the evaluation results helps to understand the street's features, including its characteristics, advantages, and disadvantages, thereby promoting more targeted optimisation schemes.

   The evaluation results of the Indicator System should be a report which includes the scores of SSI, EnSI, SoSI, and EcSI and the criteria layer rather than a simple composite index. Importantly, the purpose of sustainability evaluation is not to score the streets, but to help to understand the streets more efficiently, objectively, and comprehensively. Given this, the sustainable evaluation is not to search for a perfect street. Every street is unique because of its history, location, and users' characteristics. Just as the definition of sustainability, it is a well-balanced status instead of not a perfect condition. Moreover, the balance is among environmental, social, and economic sustainability. Therefore, the evaluation is to promote sustainable development of urban streets, and a street with a high score of SSI shows a development pattern of health and long-lasting.

Furthermore, the sustainability evaluation is an open system (explained in Chapter 2.3.2). It should be adjusted according to the implementation location and optimised based on changes of the times. Therefore, it is true that it is impossible to evaluation different streets with different social background and climate types by one system. However, for the streets in the same location (same climate type, social background, and economic development), the defined system can evaluate the performance of the streets and tell the features of the assessed streets.

2. ***How to express the evaluation results?***

The sustainability evaluation of urban streets is a report rather than a simple composite index. Then, the question might be how the evaluation reports should be? The answers depend on whom are going to use the evaluation results.

There are various types of users of evaluation reports, so the expression forms should be adapted to the requirements of the users. Firstly, the evaluation results can be used by the designers and planners as the reference or evidence for the renovation and design of urban streets. So, the analysis reports should contain more evidence of the evaluation results, like street photos and assessment notes. Secondly, if the evaluation results are for the scholars to conduct relevant studies on urban streets or sustainability evaluation, the report can focus on the quantitative comparison and the relationships among the scores of different layers. Thirdly, if the evaluation results are for the decision-maker to formula or revise relevant policies or plans, the expression of evaluation results should be integrated. The report could focus on the comparison of key indexes. Fourthly, if the evaluation results are for the public engagement and media promotion, the expression of evaluation results should be simple and straightforward. More visualised and graphic diagrams could be better than statistical tables.

Therefore, the expression form of evaluation results could be diverse according to the users. The expression forms in this research, including the score table and comparison graph, are only to facilitate the comparison and analysis of this study and does not represent the necessary expression forms for the Indicator System.

3. ***What is the key to the delivery of sustainable streets in Shanghai?***

   In China, the public is rarely able to participate in the construction and renovation of urban streets due to the political mechanism and the issues of land ownership. However, **the research indicates that public engagement is important to sustainable streets.**

   Firstly, it can be seen from the research that the evaluation results of the Indicator System are close to sustainability appraisal from the street users, which shows the public understanding and evaluation of urban streets is objective and accurate in general.

   Moreover, the experts highlighted during interviews that the public often knew the streets much better than the designers and policymakers. The street users are the biggest benefits of the streets' excellent performance and the direct victims from the street's poor performance. Hence, the street users, especially the residents living along the streets, are always clear about how to improve the streets because they know by which means the streets are used. In addition to the designer, planners, policymakers and scholars, the most significant stakeholder is the public. Also, the public participation needs to take place not only in the street evaluation and analysis stage but also in the design and renovation stage, as well as in the operation and management stage. The public can help researchers to know and analyse streets more accurately during the evaluation stage, guide and assist the implementation of design schemes, and help to supervise and maintain the daily operation of the streets.

   Furthermore, the street questionnaires showed that the concept of sustainable streets were easily accepted and agreed by the public in Shanghai, and they were very willing to promote the sustainable streets in Shanghai actively. In some brief interviews during the questionnaire process, many interviewees expressed their willingness to participate in more activities on sustainable streets and to participate in the design discussions of street renovations.

   The issue of public engagement is beyond the research scope of this study. However, it is important to note that the promotion of public participation is of great significance to the delivery of sustainable streets. Therefore, how to develop a proper mechanism for public participation in Shanghai is a critical issue deserving further discussion and in-depth study.

4. ***What are the challenges of delivery of sustainable streets in Shanghai***?

   Chapter 5.5.2 expounded that the development of Shanghai streets is under transformation. Also, the experts emphasised during interviews that the transformation just began and there was still a long way to go.

   “Shanghai Street Design Guide” states the transformation of Shanghai streets includes four aspects, namely concept transformation, mechanism transformation, methods transformation, and evaluation transformation. This research could help to promote the transformation and development of concept and evaluation, but a holistic transformation needs all forces to join together, and there are many challenges in it.

   For example, the transformation of concepts and preferences requires not only continuous advocacy and education but also more extensive public participation and popular support. Mechanism innovation requires various departments to collaborate closely from designing, policy making, constructing, and managing, to operating. Moreover, many new technologies of sustainable solutions, like rain garden and permeable pavements, need technological innovation and practice optimisation before a broad application.

   All the problems discussed above have been mentioned in this research, but they are not analysed in depth as they are beyond the research scope. It should be clear that the main challenges in the delivery of sustainable streets in Shanghai come from the difficulties in the transformation from the four aspects of the concept, mechanism, method, and evaluation.

9.5 Summary

This chapter proposed an optimised scheme on the Indicator System of Sustainability Evaluation for Shanghai streets based on the systematic analysis of results of Expert Interviews and application experiences.

All four interviewed experts agreed that the exploration and research on the Sustainable Streets are significant and valuable, and they spoke highly of the established Indicator System of Sustainable Streets. In the interview, the experts propounded comments for the potential modification regarding to 9 indicators, and put forward suggestions for the optimization of another 3 aspects involving 5 indicators. The other 3 optimisation aspects included the disadvantages of C6-1 (Blind Pavement) for the criterion of C6 (Equality), the representativeness of C7-1 (Coverage Proportion of Street Camera) and C7-2 (Coverage Safety Equipment) for the criterion

C7 (Safety), and the comprehensiveness of the selected indicators for the C12 (Efficiency). Table 9.1 summarised the experts' suggestions for the system optimisation.

Based on the potential improvements summarised by the practical applications and constructive suggestions from experts, a series of optimisation was carried out on the indicator system. The optimisation involved the modification of 8 indicators, and they were: 1) replacing of C2-2 (Temperature Difference) by C2-2(Street Shading Rate), 2) breaking the indicator of C3-1 (Average Emission of Noise) into two indicators, namely C3-1 (Average Emission of Noise -Daytime) and C3-2 (Average Emission of Noise -Night-time); 3) integrating the indicator of C10-1 (Aesthetic Quality of Street Furniture) into the indicator of C10-2 (Style Consistency with Surroundings), and then to add one indicator, called C10-1 (Cultural Promotion), 4) adding two indicators, namely C12-3 (Level of service of the sidewalk) and C12-4 (Level of service of cycling Lane) for the evaluation criterion C12 (Efficiency); 5) integrating C6-1(Tactile pavement for the blind) into C6-2 (Barrier-free facilities) and code it as C6-1 (Barrier-free facilities). Then, the standardisation methods were revised because of the indicator changes. Besides, the weighting system and aggregation model were also updated accordingly based on the original structure and logic.

Finally, a set of indicator system for sustainability evaluation is finally constructed for Shanghai streets which including 4 layers, 15 evaluation criteria and 32 indicators, a set of standardisation methods and weighting system, and a package of calculation formulas.

Chapter 10. Conclusion

10.1 Introduction

Chapter 10 aims at concluding the whole research.

Firstly, Chapter 10.2 summarises the research outcomes. the research findings are elaborated by gradually answering the research questions, completing the research objectives, and ultimately achieving the research aim. Then, Chapter 10.3 presents the contributions of this research from the theoretical and the practical perspective respectively. Finally, Chapter 10.4 analyses the limitations of this study and Chapter 10.5 suggests future work.

10.2 Achievement of Research Aim and Objectives

With the problems of lack of practical evaluation tools to guide the design work in a comprehensive and effective way, this research aims to build an evaluation system for sustainable streets in Shanghai to provide suggestions for street renovation.

Firstly, the theoretical basis of sustainable street design and an evaluation framework of sustainable streets were established by literature review. The investigations of 236 streets in Shanghai and the questionnaire survey of 50 experts were conducted to apply the evaluation framework, to assess the overall performance of Shanghai streets, and to construct a set of indicator evaluation system for sustainable streets in Shanghai. Three streets were evaluated by the established system. The evaluation results were compared with the questionnaires' data of 50 street users to examine the accuracy and objectivity of the system. Finally, 4 experts who were famous in the fields of street design, research and management in Shanghai were interviewed. The interview outcomes were integrated with the whole research findings so as to optimise the evaluation system.

Therefore, **the key findings of this study included the following 3 points**:

1) ***an establishment of the theoretical basis of sustainable street design,*** including the definition, 3 principles, 15 design objectives and a design toolbox with 75 specific methods;

2) ***the construction of a set of indicator evaluation system for sustainable streets in Shanghai,*** including 15 evaluation criteria and 32 evaluation indicators, a set of standardisation methods

and weighting system, and a package of calculation formulas. Also, the accuracy and practicality of the system were proved by application;

3) ***a relative comprehensive assessment of the overall performance of Shanghai streets and some useful suggestions for future renovations of Shanghai streets.*** In general, about 10% of Shanghai streets were in urgent need of renovation. The future development of Shanghai streets should focus on promoting environmental sustainability and activating the street economy in a targeted way.

Given this, the study successfully achieved the research aim, constructing a set of indicator evaluation system of sustainable streets that are able to support the whole design process of street renovations.

The following sections elaborate the research findings by answering twelve research questions and summarising the main outcomes of four research objectives.

10.2.1 Achievement of Objective One

Research Objective One: ***to form a theoretical basis for the design of sustainable streets and a preliminary evaluation framework of sustainable streets.***

A systematic literature review was conducted to build the theoretical basis for the design of sustainable streets, including the conceptual analysis of Climate Change, Sustainability, and Urban Streets. **The definition, 3 design principles, 15 design tasks and design toolbox with 75 specific methods of sustainable street design were sorted out, and the preliminary evaluation framework of sustainable streets was constructed (See Table 3. 12), including 4 evaluation layers, 15 evaluation criteria and 79 potential indicators.**

These findings filled the gap of theoretical research of sustainable streets. It can be seen that the evaluation framework was design-oriented: the 3 design principles were adopted as the 3 evaluation sub-targets; 15 design principles were used as 15 evaluation criteria; and 75 design methods helped to form evaluation indicators. This enabled the evaluation tool serves for street design.

Q1: What are the cause and effect of Climate Change, and how the global response to the threat?

Urban areas are the leading cause of Climate Change and also suffer from the negative effects of Climate Change the most significantly, so the urban renovations are of great importance to response the threats. Among global responses, two fundamental paradigms are mitigation of Climate Change and adaptation to Climate Change. These two paradigms are mainly based on the intervention of future trends, which is consistent with the intervention mechanism of planning and design. **Therefore, it can be said that the renovation of the built environment is a necessary solution to Climate Change.**

Q2: How to understand and interpret sustainability in the built environment, and what is sustainability assessment?

In addition to dealing with the negative impacts brought by Climate Change, sustainability in built environment highlights the comprehensive and long-term development. Sustainable assessment has the mechanism of adjustment and optimization, which can promote regional development more effectively and comprehensively in a long term. **Therefore, the promotion of theoretical and practical development of sustainable assessment is of great significance for addressing Climate Change and a range of other urban issues as well.**

Q3: What is the definition, functions and design elements of urban streets, and what kinds of threats they are confronted with under Climate Change?

Urban streets are the linear open space consisting of the lined buildings, the people, serving facilities, and the surrounding environment. With all these components, the street functions as an essential place for social interaction, cultural inheritance, political communication, economic activities as well as urban ecology. The design of either new streets or the renovations of existing street involve 28 spatial elements in 4 categories. In the context of Climate Change, the sustainable shift of urban streets is crucial since they have a profound influence on urban systems and reasonable interventions could stop the vicious circle brought by Climate Change. **Given this, street renovation and sustainable shift are of great significance to the development of urban streets and built environment.**

Q4: What is the theoretical framework of "Sustainable Streets" and the evaluation structure of sustainable streets?

Sustainable Streets are the desirable status of urban streets, successfully balancing the three aspects of environmental, social and economic sustainability in the street space, and promoting local sustainable development through the design, construction and operation. The 3 design principles embody the 3 sustainable pillars, namely society, environment, and economics. Based on 3 design principles, the research defined a total of 15 design objectives, namely Adaptability, Mitigation UHI, Pollution Reduction, Ecological Balance, Green Life Promotion, Equality, Safety, Accessibility, Diversity, Culture Inheritance, Intensive Land Utilisation, Efficiency, Business Creation, Job Creation, and Added-Value. Also, a set of design toolkit was formed with 28 spatial elements of 4 categories and 75 specific design methods. **Therefore, the theoretical framework of sustainable streets included its definition, 3 principles, 15 design objectives, and a set of design toolkit with 75 specific design methods. A preliminary evaluation structure of sustainable streets included 4 evaluation layers, 15 evaluation criteria, and 79 potential indicators (Table 3. 9).**

10.2.2 Achievement of Objective Two

Research Objective Two: ***to build the indicator system of sustainable evaluation for Shanghai streets.***

Based on a theoretical study on Shanghai streets, the preliminary evaluation framework was tested during the investigation of 236 Shanghai streets, the research summarised overall performance of Shanghai streets and suggestions for future renovation of Shanghai streets. Combing with street survey, site measurements, expert questionnaires, and desk work, **a set of indicator evaluation system of sustainable streets in Shanghai was constructed, including 1 composite Index (SSI), 3 Sub-Index (EnSI, SoSI, and EcSI), 15 evaluation criteria and 30 indicators.**

Q5: What is the past formation process, current features and classification, and future development orientation of Shanghai streets?

Chapter 5 studied the history and current development barriers of Shanghai streets, thereby demonstrating the significance and necessity of sustainability transformation of Shanghai streets. The history of Shanghai streets closely links with Shanghai development. Shanghai streets experienced multinational colonisation, national revolution, rapid construction, and development transformation. The study of the essential characteristics revealed the development barriers current Shanghai streets, including severe traffic congestion, poor public transportation service, limited street vitality, and insufficient capacity to emergency events and climate adaption respectively. **Therefore, the sustainability shift is the necessary trend of the historical development, a practical solution to the issues that Shanghai streets are confronted with, as well as the significant booster for Shanghai 2040 Master Plan.**

Q6: What are the overall assessment results of Shanghai streets by a preliminary evaluation framework, and what are the sample cases of further study?

The preliminary application of evaluation framework proved its practicality. Also, the analysis of assessment results and investigation findings shows that the overall performance of Shanghai streets is above the average level. The future development of Shanghai streets should focus on promoting environmental sustainability and activating the street economy in a targeted way. The streets of central Shanghai performed better than the surroundings within the main urban areas, and more attentions should be paid to the surrounding areas regarding the future renovations of Shanghai streets. In general, about 10% of Shanghai streets were in urgent need of renovation. Before the renovations, some demonstrative cases can be selected within the community for publicity and promotion.

Furthermore, the research selected the three sample streets for further study, namelyM3-1 (Daxue Rd), M4-10 (Sujiatun Rd), and C3-8 (Madang Rd) respectively, which was not only because they got the top three scores in the assessment, but also because they reflect the three typical street characteristics of Shanghai. An in-depth study could summarise suggestions of universal significance for renovation and promote the sustainable development of Shanghai streets.

Q7: What is the Indicator System of sustainability evaluation for Shanghai streets?

After the selection of indicators, the design of normalisation methods, calculation of weighting system, and choice of aggregation model, the research constructed a set of indicator evaluation system of sustainable streets in Shanghai. **The system consisted of 1 composite Index (SSI), 3 Sub-Index (EnSI, SoSI, and EcSI), 15 evaluation criteria, 30 indicators (Table 7. 4), a series of normalisation methods (30 Datasheets in Chapter 7.3), a set of weighting system (Table 7. 37), and corresponding aggregation model (Table 7. 39).**

10.2.3 Achievement of Objective Three

Research Objective Three: ***to apply and examine the indicator system of sustainability evaluation in sample streets.***

The established indicator system was applied to evaluate the sustainability of three sample streets. 50 questionnaires were surveyed in each street to obtain the appraisals regarding street's sustainability from street users. The practicability and accuracy of the sustainable index evaluation system were tested by the cross comparison between the evaluation data of three streets index evaluation system and the evaluation data of users' questionnaire survey.

The indicator system was tested to be practical and its evaluation results were basically consistent with those of street users. The research was to make the evaluation results positively correlated with the street users' satisfaction with the street, so as to form a set of design-oriented evaluation tools that could reflect the users' experiences at the same time.

In order to further improve its practicability and accuracy, the research proposed the improvement of 5 aspects involving 9 evaluation indicators (Table 8. 27).

Q8: What are the results of sustainability evaluation of the sample streets by the Indicator System?

Through the application of the indicator system in the practice of three sample streets, it can be found that the evaluation system was easy to apply and the evaluation results could reflect the actual performance of the three streets comprehensively and accurately.

From the perspective of application, the on-field evaluation work only needs to observe and simply measure the current situation of the streets, collate the checklists, and record the data. The measurement tools needed on site were user-friendly for normal researchers or designers. 4 out of 30 indicators need online data, but they are highly accessible. However, the biggest limitation of the system lies in the C2-2 (Temp. Difference) as it is highly sensitive to seasons.

From the perspective of evaluation results, the SSI scores of Madang Rd, Daxue Rd, and Sujiatun Rd were 7.56, 6.87, and 6.53, which were in line with the preliminary assessment in the 1st field survey. Secondly, the evaluation results could reflect the streets' characteristics. Compared with the preliminary assessment, the scores in the criteria layer of the indicator system fluctuated more and were more sensitive to the street performance. Madang Rd got the high scores regarding SoSI and

EcSI (9.67 and 8.29 respectively). Daxue Rd had outstanding performance in social and economic sustainability, but poor from environmental perspective (EnSI=4.69). The EnSI of Sujiatun Rd was the highest (7.31) while its EcSI was only 4.90 for. These scores could provide useful suggestions for the future design of their renovation. Also, statistical comparisons of evaluation results helped to find the indicators flaws, like C3-1 (Average Emission of Noise), C4-1 (Rainwater Management) and C4-2 (Ecological Planting).

Q9: What are differences and coherences between evaluation results of Indicator System and appraisal results of Questionnaire Survey among the sample streets?

The evaluation outcomes of the indicator system were basically consistent with the results of the questionnaires, and it was more sensitive to the actual street situation. The main differences between them helped for further optimization of indicator system.

The SSIs from the Indicator System were very close to those from the Questionnaires. The final SSIs from the indicator system and questionnaires were the same in Daxue Rd, and the differences of Sujiatun Rd was only 0.5%. The most significant difference lied in Madang Rd with 9.9%. In addition, the two sets of data for the three streets showed the same overall characteristics regarding three pillars of sustainability. When comparing the criteria layer of two sets of data, the scores of indicator system fluctuated much more than those of questionnaires. The variance of former was 1.86, while the later one was only 0.23, which showed the indicator system were more sensitive to the actual street situation. Some indicators for C3(pollution reduction), C4(ecological balance), C10(cultural inheritance), and C11(land intensive use) were quite different in the two sets of data, which provided a basis for further optimization of index evaluation system.

Q10: What are the improvement points of the Indicator System according to the cross-comparison of the evaluation results and the application experiences?

Based on the 8 principles of 3 aspects, the research discussed the possible improvements of the indicator system and puts forward 5 aspects modification involving 9 indicators.

Specifically speaking, the analysis included 1) the application experiences of the Indicator System in three Shanghai streets from the principles of Utilisation Convenience, Data Accessibility, and Evaluation Objectivity, 2) the analysis of evaluation results of the Indicator System from the principles of Veracity, Integrity, and Comparability; and 3) the analysis of cross-comparison of two sets of evaluation results from the principles of "Overall Consistency" and "Details No Confliction". Given this, a series of system optimisation were proposed which related to the modification of 9 indicators (See Table 8.27), including the Indicator C3-1 (Average Emission of Noise), and indicators representing C4 (Ecological Balance), C10 (Culture Inheritance), and C11 (Intensive Land Utilisation).

10.2.4 Achievement of Objective Four:

Research Objective Four: ***to optimise the established indicator system of sustainability evaluation.***

Four experts who were famous in the fields of street design, research and management in Shanghai were interviewed regarding the construction methods, theoretical basis, application results, and potential issues of the indicator system. The interview outcomes were integrated with the whole research findings to optimise the evaluation system.

After practical verification and multi-dimensional optimisation, a set of indicator system for sustainability evaluation was finally constructed for Shanghai streets which includes 4 evaluation layers, 15 evaluation criteria and 32 indicators, a set of standardisation methods and weighting system, and a package of calculation formulas.

The research provides suggestions and assistance for street renovation design in Shanghai and beyond through the established indicator system. 1) It provides a set of indicator system for Shanghai streets that are easy to use and accurate in results, which fills in the gap of lack of street evaluation tool in Shanghai. 2) The indicator system can support for the whole process of street renovation design, including problem analysis, goal setting, scheme formulation, and effect evaluation. 3) The indicator system constructed in this research can be extended to be street evaluation tool in other cities, regions, and countries, thereby promoting a wide range of street renovation and reinforcing design quality.

Q11: What are the key findings of the expert interview regarding the system improvement?

All four interviewed experts agreed that the exploration and research on the Sustainable Streets are significant and valuable, and they spoke highly of the established Indicator System of

Sustainable Streets. In the interview, the experts propounded comments for the potential modification regarding to 9 indicators, and put forward suggestions for the optimization of another 3 aspects involving 5 indicators.

The other 3 optimisation aspects included the disadvantages of C6-1 (Blind Pavement) for the criterion of C6 (Equality), the representativeness of C7-1 (Coverage Proportion of Street Camera) and C7-2 (Coverage Safety Equipment) for the criterion C7 (Safety), and the comprehensiveness of the selected indicators for the C12 (Efficiency). Table 9.1 summarised the experts' suggestions for the system optimisation.

Q12: How to refine and optimise the Indicator System of Sustainability Evaluation of Shanghai streets based on the key findings of the above stages?

Based on the potential improvements summarised by the practical applications and constructive suggestions from experts, a series of optimisation was carried out on the indicator system. The optimisation involved the modification of 8 indicators, and they were: 1) replacing of C2-2 (Temperature Difference) by C2-2(Street Shading Rate), 2) breaking the indicator of C3-1 (Average Emission of Noise) into two indicators, namely C3-1 (Average Emission of Noise -Daytime) and C3-2 (Average Emission of Noise -Night-time); 3) integrating the indicator of C10-1 (Aesthetic Quality of Street Furniture) into the indicator of C10-2 (Style Consistency with Surroundings), and then to add one indicator, called C10-1 (Cultural Promotion), 4) adding two indicators, namely C12-3 (Level of service of the sidewalk) and C12-4 (Level of service of cycling Lane) for the evaluation criterion C12 (Efficiency); 5) integrating C6-1(Tactile pavement for the blind) into C6-2 (Barrier-free facilities) and code it as C6-1 (Barrier-free facilities). Then, the standardisation methods were revised because of the indicator changes. Besides, the weighting system and aggregation model were also updated accordingly based on the original structure and logic.

Finally, a set of indicator system for sustainability evaluation is finally constructed for Shanghai streets which including 4 layers, 15 evaluation criteria and 32 indicators, a set of standardisation methods and weighting system, and a package of calculation formulas.

10.3 Contribution of the research

The research established the theoretical framework of sustainable streets design and successfully built the indicator system of sustainability evaluation for Shanghai streets. In summary, there are three main contributions theoretically and practically:

1. **It promoted the theoretical development of sustainable street design and filled the academic gaps.** According to literature review, sustainable street is to balance streets' development of society, economy, and environment from a long-term perspective. When comparing the theoretical definition with the practical samples of sustainable streets, it can be found that although the definition is relatively abstruse, but the practices of sustainable streets are not necessarily equipped with complex or unique high-tech products or cutting-edge technologies. The common images of sustainable streets are just green, safe, and vibrant streets where people and even some small animals would like to stay. According to the findings of comprehensive field surveys, those outstanding sustainable streets are not achieved overnight, but over a relatively long period via constant micro-updating according to users' needs and environmental changes to balance various development demands. The integration the theory and practical samples clearly interprets 3 key characteristics of sustainable street design: 1) Sustainable street design is not necessary to invent new technologies or methods, but to choose appropriate schemes according to local conditions and users' demands; 2) Sustainable street design is supposed to not only address current issues, but also promote a long-term development; 3) Sustainable street design is a dynamic life cycle, and there is no "One for All" solution. With the changes of user needs and new challenges from Climate Change, designers need to continuously follow up with streets' updating based on regular assessments.
2. **The research provided a set of design toolkits to promote the practice of sustainable street design. The toolkit not only provided a framework for comprehensive thinking, but also delivered 75 design methods in 4 types of spatial elements of street design.** The evaluation framework includes 15 evaluation criteria based on three dimensions of sustainability, which guides designers to discover the problems and propose future development goals from a holistic perspective. The statistics of 50 experts' questionnaires and the findings from street investigation and expert interviews showed the priority level of 15 criteria: "Safety", "Equity" and "Accessibility" are the three most important design objectives; "Business Creation" and "Intensive Land Utilisation" are important regarding economy; and "Green Life Promotion" and "Adaptability" are significant objectives regarding environmental

sustainability. Also, the set of toolkits with 68 design methods is a useful manual for sustainable street design in practices.

3. **This research delivered a set of sustainable evaluation tools for Shanghai streets, and its framework and the construction method could be expanded to other cities and regions. This is a tool to measure the sustainability, not only helping the designer to identify issues and find solutions, but also helping decision-makers to compare different schemes and quantify their selections.** There was always a lack of evaluation tool in street design while sustainability was just an immeasurable concept, so this research filled the gaps. With the established indicator evaluation system for sustainable streets and a quantified composite indicator of Sustainable Street Index (SSI), street sustainability can be measured so that different streets or the renovation effectiveness of one street can be compared, which also helps to popularize the concept of sustainable streets to the general public and promotes broader sustainable development.

10.4 Limitation of the study

The researcher was striving to minimise the uncertainties and range of scope of limitations throughout the research process, but some limitations still lie in the study. The following parts summarise the five limitations of this study:

Firstly, the main limitation lies in the indicator selection for the evaluation system, which has been identified by the Uncertainty Analysis in Chapter 7.6 and the discussion of system optimisation. The analysis report shows that the most uncertainties lied in the stage of indicator selection, and the dimensions of some of these uncertainties were medium. Even to the optimised system, some indicators are not representative enough to the criterion due to the unavailability of those better indicators. Also, there are 32 indicators selected for the evaluation system finally, and most of them are the indicators linked to the completion of design requirements. In the Indicator System, twenty indicators, accounting for 62.5%, are Mode D (indicators linked to the completion of design requirements), nine indicators, accounting for 28.1%, are Mode M (indicators linked to on-site measurements), two indicators, accounting for 6.3%, are Mode C: indicators linked to the calculation of some officially published indexes), and only one indicator, accounting for 3.1%, is Mode N (indicators linked to officially published indexes). The proportion of indicator modes might cause bias of qualitative judgements and measurement errors. Furthermore, it has been identified in Chapter 9.2 that some indicators, like annual traffic accidents and street crimes, are much more directly and representative than the selected indicators, namely C7-1 (Coverage Proportion of Street Camera) and C7-2 (Coverage Safety Equipment), to the evaluation criterion of “Safety”. However, those better indicators are not open to the public and not available by the researcher. The researcher acknowledges this as a limitation of this research, and encourage follow-on studies that could refine the indicator selection based on the evaluation framework.

Secondly, another limitation of this research could be the subjectivity of indicator normalisation of the evaluation system. Concerning the characteristics of selected indicators and evaluation property, the research adopted the Categorical Scale as the normalisation method for the evaluation system. However, Categorical Scale might be criticised as “too subjective,” and the choice of thresholds are “too arbitrarily” (Jacobs, et al., 2004). Most of the selected indicators are linked to the evaluation of its completion of design requirements, and there are no existing benchmarks for normalising these indicators. Therefore, the normalisation rules of these indicators were designed according to relevant policies or documents and the findings of the 1st Field Survey. Though the researcher expanded the scope of relevant literature and increase the number of street samples of 1st Field Survey to 236, there is still inevitable subjectivity in the process of determining the rating system and threshold selection.

Thirdly, the limitation might also lie in the construction of the weighting system for the evaluation framework. Firstly, the study employed the Expert Questionnaire as the technique to calculate the Weighting system for the evaluation framework due to the limitation of time and resources. Chapter 4.4.2.2 pointed out that other techniques, like Delphi Method (DM) and the Analytic Hierarchy Process (AHP), are more structured and robust for dealing with complex decision making, which might deliver more reliable and accurate results. However, many of the invited respondents refused to participate DM or AHP as they are too complex and time-consuming. Secondly, the researcher increased the respondents of Expert Questionnaires to reduce the technical limitations. Finally, a total of 50 experts participated in the questionnaires, but the sample size might still not big enough to eliminate the uncertainties. Thirdly, in theoretical, the weights of the indicator layer should also be figured out according to their reliability, importance, and other principles. However, concerning the potential uncertainties and limited research conditions, the study allocated the equal weights to the indicators representing the same criterion.

Fourthly, the insufficiency of the sample size of data collection may be another limitation of this study. The limited sample size includes 50 expert questionnaires for the weighting system, 50 street questionnaires for the statistical comparison, 3 sample streets to apply the indictor system, and 4 experts for interview. The number and diversity of samples might not be enough in terms of robustness. Above all, three streets that got the highest score among the preliminary evaluation were selected as the sample streets to apply the Indicator System.The reason for not choosing more streets is because of the constraints of the researcher's time and energy. Moreover, due to the limited time and resources, the number of street questionnaires and expert questionnaires is designed to be 50. If the sample size could be expanded, the results might be more accurate and objective. Furthermore, the Expert Interviews are helpful in acquiring valuable insights and suggestions on the system optimisation. So, the researcher conducted the semi-structured interview with four experts respectively. All experts interviewed were authoritative and professional. However, due to the relatively small number, the interview findings may not represent the inclusiveness of perspectives, and the scope and depth of discussions on system improvements might be not comprehensive enough.

10.5 Future work

The aim and objectives of this study have been achieved, and during the research, some areas were found to have the potential for future work. The suggested areas are as follows:

Firstly, further research is essential to enrich and refine the theoretical framework of sustainable streets. This study constructed a preliminary theoretical framework of sustainable streets by developing its definition, design objectives, design toolbox and evaluation structure, but a complete theoretical framework should contain more abundant contents, such as its features, rules, and relations. Therefore, future work could test and review the theoretical outcomes formed in this research and further explore other theoretical advancements on sustainable streets, thereby enriching and refining the theoretical framework of sustainable streets.

Secondly, a fertile area for future study is to apply, test and optimise the Indicator System of Sustainability Evaluation for Shanghai streets. Most of the potential areas on this topic has been identified, to some extents, in the discussion of research limitation. For example, the test and application of the Indicator System can expand the sample size to evaluate more Shanghai streets to obtain more practical experiences and more reliable statistical analysis. Concerning the system optimisation, there are four potential areas for further study based on the established Indicator System: a) Exploration of better indicators; b) Refinement of normalisation methods; c) Construction of a robust weighting system; d) Test and review of the aggregation model; d) Study of various expressions of evaluation results. It is worth noting that those indicators that could not be obtained in this study are listed in Table 7.2, which is worthy of further review and inclusion in the future under certain conditions. In addition, the indicator system may also need to be refined regarding to different types of streets, so that the evaluation results can provide more specific design guides for different types of streets.

Thirdly, further work could also focus on the delivery of sustainable streets in Shanghai. As what has been highlighted in Chapter 5.5 and 9.4, the Shanghai streets are experiencing the sustainability transformation, and a holistic and thorough transformation includes concept transformation, mechanism transformation, methods transformation, and evaluation transformation. Though this research actively promoted the sustainable transformation, especially from the concept and evaluation perspectives, a further study is still necessary to make full use of the opportunities of transformation, to find the key to advancement, and actively respond to the difficulties in the process. The potential topics might include the reform of Shanghai Street Design Standards, four-dimensional innovations of sustainable transformation of Shanghai streets, and the promotion of public engagement in sustainable streets promotion of Shanghai.

Fourthly, in light of the established evaluation framework of sustainable streets, future researches could build the Indicator System of sustainable streets for other cities or countries, which would be of great significance to the practical exploration of sustainable streets. This study provided the evaluation framework of sustainable streets and elaborated on the construction process of the Indicator System in detail. Therefore, it is feasible and meaningful to apply the evaluation framework and study methodologies of this research to explore its application in other practical contexts.

As what was highlighted by the compilation team of “Shanghai Street Design Guide” in 2016, the sustainable development of urban streets needed to be promoted from four dimensions: concept, technology, method, and evaluation respectively. However, this research was just at the beginning at that time. It was a pity that it could not be included in "Shanghai Street Design Guide" to promote the development of street evaluation. However fortunately, the key research outcomes were successfully applied into both “Bengbu Street Design Guide” and “Chinese Street Design Guide” in 2020, including the conetpt, design methods, and evalution framework of sustianble streets. In April 2021, when this paper is about to be submitted, “Bengbu Street Design Guide” has been approved by the government and will be released to the public soon. “Chinese Street Design Guide” has also been published online for soliciting comments. It is hoped that this research can serve as a strong support for sustainable development and promote the development of streets in China and worldwide as well.

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Appendix

Appendix A: Rating Standard and Rating of Sustainable Street Evaluation in 1st Field Study:

Evaluation Criteria	Code	Title	Definition	*Rating Standard*	*Rating methods*
Environmental Sustainability	C1	Adaptability	Adaptation ability to local climate and Climate Change.	*3: All street elements, including the choice of street plant, section layout, and all facilities, show strong adaptability to local climate type and extreme weather events. It can be a demonstration example.* *2: The street elements are designed according to the local climate, and it can adapt to extreme weather events to some extent.* *1: The street is neither able to adapt to extreme weather events nor exacerbating the adverse effects of local climate and Climate Change;* *0: The street cannot adapt to the local climate but exaggerate the effect of extreme weather events.*	*Field observation*
	C2	Mitigation UHI	Contribution to the mitigation of Urban Heat Island effects.	*3: All street elements, including street plants, pavement, section design, shading facilities, show a significant consideration to UHI Mitigation and it can be easily felt the cooling effect when walking on it during summer.* *2: All street elements, including street plants, pavement, section design, shading facilities, are considered to mitigate the effect of Urban Heat Island; but it cannot be felt when walking on it during summer.* *1: The street does not help to mitigate UHI, and there is no apparent difference regarding thermal comfort when walking on it during summer* *0: The street even aggravates the effect of UHI, and it is even hotter when walking on it during the summer.*	*Field observation & intuitive feeling*
	C3	Pollution Reduction	Contribution to reducing pollution of air, noise, lighting, and waste.	*3: All street elements, including street plants, pavement, speed control facilities, garbage bins, and lighting system, help to reduce the pollution of air, noise, lighting, and waste. It is a tranquil and clean street without any lighting pollution during the night.* *2: The street elements help to mitigate the pollution of air, noise, lighting, and waste to some extent, but still some pollution, such as dust, noise, or rubbish, can found in the street.* *1: The street can neither help nor exaggerate the relevant pollutions.* *0: The street is unable to reduce pollution but becomes a significant source of pollution concerning noise, air, lighting, and waste.*	*Field observation*

Evaluation Criteria				Rating Standard	Rating methods
	Code	Title	Definition		
Environmental Sustainability	C4	Ecological Balance	Minimising impact on the environment and support the ecological systems in the built environment.	*3: The street layout and all elements, including permeable pavement, the choice of street plant and rainwater collection facilities, can contribute to ecological balance concerning urban wind corridors, rainfall water permeability as well as urban ecological diversity. So, it is a very natural and ecological street, and the traffic function cannot be felt obviously.* *2: The street layout and all elements can help to form urban wind corridor, rainfall water permeability or urban ecological diversity to some extent, but the traffic function is still dominant.* *1: The street layout and elements neither help to form natural ecological corridors nor destroy the ecological environment.* *0: The street has an apparent adverse effect on the ecological balance concerning rainwater penetration, urban vegetation preservation, and ecological diversity.*	*Field observation*
	C5	Green Life Promotion	Promotion and publicity of green lifestyle.	*3: The street not only fully supports and encourages green lifestyle, such as jogging, walking, cycling and using public transportation, but also actively promotes the significance of environmental protection and sustainable life by advertisement posting and various street campaigns.* *2: The street supports green life, including jogging, walking, cycling, and using public transportation.* *1: The street provides basic choices of transportation: walking, cycling, and public transportation system.* *0: The street does not support green life but even pushes people to drive due to lousy walking and cycling environment and inadequate public transportation service.*	*Field observation*
Social Sustainability	C6	Equality	Providing convenient arrival for all kinds of people to support social equality.	*3: The street provides reliable and convenient blind-pavement and barrier-free facilities. The width of the sidewalk and height difference in intersections are considered the convenience of seniors as well as disabled people. This street can be used comfortably for all kinds of people.* *2: The street provides blind-pavement and barrier-free facilities, but some of them are blocked or out of service. The width of the sidewalk and height difference in the intersection is considered the usage of all kinds of people.* *1: The street provides blind-pavement, and most of them are blocked or unreliable. People with luggage or baby carriage are difficult to use this street.* *0: The street does not consider the usage of seniors and disabled people. People with luggage or baby carriage can even not walk on the sidewalk.*	*Field observation*

Evaluation Criteria				Rating Standard	Rating methods
	Code	Title	Definition		
Social Sustainability	C7	Safety	Providing safe and reliable streets to all users at all times of the day.	*3: All street elements, including street signals, guide signs, safety islands, plants, street cameras, lighting system and section layout, help to guarantee street safety in each part of the street, especially the safety of pedestrian and cyclists. It can be called a very safe and reliable street.* *2: The most street elements help to create a safe street, but there are still some potential safety hazards in the intersection or some parts of the street. In general, it is a safe street.* *1: The street is equipped with the necessary safety facilities, but there are still many safety loopholes. So, it cannot be called a safe street.* *0: There are many apparent safety hazards in the streets. So, it is a very dangerous street.*	*Field observation*
	C8	Accessibility	Providing high accessibility for various ways of arrival.	*3: The street provides various ways of arrival, including walking, cycling, by bus, by railway as well as driving private cars. So, all of the arrival ways are convenient and comfortable.* *2: The street provides all arrival ways, but some of them are not convenient. For example, the bus station is too far away, or there is no car parking nearby.* *1: The street provides 2-3 arrival ways, but still some of them are not convenient or comfortable.* *0: The street is hardly accessible. People can only drive there, but no car parking area is nearby.*	*Field observation*
	C9	Diversity	Encouraging the diversity of street functions and the variety of street activities	*3: The street encourages and meets the demand of various public activities. It often serves as many different functions, such as transportation corridor, social space, commercial space, cultural hub, public space and ecological corridors. So, it can be called a very dynamic and diverse street.* *2: The street can meet the demand of many different social activities, but the place does not encourage them to have more frequently. The street sometimes serves as the different function but not often.* *1: Except for traffic and transportation, the street also serves as other functions and works as a place for optional activities, but the phenomenon is rare.* *0: The street only serves as the transportation space. Except for passing by, no other activity is observed.*	*Field observation*

Evaluation Criteria				Rating Standard	Rating methods
	Code	**Title**	**Definition**		
Social Sustainability	C10	Culture Inheritance	*Being in accord with the historical characteristics and cultural identity, thereby preserving, inheriting, and even shaping local culture.*	*3: All street elements, including the plants, street furniture, pavement, signs, and signals, are well designed and dedicatedly constructed so as to form as a whole to display high aesthetic quality. The streetscape is consistent with the surroundings, and not only inherits but also highlights local culture and historical characteristics.* *2: Most of the street elements look as a whole and show relatively high aesthetic quality. Also, the streetscape can reflect local culture or historical features to some extent.* *1: The streetscape is not designed specially and similar to others, but do not harm local culture and surrounding landscape* *0: The street and its streetscape damage and undermines the local culture or historical characters of the surrounding area.*	*Field observation*
Economic Sustainability	C11	Intensive Land Utilisation	*Intensive land utilisation and promote mixed and sharing usage within the streets.*	*3: The layout and usage of the street space, including the width of travel lanes, cycling lanes sidewalk, and intersection, are very reasonable and efficient. All street furniture and facilities are designed for multifunctional usage. All of the street lands are considered mixed usage, time/space sharing with the aim of intensive utilisation and land saving.* *2: In general, most of layout and usage of the street space is relatively reasonable and efficient. Also, most of the street land and furniture are designed for multifunctional usage or time/space sharing.* *1: Some of the layout and usage of street space is reasonable while the others are not. So, a few of street furniture and facilities are designed for multifunctional usage while more of them are not.* *0: The width of travel lanes, cycling lanes, sidewalk, and the intersection is unreasonable and wasteful. Many of the street space is designed and used for decoration and symbol rather than intensive usage and functional consideration.*	*Field observation*
	C12	Efficiency	*Promoting the efficient mobility for all street users.*	*3: The traffic is in excellent condition. The average traffic density of the street is small, and the car speed is high.* *2: The traffic condition is good. The average density of the street network is relatively small, and the car speed is relatively high. Only a small part of the street is congested or blocked.* *1: the traffic condition is average. The average traffic density of the street network is large, and the car speed is not high. A remarkable proportion of the street is congested or blocked.* *0: the traffic condition is very low or even blocked entirely. The congested part occupies a very high proportion of the street.*	*Field observation*

Evaluation Criteria				Rating Standard	Rating methods
	Code	Title	Definition		
Economic Sustainability	C13	Business Creation	Creating various opportunities for street businesses.	*3: There are various businesses along the whole street, including fixed businesses (stores) and temporary businesses (like street vendors and mobile food station).* *2: There are many businesses, including fixed businesses and temporary businesses, along with the majority of the street.* *1: There are only a few businesses, fixed shops or temporary businesses, along with part of the street.* *0: There is no any business along the street.*	*Field observation*
	C14	Job Creation	Creating various and considerable employment opportunities along the streets.	*3: There are various jobs, such as salesmen, waitress, agent, craftsmen, officers, parking assistants, street vendors, created not only within the street space and the store on the first floor of the sided buildings but also on the upper floors of the buildings along the street* *2: There are many different jobs created within the street space and the store on the first floor of the sided buildings.* *1: There are some jobs created within the street space or the store on the first floor of the sided buildings.* *0: There are no any jobs created along the street*	*Field observation*
	C15	Added Value	Increasing the values and attractions of land, real estate and businesses along the streets.	*3: The street can bring considerable added value to the surrounding areas, including the increase of commercial leases and rent, the price of real estate transaction and market sales, as well as the rental prices of street advertising positions.* *2: The street can bring a certain of added-value to the land, real estate, and business along the street.* *1: The street has neither positive nor negative influences on the value of the land, real estate, and business along the street.* *0: Poor performance of the street even reduces the value of the surrounding buildings, especially the buildings next to the street.*	*Field observation & Agency visit*

Note: the table was designed and made by the author.

Appendix B: Background Information of Questionnaire Respondents

NO.	Age	Gender	Position	Company
1	35	Female	Project Manager	National development and reform commission cities and small towns reform and development centre
2	62	Male	Professor	Tongji University
3	36	Male	Project Director	Shanghai Jingke garden landscape planning and design co. LTD
4	36	Female	Project Director	DEUX Architectural Ltd
5	34	Female	Project Planner	Tongji Urban Planning and Design Institute
6	36	Male	Deputy Director	China Energy Engineering Group Co., Ltd.
7	36	Male	Lecturer	Tongji University
8	35	Male	Project Director	Huaxia happy base industry investment development Limited by Share Ltd
9	35	Female	Director	Green Land Group
10	35	Female	Deputy Director	Shanghai Putuo District Town Planning Bureau
11	36	Female	Chief Planner	China Urban planning and design institute
12	36	Male	Chief Planner	Huazhong design (group) co. LTD
13	35	Female	Project Planner	Tongji Bite Design Co. LTD.
14	40	Female	Chief Planner	Shanghai Urban Planning and Design Institute
15	36	Male	Project Director	China urban planning and design institute
16	35	Female	Director	Shanghai Pudong Huamu Street Office
17	36	Male	Lecturer	Urban and Rural Planning Department of Zhejiang Normal University
18	35	Female	Office Manager	Shanghai Real Estate Group
19	35	Female	Deputy Director	Nanning Urban Planning Bureau
20	35	Female	Deputy Director	Shanghai Pudong Planning and Land Resource Management Bureau
21	38	Female	Director	Hangzhou Dajiang Qianjin Street Office
22	36	Male	Project Director	Tongji Urban Planning and Design Institute
23	40	Male	Project Director	New Space Design Consulting Ltd.
24	36	Female	Project manager	Shenyang Urban planning and Design Institute
25	35	Female	Deputy director	Shanghai Jingan district planning and land administration bureau
26	36	Male	Director	China Urban Construction Research Institute
27	35	Female	Director	Tianjin Municipal Part Committee
28	36	Male	Director	Shanghai South waterfront investment and development Co. LTD.
29	35	Female	Director	Pacific Design Group
30	35	Female	Director	Shanghai Jiading Planning Consulting service centre
31	36	Male	Chief Planner	Tongji Urban planning and design institute
32	37	Male	Project Architect	Tongji Urban planning and Design Institute

NO.	**Age**	**Gender**	**Position**	**Company**
33	37	Male	CEO	Shanghai Yihui agricultural science and Technology Co., Ltd
34	35	Female	Editor	"Urban and Rural Planning" magazine
35	40	Female	Project Architect	Shanghai Huafang Architect Design Ltd.
36	38	Female	Project Planner	Tongji Urban Planning design institute
37	37	Male	Vice President	Shanghai Mai CE Data Technology Co., Ltd
38	35	Female	Lecturer	Changan University
39	35	Female	Project Manager	Shanghai Pudong Planning and Construction Co. LTD.
40	35	Female	Architect Director	Tongji Architectural design institute
41	35	Female	Chief Planner	Rectangular Stone Design
42	35	Female	Partner	Shanghai park real estate development co. LTD
43	35	Female	Lecturer	Shanghai Urban Construction Vocational College
44	35	Female	Ph.D. candidate	Tongji University
45	35	Male	Project Director	East China Architectural Design and Research Institute
46	35	Male	Project manager	SOM
47	35	Female	Chief Planner	AECOM Asia
48	35	Female	Chief Planner	Shanghai Pudong Urban planning and Design Institute
49	35	Male	Director	Shanghai Pudong Planning and Land Resource Management Bureau
50	35	Female	Chief Planner	Shanghai Urban Planning and Design Institute

Appendix C: Invitation Email for Expert Questionnaire

您好，

Dear Sir/Madam,

我的来信是邀请您参加一项“关于可持续评估框架标准重要性”的问卷调查，这是我的博士研究“通往可持续街道：理论框架及其在上海应用”的一部分工作。

I am writing to invite you to participate in the questionnaire survey on “the Importance of the Selected Criterion for Sustainability Evaluation Framework” that is one part of my Ph.D. research of “Towards Sustainable Streets: Theoretical Framework and Its Application in Shanghai, China”.

整个博士课题的目的是研究可持续街道的理论框架以及在上海街道可持续性评估的实践。确定权重体系是构建上海街道可持续评估的指标体系过程中的重要一步。因此，本次专家问卷是用来搜集关于评估框架中的评估指标重要性的专家评价意见。并在问卷结果统计计算的基础上相应地计算出权重体系。

The overall aim of the Ph.D. research is to study the theoretical framework of sustainable streets and its application of sustainability evaluation to Shanghai streets. In order to build the Indicator System of sustainability evaluation for Shanghai streets, the construction of the weighting system is a critical step. Therefore, the expert questionnaire is used to obtain a certain number of experts’ judgments on the importance of fifteen criteria in the evaluation framework. Then based on the statistics of questionnaire results, the weighting system is worked out accordingly.

我希望您能够同意此次调查并帮助我完成这项问卷。问卷的主要内容是询问所列出的 15 个评估标准的重要性，并请您根据您的判断给出相应的评级。整个问卷的完成将不会超过 10 分钟。

I hope that you are able to accept the survey and help me with the questionnaire. You are asked to judge the importance of 15 criterion for the evaluation of sustainable streets in the questionnaire. The questionnaire should not take longer than 10 minutes to complete.

您对于这次项目的参与完全是自愿的，您可以在调查的任何时候退出。您提供的所有信息都将是保密的，并且所有的数据都是匿名的。您的名字将不会以任何方式出现在研究的报告或者分析中。

Your participation in this project is entirely voluntary and you can withdraw from the survey at any time. The information you provide will be treated confidentially and the data will be anonymised. Your name will not be used in the reporting or analysis in any way.

如果您有任何关于本次问卷调查的问题， 请不要有任何犹豫并联系我。我非常乐意回答您的任何疑问。

If you have any questions about the questionnaire survey please do not hesitate to contact me. I am happy to respond to any queries you may have.

万分感谢您的帮助和支持。

Thank you very much in advance for your help.

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Appendix D: Sample of Expert Questionnaire

Dear Sir/Madam,

This questionnaire is to survey your judgments of the importance of the following criterion in the sustainability evaluation system which is one part of my Ph.D. research. Fifteen criteria are listed in the evaluation framework for sustainable streets as the table below. Please assess their importance from your judgment, and tick the box closest to your level of importance.

Sustainability	**Evaluation Criteria**		**Importance**				
	Criteria	**Definition & Explanation**	**Very Important**	**Important**	**Medium**	**Unimportant**	**No Relationship**
Environmental sustainability	**Adaptability**	*Adaptation ability to the effect of Climate Change, such as rainstorm and extreme weather events*					
	Mitigation UHI	*Contribution to mitigation of Urban Heat Island effect*					
	Pollution Reduction	*Contribution to reducing pollution of air, noise, lighting, and waste*					
	Ecological Balance	*Minimising impact to the environment and support a natural ecological balance in urban areas.*					
	Green Life Promotion	*Promotion and publicity of green lifestyle*					
Social Sustainability	**Equality**	*Providing accessibility and convenience for all kinds of people and supporting social equality.*					
	Safety	*Providing a safe and reliable street.*					
	Accessibility	*Providing high accessibility for various ways of arrival*					
	Diversity	*Encouraging a variety of activities and social life*					
	Culture Inheritance	*Coherent to the surroundings and positively displaying local characteristics and cultural identity*					
Economic Sustainability	**Intensive Land Utilisation**	*Intensive land utilisation and promote mix-use within the streets*					
	Efficiency	*Promotion of traffic efficiency and mobility*					
	Business Creation	*Creation of various and vibrant business opportunities along the streets*					
	Job Creation	*Creation of various employment positions along the streets*					
	Added-Value	*Creation of the added value to the surrounding land, real estate, and business.*					

Thank you so much for your time to participate in this questionnaire survey and support my Ph.D. study.

Xuan SHEN

2017.9

您好，

由于博士研究的需要，真诚邀请您能够抽出宝贵的时间完成这项 “关于可持续街道评估体系权重”的问卷。在下面的表格中里，可持续街道的评估框架一共包含有 15 个相关的评价标准。请您根据您的判断，对这 15 个评价标准的重要性进行评估，并在最符合您的判断的重要性一栏中打勾：

可持续性	评价标准		重要性				
	评价要素	定义&解释	很重要	重要	一般	不重要	没关系
	变化适应性	对气候变化所带来的影响的适应性，例如暴雨和极端天气情况等。					
	城市热岛效应缓解性	对缓解城市热岛效应具有贡献					
	减少污染性	对减少包括空气、噪音、光线以及废物等方面的污染具有贡献					
	生态型平衡性	减少对环境的影响，并且促进自然和生态的平衡。					
	绿色生活促进性	在城市街道上帮助促进和宣扬绿色生活					
	公平性	给所有人群提供可达和方便并促进社会公平。					
	安全性	提供安全可靠的城市街道					
	可达性	提供各种到达街道的可能，并最大化其可达性					
	多样性	鼓励城市街道上的各种活动以及社会生活的发生					
	文化传承	城市街道与周围环境相辅相成，积极传承并发扬地方文化					
	土地集约型	集约化利用土地并促进街道用地的复合化利用					
	高效性	促进交通的高效流动性					
	商业创造性	沿路创造多种商业机会					
	就业创造性	沿路创造各种各样的就业机会					
	价值附加性	给沿路的土地、房地产以及商业创造附加值					

再次感谢您对本人博士研究的支持！

沈璇

2017.9

Sample of digital questionnaire in WENJUANXING platform:


可持续街道评估体系权重问卷

您好,
由于博士研究的需要，真诚邀请您能够抽出宝贵的时间完成这项“关于可持续街道评估体系权重”的问卷。

* 在评价可持续的城市街道中，请您从您的角度出发评估以下这些评价要素的重要性，并在重要性一栏中打勾：

不重要 不太重要 一般 重要 很重要

变化适应性：街道对气候变化所来带的影响，例如高温，暴雨等极端天气情况的适应性

城市热岛效应缓解性：城市街道对缓解城市热岛效应具有帮助

减少污染性：城市街道对减少包括空气、噪音、光线以及废物等方面的污染具有贡献

生态型平衡性：城市街道的建设和运营中能最小化对环境的影响，并且有助于形成城市生态走廊

可持续街道评估体系权重问卷

不重要 不太重要 一般 重要 很重要

绿色生活方式的促进性：在城市街道上帮助促进和宣扬绿色生活

公平性：城市街道能给所有人群，包括老人，孕妇，残障人士提供方便性和到达性，从而促进社会公平

安全性：提供安全可靠的城市街道

可达性：提供各种到达可能，最大化城市街道的可达性

不重要 不太重要 一般 重要 很重要

多样性：鼓励城市街道上的各种活动以及社会生活的发生

文化传承：城市街道与周围环境以及建筑风貌相辅相成，积极传承并发扬地方文化

土地集约型：集约化利用土地并促进街道用地的复合化利用

可持续街道评估体系权重问卷

不重要 不太重要 一般 重要 很重要

多样性：鼓励城市街道上的各种活动以及社会生活的发生

文化传承：城市街道与周围环境以及建筑风貌相辅相成，积极传承并发扬地方文化

土地集约型：集约化利用土地并促进街道用地的复合化利用

高效性：促进交通的高效流动性

不重要 不太重要 一般 重要 很重要

商业创造性：沿路创造多种商业机会

就业创造性：沿路创造各种各样的就可机会

价值附加性：提升沿路土地、房地产以及商业的价值

可持续街道评估体系权重问卷

文化传承：城市街道与周围环境以及建筑风貌相辅相成，积极传承并发扬地方文化

土地集约型：集约化利用土地并促进街道用地的复合化利用

高效性：促进交通的高效流动性

不重要 不太重要 一般 重要 很重要

商业创造性：沿路创造多种商业机会

就业创造性：沿路创造各种各样的就可机会

价值附加性：提升沿路土地、房地产以及商业的价值

提交

举报

Appendix E: Sample of Street Questionnaire

Dear Sir/Madam,

I am conducting a Ph.D. research on "Sustainable Urban Streets", and sincerely invite you to participate in this assessment questionnaire. According to your judgment, please rate on the following 15 sustainability evaluation criteria for this street:

Sustainability	Evaluation Criteria		Your Judgment			
	Criteria Title	**Explanation**	**Very Good (3)**	**Good (2)**	**Medium (1)**	**Bad (0)**
Environmental sustainability	Adaptability	*Please judge adaptation ability of this street to the effect of Climate Change, such as the rainstorm, snowstorm, and extreme hot/cold weather.*				
	Mitigation UHI	*Urban Heat Island (UHI) effect means the temperature of the city center is normally higher than suburb areas. So please judge whether this street can contribute the mitigation of UHI.*				
	Pollution Reduction	*Please judge the street's contribution to reducing pollution of air, noise, lighting, and waste.*				
	Ecological Balance	*Please judge whether this street has low impact to the environment and promotes a natural and ecological balance in the urban area.*				
	Green Life Promotion	*Please judge if the street contributes to the promotion and publicity of a green lifestyle*				
Social sustainability	Equality	*Please judge whether the street is accessible and used convenient for all kinds of people and promotes social equality.*				
	Safety	*Please judge if the street is safe and reliable。*				
	Accessibility	*Please judge if the street provides various ways of arrival, and all of them are convenient and reliable.*				
	Diversity	*Please judge if the street welcomes and encourages a variety of activities and social life in it.*				
	Culture Inheritance	*Please judge if the streetscape is coherent to the surroundings and positively display local characteristics and cultural identity.*				
Economic sustainability	Intensive Land Utilisation	*Please judge if the street land is used efficiently and effectively, and each part of the land is utilized functionally and reasonably.*				
	Efficiency	*Please judge the mobility and efficiency of the street traffic efficiency and mobility*				
	Business Creation	*Please judge if the street helps to create various business opportunities along the streets.*				
	Job Creation	*Please judge if the street helps to create various employment positions along the streets*				
	Added-Value	*Please judge if the street helps to create added-value to the surrounding land, real estate, and business*				

Thank you very much for supporting my research, let's join our hands to push the development of sustainable street together!

Xuan SHEN

2017

您好，

我正在进行一项“关于可持续城市街道”的博士研究，真诚邀请您能抽出宝贵的时间完成本街道可持续性的评估问卷。请根据您的判断，对这条街道就以下 15 项“可持续性的评价要素”方面的表现进行打分：

可持续性	评价标准		您的评分			
	标准名称	解释说明	非常好	好	中等	差
环境可持续	气候变化适应性	请判断这条街道对气候变化所带来的影响例如暴雨、暴风或者极冷极热等恶劣天气情况的适应能力。				
	城市热岛缓解性	城市热岛效应是指中心区的温度往往要高于郊区。请判断这条街道在缓解这一效应中是否有积极作用				
	减少污染性	请判断这条街道在减少包括空气、噪音、光和废物等一系列污染中是否有积极的作用。				
	生态平衡性	请判断这条街道减少对环境的影响，并且促进城市中自然和生态的平衡。				
	绿色生活促进性	请判断这条街道是否对促进和宣扬绿色生活有积极的促进作用				
社会可持续	公平性	请判断这条街道是否对所有人群来说是方便可达的，并且促进并推动社会公平。				
	安全性	请判断这条街道是否是安全可靠的。				
	可达性	请判断这条街道是否提供了各种各样的到达方式，并且每一种到达方式都是方便且可靠的。				
	多样性	请判断这条街道是否欢迎并鼓励各种活动和社会生活在此发生。				
	文化传承性	请判断这条街道的景观是否与周围和谐一致，并且积极地展示地方特色和文化特质。				
经济可持续	土地集约型	请判断这条街道的土地是否被有效地使用，也就是说每一块土地都是有功能地合理地被利用起来了。				
	高效性	请判断这条街道是否高效流动				
	商业创造性	请判断这条街道是否给沿路创造了丰富的商业机会。				
	就业创造性	请判断这条街道是否给沿路创造了很多就业岗位。				
	价值附加性	请评价这条街道是否给周围的土地、房产和商业创造了附加值。				

非常感谢您对本人博士研究的支持，让我们共同努力推进城市街道的可持续发展！

沈璇

2017

Appendix F: Prepared Questions for Expert Interview

The four prepared questions that will be talked about in the interview are:

QUESTION ONE: What will you describe a sustainable street from your understanding? And could you list one or more Shanghai street/streets that can be called a sustainable street/street from your point of view?

QUESTION TWO: Regarding the established Indicator System of sustainability evaluation (*Table 1*), some potential improvement points and solutions that are summarised from the implementation and statistical analysis of three Shanghai streets (*Table 2*). What's your opinion about them?

Table 1: Evaluation Framework of Sustainable Streets

Evaluation Framework			
Target Layer	***Sub-Target Layer***	***Criteria Layer***	***Indicator Layer***
Sustainability	Environmental Sustainability	C1: Adaptability	C1-1: Adaptable Capacity to Local Climate
			C1-2 Adaptable Capacity to Extreme Weather Events
		C2: Mitigation UHI	C2-1: Street Green Rate
			C2-2: Air Temp. Difference
		C3: Pollution reduction	C3-1: Average Emission of Noise
			C3-2: Pollution Reduction
		C4: Ecological balance	C4-1: Rainwater management
			C4-2: Ecological Planting
		C5: Green life promotion	C5-1: Green Lifestyle Promotion
			C5-2: Green Travel Support
	Social Sustainability	C6: Equality	C6-1: Tactile pavement for the blind
			C6-2: Barrier-Free Facilities
		C7: Safety	C7-1: Coverage Proportion of Street Cameras
			C7-2: Coverage Safety Equipment
		C8: Accessibility	C8-1: The Variety of Arrival Ways
			C8-2: Clear Sign and Guidance System
		C9: Diversity	C9-1: Diversity of Street Activities
			C9-2: Diversity of Street Functions
		C10: Culture Inheritance	C10-1: Aesthetic Quality of Street Furniture
			C10-2: Style Consistency with Surroundings
	Economic Sustainability	C11: Intensive Land Utilisation	C11-1: Intensiveness of Street Space
			C11-2: Mixed-Use of Street Land
		C12: Efficiency	C12-1: Intelligent Transportation System
			C12-2: Traffic Performance Index
		C13: Business Creation	C13-1: Density of Shops
			C13-2: Types of Temporary Business
		C14: Job Creation	C14-1: Employment Creation
			C14-2: Types of Jobs
		C15: Added-Value	C15-1: Added Value of Commercial Rents
			C15-2: Added-Value of Housing Prices

Table 2: Summary of potential improvements to the Indicator System of sustainability evaluation

NO.	Improvement points	Potential solutions
1	To decrease the limitation of evaluation time of C2-2 (Temp. Difference) to the evaluation time.	To search published data or the better replacement indicator of C2-2.
2	To enhance the sensitivity of C3-1 (Average Emission of Noise) so as to raise the evaluation results	To review the scoring criteria or measurement methods;
3	To reinforce the sensitivity and expressiveness of the indicators that represent C4 (Ecological Balance)	To modify the scoring criteria of C4-1 (Rainwater management) and C4-2 (Ecological Planting), or searching better indicators for C4 (Ecological Balance).
4	To discuss whether the indicators representing C3 (Pollution Reduction) and C4 (Ecological Balance) can be modified so as to increase the corresponding evaluation results;	To revise of the scoring criteria of the indicator or to search the indicator replacements.
5	To discuss whether the indicators representing C10 (Culture Inheritance) and C11 (Intensive Land Utilisation) can be modified to decrease the evaluation results accordingly.	To revise the scoring criteria of the indicator or to search the indicator replacements.

QUESTION THREE: What else within the established evaluation system do you think can be improved?

QUESTION FOUR: What are the potential difficulties to promote the sustainable streets in Shanghai from your point of view?

专家访谈设计问题

Questions for Expert Interview

问题一： 从您的认识来看，您会如何形容一条可持续街道？您能否列出一条或几条上海街道，这些街道您觉得是可以被称之为可持续街道的？

QUESTION ONE: What will you describe a sustainable street from your understanding? And could you list one or more Shanghai street/streets that can be called a sustainable street/streets from your point of view?

问题二： 就已经构建的可持续街道评估的指标体系（表 1），通过对这个指标体系的应用，一些潜在的改进要点和方法已经被总结出来（表 2），请问，您怎么看这个指标评估体系以及所列出的这些改进要点？

QUESTION TWO: Regarding the established indicator system of sustainability evaluation (*Table 1*), some potential improvement points and solutions that are summarized from the implementation and statistical analysis of three Shanghai streets (*Table 2*). What's your opinion about them?

问题三： 在这个已经构建的评估体系中您认为还有什么可以改进优化的地方？

QUESTION THREE: What else within the established evaluation system do you think can be improved?

问题四： 从您的角度出发，您认为在上海促进可持续街道有哪些潜在的困难？

QUESTION FOUR: What are the potential difficulties to promote the sustainable streets in Shanghai from your point of view?

表 1：可持续街道评估框架

Table 1: Evaluation Framework of Sustainable Streets

评估框架 EVALUATION FRAMEWORK			
目标层 *Target Layer*	**子目标层** *Sub-Target Layer*	**标准层** *Criteria Layer*	**指标层** *Indicator Layer*
可持续 SUSTAINABILITY	环境可持续 Environmental Sustainability	C1: 气候变化适应性 Adaptability	C1-1: 当地气候的适应性 Adaptable Capacity to Local Climate
			C1-2 对极端天气事件的适应性 Adaptable Capacity to Extreme Weather Events
		C2: 城市热岛缓解性 Mitigation UHI	C2-1:街道绿化率 Street Green Rate
			C2-2: 空气温度差 Air Temp. Difference
		C3: 减少污染性 Pollution reduction	C3-1: 平均噪音释放 Average Emission of Noise
			C3-2: 污染减少 Pollution Reduction
		C4:生态平衡性 Ecological balance	C4-1: 雨水管理 Rainfall Management
			C4-2: 生态种植 Ecological Planting
		C5:绿色生活促进性 Green life promotion	C5-1: 绿色生活促进性 Green Lifestyle Promotion
			C5-2: 绿色交通促进 Green Travel Support
	社会可持续 Social Sustainability	C6: 公平性 Equality	C6-1: 盲道铺设 Blind Pavement
			C6-2: 无障碍设施 Barrier-Free Facilities
		C7: 安全性 Safety	C7-1: 街道摄像头的覆盖率 Coverage Proportion Of Street Cameras
			C7-2: 安全设施覆盖率 Coverage Safety Equipment
		C8: 可达性 Accessibility	C8-1: 到达方式的多样性 The Variety of Arrival Ways
			C8-2: 导识和指引系统 Clear Sign and Guidance System
		C9: 多样性 Diversity	C9-1: 街道活动的多样性 Diversity of Street Activities
			C9-2: 街道功能的多样性 Diversity of Street Functions
		C10: 文化传承 Culture Inheritance	C10-1: 街道家具的审美品质 Aesthetic Quality of Street Furniture
			C10-2: 与周边风格一致性 Style Consistency with Surroundings
	经济可持续 Economic Sustainability	C11:土地集约 Intensive Land Utilization	C11-1: 街道空间的集约性 Intensiveness of Street Space
			C11-2: 街道土地的混合使用 Mixed-Use of Street Land
		C12: 高效性 Efficiency	C12-1: 智能交通系统 Intelligent Transportation System
			C12-2: 交通拥挤指数 Traffic Performance Index
		C13: 商业创造性 Business Creation	C13-1: 沿街店铺密度 Density of Shops
			C13-2: 沿街临时商业种类 Types of Temporary Business
		C14: 就业创造性 Job Creation	C14-1: 沿街就业创造 Employment Creation
			C14-2: 沿街工作种类 Types of Jobs
		C15: 价值附加性 Added-Value	C15-1: 沿街商业租金的附加值 Added Value of Commercial Rents
			C15-2: 沿街住房价格的附加值 Added-Value of Housing Prices

表 2：可持续街道评估指标体系的改进要点总结

Table 2: Summary of potential improvements to the indicator system of sustainability evaluation

序号 NO.	**改进要点** IMPROVEMENT POINTS	**可能的解决方案** POTENTIAL SOLUTIONS
1	减少获得指标 C2-2（空气温度差）数据的测量局限； To decrease the limitation of evaluation time of C2-2 (Temp. Difference) to the evaluation time.	就 C2-2（温度差）这一指标，查询是否有相关官方公布的数据，或者是否有更好的替代指标。 To search published data or the better replacement indicator of C2-2.
2	提高指标 C3-1（平均噪音释放）的评分敏感性从而适当提高评估结果的得分； To enhance the sensitivity of C3-1 (Average Emission of Noise) so as to raise the evaluation results	检查得分标准和探测方法 To review the scoring criteria or measurement methods;
3	强化代表评估标准 C4（生态平衡性）中两个指标的得分敏感度和代表性； To reinforce the sensitivity and representativeness of the indicators that represent C4 (Ecological Balance)	修改 C4-1（雨水管理）和 C4-2（生态种植）的评分标准，或寻找是否有能代表 C4（生态平衡）的更好的评估指标 To modify the scoring criteria of C4-1 (Rainfall Management) and C4-2 (Ecological Planting), or searching for better indicators for C4 (Ecological Balance).
4	探讨代表评估标准 C3（减少污染性）和 C4（生态平衡性）的评分指标能否适当调整从而提高其评估结果的得分； To discuss whether the indicators representing C3 (Pollution Reduction) and C4 (Ecological Balance) can be modified so as to increase the corresponding evaluation results;	相应调整评估指标的评分标准或者查找可替换的指标 To revise the scoring criteria of the indicator or to search the indicator replacements.
5	探讨代表评估标准 C10（文化传承）和 C11（土地集约使用）的评分指标能否进行适当调整从而降低评估结果的得分。 To discuss whether the indicators representing C10 (Culture Inheritance) and C11 (Intensive Land Utilization) can be modified to decrease the evaluation results accordingly.	相应地调整得分标准或者查找可替换的指标 To revise the scoring criteria of the indicator or to search the indicator replacements.

Appendix G: Invitation Email of Expert Interview

Dear Sir/Madam,

I am writing to invite you to participate in the interview on "the Improvements of the Sustainability Evaluation Framework for Shanghai streets" that is one part of my PhD research of "Towards Sustainable Streets: Theoretical Framework and Its Application in Shanghai, China".

The overall aim of the PhD research is to study the theoretical framework of sustainable streets and its application of sustainability evaluation to Shanghai streets. Therefore, after the establishment and implementation of the sustainability evaluation framework, the interview is to discuss the potential improvements of established Indicator System from academic, practical, and management perspectives, thereby refining the sustainability evaluation framework.

I hope that you can accept the interview invitation. This is a semi-structured interview, and it will last about 30 minutes. The questions that will be talked about in the interview are attached in this email.

Your participation in this project is entirely voluntary, and you can withdraw from the study at any time. The information you provide will be treated confidentially, and the data will be anonymised. The information will be treated in accordance with the General Data Protection Regulation (GDPR) (EU) 2016/679 and the Data Protection Act 2018 (DPA 2018). Your name will not be used in the reporting or analysis in any way. The interview has been approved by the Research Ethics Committee of the Welsh School of Architecture (*EC1808.365*).

If you have any questions about this interview, please do not hesitate to contact me. I am happy to respond to any queries you may have.

Xuan SHEN

Welsh School of Architecture

Cardiff University

Bute Building, King Edward VII Avenue

Cardiff, Wales, CF10 3NB

Tel: 0086-13918064826

Email: ShenX8@cardiff.ac.uk

One Sample of Invitation Email to One Expert:

Xuan Shen

发件人:	Xuan Shen
发送时间:	2018年9月19日星期三 9:54
收件人:	'292931341@qq.com'
主题:	沈璇的博士研究专家访谈邀请函
附件:	访谈问题.pdf

亲爱的葛岩女士:

Dear Ms. GE Yan,

来信邀请您参与 “优化上海街道的可持续评估框架”的访谈，这是本人博士研究“迈向可持续街道：理论框架及其在上海应用”中的一部分工作。

I am writing to invite you to participate in the interview on "the Improvements of the Sustainability Evaluation Framework for Shanghai streets" that is one part of my PhD research of "Towards Sustainable Streets: Theoretical Framework and Its Application in Shanghai, China".

本次博士研究的主要目的是“探索可持续街道的理论框架以及可持续街道评估在上海的应用”。因此，本次访谈的主要是从学术、实践和管理等方面探讨本研究中构建的可持续街道评估的指标体系，从而得出优化意见。

The overall aim of the PhD research is to study the theoretical framework of sustainable streets and its application of sustainability evaluation to Shanghai streets. Therefore, after the establishment and implementation of the sustainability evaluation framework, the interview is to discuss the potential improvements of established indicator system from academic, practical, and management perspectives, thereby refining the sustainability evaluation framework.

我真诚地希望您能接受此次访谈邀请。这将是一个半结构式访谈，一对一的访谈将会占用您约 30 分钟的时间。访谈中会涉及的问题已经随邮件的附件一同发送给您，请您过目。在访谈中，我们将主要就附件中列出的四个问题进行探讨。

I hope that you can accept the interview invitation. This is a semi-structured interview, and it will last about 30 minutes. The questions that will be talked about in the interview are attached in this email. We will mainly discuss on the four listed questions in our interview.

您在本项目中的参与是绝对自愿的，您可以在任何时候选择退出本访谈。在访谈中您提供的所有信息都是受到严格保护的，所有信息都将采用保密和匿名的形式。您的所有个人信息以及访谈内容都将严格遵循《欧盟数据保护条例》【(GDPR) (EU) 2016/679】和 英国的《数据保护法》【DPA 2018】。您的名字和任何您的个人信息将不会被用在论文报告和分析的任何地方。此外，本次访谈的内容和形式已送交威尔士建筑学院学术伦理委员会审批并获得通过（同意书编号：EC1808.365）。

Your participation in this project is entirely voluntary, and you can withdraw from the study at any time. The information you provide will be treated confidentially, and the data will be anonymised. The information will be treated in accordance with the General Data Protection Regulation (GDPR) (EU) 2016/679 and the Data Protection

1

Act 2018 (DPA 2018). Your name will not be used in the reporting or analysis in any way. The interview has been approved by the Research Ethics Committee of the Welsh School of Architecture (*Reference Number: EC1808.365*).

如果您关于此次访谈有任何问题，请不要有任何犹豫直接和我联系。我非常乐意回答您的所有疑问。

If you have any questions about this interview, please do not hesitate to contact me. I am happy to respond to any queries you may have.

沈璇 Xuan SHEN

威尔士建筑学院 Welsh School of Architecture

卡迪夫大学 Cardiff University

Bute Building, King Edward VII Avenue

Cardiff, Wales, CF10 3NB

0086-13918064826

ShenX8@cardiff.ac.uk

CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD

Appendix H: Consent Form of Expert Interview

Consent Form - Confidential data

I understand that my participation in this project will involve an interview about the sustainability evaluation of Shanghai streets which will require approximately 30 minutes of my time.

I understand that participation in this study is entirely voluntary and that I can withdraw from the study at any time without giving a reason.

I understand that I am free to ask any questions at any time. I am free to withdraw or discuss my concerns with Xuan SHEN.

I understand that the information provided by me will be held confidentially, such that only the Principal Investigator (Xuan SHEN) can trace this information back to me individually.

I understand that I can ask for the information I provide to be deleted/destroyed at any time and, in accordance with the General Data Protection Regulation (GDPR) (EU) 2016/679 and the Data Protection Act 2018 (DPA 2018). I can have access to the information at any time.

I, ___________________________________ **[PRINT NAME]** consent to participate in the study conducted by Xuan SHEN, Welsh School of Architecture, Cardiff University with the supervision of Phillip Jones.

Signed:

Date:

同意表 – 数据保护

Consent Form - Confidential data

我明白我参与的项目是一次关于上海可持续街道评估的访谈，这将占用我大约 30 分钟的时间。

我明白我参与到本研究是完全自愿的，我可以在项目的任何时候退出，并且不给出任何理由。

我明白我可以在任何时候提出疑问。我也可以非常自由地退出或者与沈璇讨论我的担忧。

我明白我所提供的所有信息将会被严格保密，只有调查者（沈璇）可以就这些信息单独追述到我。

我明白我可以在任何时候要求对我所提供的信息进行删除和销毁，这些都将严格遵循《欧盟数据保护条例》【(GDPR) (EU) 2016/679】和 英国的《数据保护法》【DPA 2018】中所规定的内容。我也可以在任何时候获取我所提供的所有信息。

我，赵波 同意参与沈璇的这次研究项目（卡迪夫大学威尔士建筑学院的，由 Phillip Jones 为导师的博士研究）。

I understand that my participation in this project will involve an interview about the sustainability evaluation of Shanghai streets which will require approximately 30 minutes of my time.

I understand that participation in this study is entirely voluntary and that I can withdraw from the study at any time without giving a reason.

I understand that I am free to ask any questions at any time. I am free to withdraw or discuss my concerns with Xuan SHEN.

I understand that the information provided by me will be held confidentially, such that only the Principal Investigator (Xuan SHEN) can trace this information back to me individually.

I understand that I can ask for the information I provide to be deleted/destroyed at any time and, in accordance with the General Data Protection Regulation (GDPR) (EU) 2016/679 and the Data Protection Act 2018 (DPA 2018). I can have access to the information at any time.

I, ZHAO Bo consent to participate in the study conducted by Xuan SHEN, Welsh School of Architecture, Cardiff University with the supervision of Phillip Jones.

签名： 赵波.

Signed:

日期： 2018.9.25.

Date:

同意表 － 数据保护

Consent Form - Confidential data

我明白我参与的项目是一次关于上海可持续街道评估的访谈，这将占用我大约 30 分钟的时间。

我明白我参与到本研究是完全自愿的，我可以在项目的任何时候退出，并且不给出任何理由。

我明白我可以在任何时候提出疑问。我也可以非常自由地退出或者与沈璇讨论我的担忧。

我明白我所提供的所有信息将会被严格保密，只有调查者（沈璇）可以就这些信息单独追述到我。

我明白我可以在任何时候要求对我所提供的信息进行删除和销毁，这些都将严格遵循《欧盟数据保护条例》【(GDPR) (EU) 2016/679】和 英国的《数据保护法》【DPA 2018】中所规定的内容。我也可以在任何时候获取我所提供的所有信息。

我，曹曙 同意参与沈璇的这次研究项目（卡迪夫大学威尔士建筑学院的，由 Phillip Jones 为导师的博士研究）。

I understand that my participation in this project will involve an interview about the sustainability evaluation of Shanghai streets which will require approximately 30 minutes of my time.

I understand that participation in this study is entirely voluntary and that I can withdraw from the study at any time without giving a reason.

I understand that I am free to ask any questions at any time. I am free to withdraw or discuss my concerns with Xuan SHEN.

I understand that the information provided by me will be held confidentially, such that only the Principal Investigator (Xuan SHEN) can trace this information back to me individually.

I understand that I can ask for the information I provide to be deleted/destroyed at any time and, in accordance with the General Data Protection Regulation (GDPR) (EU) 2016/679 and the Data Protection Act 2018 (DPA 2018). I can have access to the information at any time.

I, CAO Shu consent to participate in the study conducted by Xuan SHEN, Welsh School of Architecture, Cardiff University with the supervision of Phillip Jones.

签名：

Signed:

日期：

Date: 2018,9,14

CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD

同意表 – 数据保护

Consent Form - Confidential data

我明白我参与的项目是一次关于上海可持续街道评估的访谈，这将占用我大约 30 分钟的时间。

我明白我参与到本研究是完全自愿的，我可以在项目的任何时候退出，并且不给出任何理由。

我明白我可以在任何时候提出疑问。我也可以非常自由地退出或者与沈璇讨论我的担忧。

我明白我所提供的所有信息将会被严格保密，只有调查者（沈璇）可以就这些信息单独追述到我。

我明白我可以在任何时候要求对我所提供的信息进行删除和销毁，这些都将严格遵循《欧盟数据保护条例》【(GDPR) (EU) 2016/679】和 英国的《数据保护法》【DPA 2018】中所规定的内容。我也可以在任何时候获取我所提供的所有信息。

我，金山 同意参与沈璇的这次研究项目（卡迪夫大学威尔士建筑学院的，由 Phillip Jones 为导师的博士研究）。

I understand that my participation in this project will involve an interview about the sustainability evaluation of Shanghai streets which will require approximately 30 minutes of my time.

I understand that participation in this study is entirely voluntary and that I can withdraw from the study at any time without giving a reason.

I understand that I am free to ask any questions at any time. I am free to withdraw or discuss my concerns with Xuan SHEN.

I understand that the information provided by me will be held confidentially, such that only the Principal Investigator (Xuan SHEN) can trace this information back to me individually.

I understand that I can ask for the information I provide to be deleted/destroyed at any time and, in accordance with the General Data Protection Regulation (GDPR) (EU) 2016/679 and the Data Protection Act 2018 (DPA 2018). I can have access to the information at any time.

I, JIN Shan consent to participate in the study conducted by Xuan SHEN, Welsh School of Architecture, Cardiff University with the supervision of Phillip Jones.

签名：

Signed:

日期： 2018.10.11

Date:

CARDIFF UNIVERSITY PRIFYSGOL CAERDYD

同意表 – 数据保护

Consent Form - Confidential data

我明白我参与的项目是一次关于上海可持续街道评估的访谈，这将占用我大约 30 分钟的时间。

我明白我参与到本研究是完全自愿的，我可以在项目的任何时候退出，并且不给出任何理由。

我明白我可以在任何时候提出疑问。我也可以非常自由地退出或者与沈璇讨论我的担忧。

我明白我所提供的所有信息将会被严格保密，只有调查者（沈璇）可以就这些信息单独追述到我。

我明白我可以在任何时候要求对我所提供的信息进行删除和销毁，这些都将严格遵循《欧盟数据保护条例》【(GDPR) (EU) 2016/679】和 英国的《数据保护法》【DPA 2018】中所规定的内容。我也可以在任何时候获取我所提供的所有信息。

我，__葛岩__ 同意参与沈璇的这次研究项目（卡迪夫大学威尔士建筑学院的，由 Phillip Jones 为导师的博士研究）。

I understand that my participation in this project will involve an interview about the sustainability evaluation of Shanghai streets which will require approximately 30 minutes of my time.

I understand that participation in this study is entirely voluntary and that I can withdraw from the study at any time without giving a reason.

I understand that I am free to ask any questions at any time. I am free to withdraw or discuss my concerns with Xuan SHEN.

I understand that the information provided by me will be held confidentially, such that only the Principal Investigator (Xuan SHEN) can trace this information back to me individually.

I understand that I can ask for the information I provide to be deleted/destroyed at any time and, in accordance with the General Data Protection Regulation (GDPR) (EU) 2016/679 and the Data Protection Act 2018 (DPA 2018). I can have access to the information at any time.

I, __GE Yan__ consent to participate in the study conducted by Xuan SHEN, Welsh School of Architecture, Cardiff University with the supervision of Phillip Jones.

签名：葛岩

Signed:

日期：2018. 9. 30

Date:

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

Appendix I: Consent Form of Voluntary Task

同意表 – 数据保护

Consent Form - Confidential data

我明白我参与的是一项关于对 236 条上海街道可持续性的评估工作，这项自愿的评估工作将占用我大概 3 天的时间。

我明白我参与到本研究是完全自愿的，我可以在项目的任何时候退出，并且不给出任何理由。

我明白我可以在任何时候提出疑问。我也可以非常自由地退出或者与沈璇讨论我的担忧。

我明白我所提供的所有信息将会被严格保密，只有调查者（沈璇）可以就这些信息单独追述到我。

我明白我可以在任何时候要求对我所提供的信息进行删除和销毁，这些都将严格遵循《欧盟数据保护令》【95/46/EC】和 英国的《数据保护法》【DPA 1998】中所规定的内容。我也可以在任何时候获取我所提供的所有信息。

我，_申硕璞_ 同意参与沈璇的这次研究项目（卡迪夫大学威尔士建筑学院的，由 Phillip Jones 为导师的博士研究）。

I understand that my participation in this project will involve an interview about the sustainability evaluation of Shanghai streets which will require approximately 30 minutes of my time.

I understand that participation in this study is entirely voluntary and that I can withdraw from the study at any time without giving a reason.

I understand that I am free to ask any questions at any time. I am free to withdraw or discuss my concerns with Xuan SHEN.

I understand that the information provided by me will be held confidentially, such that only the Principal Investigator (Xuan SHEN) can trace this information back to me individually.

I understand that I can ask for the information I provide to be deleted/destroyed at any time and, in accordance with the Data Protection Directive 95/46/EC and the Data Protection Act 1998 (DPA 1998). I can have access to the information at any time.

I, _SHEN Shupu_ consent to participate in the study conducted by Xuan SHEN, Welsh School of Architecture, Cardiff University with the supervision of Phillip Jones.

签名：申硕璞

Signed:

日期：2017.7.25

Date:

CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD

Appendix J: Approval Form from School Research Ethics Committee

EC1808.365

Project One: Expert Interview

WELSH SCHOOL OF ARCHITECTURE
ETHICS APPROVAL FORM FOR STAFF AND PHD/MPHIL PROJECTS WS

Tick one box:	☐ STAFF ×☐ PHD/MPHIL
Title of project:	Expert interview: A semi-structured interview on the improvements of indicator system of sustainability evaluation for Shanghai streets
	Shanghai, China
Name of researcher(s):	Xuan SHEN
Name of principal investigator	Xuan SHEN
Contact e-mail address:	ShenX8@cardiff.ac.uk
Date:	6th July.2018

Participants		YES	NO	N/A
Does the research involve participants from any of the following groups?	• Children (under 16 years of age)		×	
	• People with learning difficulties		×	
	• Patients (NHS approval is required)		×	
	• People in custody		×	
	• People engaged in illegal activities		×	
	• Vulnerable elderly people		×	
	• Any other vulnerable group not listed here		×	
• When working with children: I have read the Interim Guidance for Researchers Working with Children and Young People (http://www.cardiff.ac.uk/archi/ethics_committee.php)				

Consent Procedure	YES	NO	N/A
• Will you describe the research process to participants in advance, so that they are informed about what to expect?	×		
• Will you tell participants that their participation is voluntary?	×		
• Will you tell participants that they may withdraw from the research at any time and for any reason?	×		
• Will you obtain valid consent from participants? (specify how consent will be obtained in Box A)[1]	×		
• Will you give participants the option of omitting questions they do not want to answer?	×		
• If the research is observational, will you ask participants for their consent to being observed?	×		
• If the research involves photography or other audio-visual recording, will you ask participants for their consent to being photographed / recorded and for its use/publication?	×		

Possible Harm to Participants	YES	NO	N/A
• Is there any realistic risk of any participants experiencing either physical or psychological distress or discomfort?		×	
• Is there any realistic risk of any participants experience a detriment to their interests as a result of participation?		×	

Data Protection		YES	NO	N/A
• Will any non-anonymous and/or personalised data be generated or stored?			×	
• If the research involves non-anonymous and/or personalised data, will you:	• gain written consent from the participants	×		
	• allow the participants the option of anonymity for all or part of the information they provide	×		

Health and Safety	YES
Does the research meet the requirements of the University's Health & Safety policies? (http://www.cf.ac.uk/osheu/index.html)	×

Research Governance	YES	NO	N/A

[1] If any non-anonymous and/or personalised data be generated or stored, *written consent* is required.

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Does your study include the use of a drug? You need to contact Research Governance before submission (resgov@cf.ac.uk)		×	
Does the study involve the collection or use of human tissue? You need to contact the Human Tissue Act team before submission (hta@cf.ac.uk)		×	

Prevent Duty	**YES**	
Has due regard be given to the 'Prevent duty', in particular to prevent anyone being drawn into terrorism? https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/445916/Prevent_Duty_Guidance_For_Higher_Education__England__Wales_.pdf http://www.cardiff.ac.uk/publicinformation/policies-and-procedures/freedom-of-speech	×	

If any of the shaded boxes have been ticked, you must explain in Box A how the ethical issues are addressed. If none of the boxes have been ticked, you must still provide the following information. The list of ethical issues on this form is not exhaustive; if you are aware of any other ethical issues you need to make the SREC aware of them.

Box A The Project (provide all the information listed below in a separate attachment)

1. Title of Project
2. Purpose of the project and its academic rationale
3. Brief description of methods and measurements
4. Participants: recruitment methods, number, age, gender, exclusion/inclusion criteria
5. Consent and participation information arrangements - please attached consent forms if they are to be used
6. A clear and concise statement of the ethical considerations raised by the project and how is dealt with them
7. Estimated start date and duration of project

All information must be submitted along with this form to the School Research Ethics Committee for consideration

Researcher's declaration (tick as appropriate)	
• I consider this project to have **negligible ethical implications** (*can only be used if none of the grey areas of the checklist have been ticked*).	×
• I consider this project research to have **some ethical implications**.	
• I consider this project to have **significant ethical implications**	

Signature Researcher or MPhil/PhD student	**Name** Xuan SHEN	**Date**	8th Aug.2018
Signature Lead investigator or supervisor	**Name** Prof. Phillip Jones	**Date**	9th Aug.2018

Advice from the School Research Ethics Committee

STATEMENT OF ETHICAL APPROVAL

This project had been considered using agreed Departmental procedures and is now approved

Signature	**Name** GRANT VAN CASTEREN	3/9/18	**Date**
Chair, School Research Ethics Committee			

Box A – THE PROJECT

1. Title of Project

Expert interview: A semi-structured interview on the improvements of indicator system of sustainability evaluation for Shanghai streets

2. Purpose of the project and its academic rationale

This project is one part of a PhD research of "Towards Sustainable Streets: Theoretical Framework and Its Application in Shanghai, China". The overall research aim is to study the theoretical framework of sustainable streets and its application of sustainability evaluation to Shanghai streets. Therefore, after the establishment and implementation of the sustainability evaluation framework, it is necessary to refine the sustainability evaluation framework.

Due to the limitation of the literature and practices on sustainability evaluation of urban streets, the use of expert interviews is an important method to discuss the system improvements. The interview is often regarded as a widely preferred approach when the researcher need an in-depth understanding of a specific topic (Robson, 2002; Kvale, 1996). Semi-structured interviews are reasonably useful for problem solving and thinking broaden, because semi-structured interviews not only enable the researcher to explore the topics and questions that have been predesigned carefully but also facilitate to uncover the potential issues that had not been considered previously but were raised during the process of open discussion (Gray, 2004; Robson, 2002). Moreover, expert interviews help to obtain more sophisticated information from experts (Grillham, 2000) and to gain professional opinions and insightful suggestions on a specific topic in a very efficient way (Bogner, et al., 2009).

3. Brief description of methods and measurements

The face-to-face and one-to-one are the main forms of the interview survey. Each interview will last about 30 minutes. A list of questions are prepared in advance (See appendix A). Therefore, the four prepared questions will be asked in the interview. Also, some new issues or topics that arise during the interview will also be discussed.

Before the interview, a formal invitation email is sent to the interviewees (See Appendix B). The invitation includes details of the project as well as information about data protection and voluntariness of participation.

4. Participants:

NO.	*Age*	*Gender*	*Position*	*Company*	*Inclusion criteria*
1	62	Male	Professor	Tongji University	- Having conducted many academic pieces of research on urban open space, especially on the public streets; - Having insightful knowledge and rich experiences of sustainable streets from the theoretical perspective.
2	40	Female	Chief Planner	Shanghai Urban Planning and Design Institute	- Being a leading author to write "the Shanghai street design guideline"; - Having engaged in the design and renovation of Shanghai streets for many years.
3	35	Male	Director	Shanghai Pudong Planning and Land Resource Management Bureau	- As a director in the Planning and Land Resource Management Bureau, in charge of the management of public streets; - Having rich experiences in street renovation and improvement from the practical perspective.

5. Consent and participation information arrangements

A consent form is to be used to get a formal agreement to the participation from the respondents by signing the form (See Appendix C).

6. A clear and concise statement of the ethical considerations raised by the project and how is dealt with them

Ethical considerations arise with the personal information of the three selected interviewers. However, personal information, such as name, email address, and cell phone number, will only be used to contact and book time of interview. All these personal information will not be used in the research in any way.

7. Estimated start date and duration of project

I intend to start the interview immediately after the project has been approved by the School Research Ethics Committee.

References:

Bogner, A., Littig, B. & Menz, W., 2009. *Interviewing Experts.* London: Palgrave Macmillan UK.

Gray, D., 2004. *Doing Research in the Real World.* London: SAGE.

Grillham, B., 2000. *Case Study Research Methods.* London: Continuum.

Kvale, S., 1996. *Interviews: an Introduction to Qualitative Research Interviewing.* London: SAGE.

Robson, C., 2002. *Real World Research: A Resource for Social Scientists and Practitioner - Researchers.* 2nd Ed ed. Oxford: Blackwell Publishers Ltd.

Appendix A: Questions for Expert Interview

The four prepared questions that will be talked about in the interview are:

QUESTION ONE: What will you describe a sustainable street from your understanding? And could you list one or more Shanghai street/streets that can be called a sustainable street/streets from your point of view?

QUESTION TWO: Regarding the established indicator system of sustainability evaluation (*Table 1*), some potential improvement points and solutions that are summarized from the implementation and statistical analysis of three Shanghai streets (*Table 2*). What's your opinion about them?

Table 1: Evaluation Framework of Sustainable Streets

Evaluation Framework			
Target Layer	***Sub-Target Layer***	***Criteria Layer***	***Indicator Layer***
Sustainability	Environmental Sustainability	C1: Adaptability	C1-1: Adaptable Capacity to Local Climate
			C1-2 Adaptable Capacity to Extreme Weather Events
		C2: Mitigation UHI	C2-1: Street Green Rate
			C2-2: Air Temp. Difference
		C3: Pollution reduction	C3-1: Average Emission of Noise
			C3-2: Pollution Reduction
		C4: Ecological balance	C4-1: Rainfall Management
			C4-2: Ecological Planting
		C5: Green life promotion	C5-1: Green Lifestyle Promotion
			C5-2: Green Travel Support
	Social Sustainability	C6: Equality	C6-1: Blind Pavement
			C6-2: Barrier-Free Facilities
		C7: Safety	C7-1: Coverage Proportion Of Street Cameras
			C7-2: Coverage Safety Equipment
		C8: Accessibility	C8-1: The Variety of Arrival Ways
			C8-2: Clear Sign and Guidance System
		C9: Diversity	C9-1: Diversity of Street Activities
			C9-2: Diversity of Street Functions
		C10: Culture Inheritance	C10-1: Aesthetic Quality of Street Furniture
			C10-2: Style Consistency with Surroundings
	Economic Sustainability	C11: Intensive Land Utilization	C11-1: Intensiveness of Street Space
			C11-2: Mixed-Use of Street Land
		C12: Efficiency	C12-1: Intelligent Transportation System
			C12-2: Traffic Performance Index
		C13: Business Creation	C13-1: Density of Shops
			C13-2: Types of Temporary Business
		C14: Job Creation	C14-1: Employment Creation
			C14-2: Types of Jobs
		C15: Added-Value	C15-1: Added Value of Commercial Rents
			C15-2: Added-Value of Housing Prices

Table 2: Summary of potential improvements to the indicator system of sustainability evaluation

NO.	Improvement points	Potential solutions
1	To decrease the limitation of evaluation time of C2-2 (Temp. Difference) to the evaluation time.	To search published data or the better replacement indicator of C2-2.
2	To enhance the sensitivity of C3-1 (Average Emission of Noise) so as to raise the evaluation results	To review the scoring criteria or measurement methods;
3	To reinforce the sensitivity and expressiveness of the indicators that represent C4 (Ecological Balance)	To modify the scoring criteria of C4-1 (Rainfall Management) and C4-2 (Ecological Planting), or searching for better indicators for C4(Ecological Balance).
4	To discuss whether the indicators representing C3 (Pollution Reduction) and C4 (Ecological Balance) can be modified so as to increase the corresponding evaluation results;	To revise the scoring criteria of the indicator or to search the indicator replacements.
5	To discuss whether the indicators representing C10 (Culture Inheritance) and C11 (Intensive Land Utilization) can be modified to decrease the evaluation results accordingly.	To revise the scoring criteria of the indicator or to search the indicator replacements.

QUESTION THREE: What else within the established evaluation system do you think can be improved?

QUESTION FOUR: What are the potential difficulties to promote the sustainable streets in Shanghai from your point of view?

Appendix B: Invitation Email for Expert Interview

Dear Sir/Madam,

I am writing to invite you to participate in the interview on "the Improvements of the Sustainability Evaluation Framework for Shanghai streets" that is one part of my PhD research of "Towards Sustainable Streets: Theoretical Framework and Its Application in Shanghai, China".

The overall aim of the PhD research is to study the theoretical framework of sustainable streets and its application of sustainability evaluation to Shanghai streets. Therefore, after the establishment and implementation of the sustainability evaluation framework, the interview is to discuss the potential improvements of established indicator system from academic, practical, and management perspectives, thereby refining the sustainability evaluation framework.

I hope that you can accept the interview invitation. This is a semi-structured interview, and it will last about 30 minutes. The questions that will be talked about in the interview are attached in this email.

Your participation in this project is entirely voluntary, and you can withdraw from the study at any time. The information you provide will be treated confidentially, and the data will be anonymised. The information will be treated in accordance with the General Data Protection Regulation (GDPR) (EU) 2016/679 and the Data Protection Act 2018 (DPA 2018). Your name will not be used in the reporting or analysis in any way. The interview has been approved by the Research Ethics Committee of the Welsh School of Architecture (*Reference Number*).

If you have any questions about this interview, please do not hesitate to contact me. I am happy to respond to any queries you may have.

Xuan SHEN

Welsh School of Architecture

Cardiff University

Bute Building, King Edward VII Avenue

Cardiff, Wales, CF10 3NB

Tel: 0086-13918064826

Email: ShenX8@cardiff.ac.uk

Appendix C: Consent Form for Expert Interview

Consent Form - Confidential data

I understand that my participation in this project will involve an interview about the sustainability evaluation of Shanghai streets which will require approximately 30 minutes of my time.

I understand that participation in this study is entirely voluntary and that I can withdraw from the study at any time without giving a reason.

I understand that I am free to ask any questions at any time. I am free to withdraw or discuss my concerns with Xuan SHEN.

I understand that the information provided by me will be held confidentially, such that only the Principal Investigator (Xuan SHEN) can trace this information back to me individually.

I understand that I can ask for the information I provide to be deleted/destroyed at any time and, in accordance with the General Data Protection Regulation (GDPR) (EU) 2016/679 and the Data Protection Act 2018 (DPA 2018). I can have access to the information at any time.

I, ________________________________ **[PRINT NAME]** consent to participate in the study conducted by Xuan SHEN, Welsh School of Architecture, Cardiff University with the supervision of Phillip Jones.

Signed:

Date:

Project Two: Expert questionnaire

1. Title of Project

Expert questionnaire: A survey of the importance of the selected criterion in the sustainability evaluation framework

2. Purpose of the project and its academic rationale

This project is one part of a PhD research of "Towards Sustainable Streets: Theoretical Framework and Its Application in Shanghai, China". The overall research aim is to study the theoretical framework of sustainable streets and its application of sustainability evaluation to Shanghai streets. In order to build the indicator system of sustainability evaluation for Shanghai streets, the construction of the weighting system is a critical step. So the questionnaire survey is to obtain the experts' judgments of the importance of the selected criterion in the sustainability evaluation system. Then based on the statistics of questionnaire results, the weighting system is calculated accordingly.

The expert questionnaire is selected because of its simple procedure, easy operability, and high adaptability according to the established evaluation structure.

3. Brief description of methods and measurements

Data will be collected using the questionnaire (***See Appendix D***). The questionnaire consists of three parts. 1) A brief introduction to the research purpose; 2) 15 questions. The main body of the questionnaire to ask the respondent to judge the importance of the 15 evaluation criteria. There are five judgment levels of the importance for the respondent to choose, namely very important, important, medium, unimportant, no relationship respectively. 3) The gratitude of the respondents' time and devote.

Before the survey, a formal invitation letter is sent to all selected experts by email. The invitation includes details of the project as well as information about data protection and voluntariness of participation. (***See Appendix E***).

The questionnaires are handed out via a survey online survey platform which is called Wenjuanxing (https://www.wjx.cn/). The questionnaire is inputted into the online database. As soon as the respondent accepts the survey, a survey link will be sent to him/her. So he/she can open the questionnaire link and complete online. As the respondent clicks the button of "Done", the survey result will be uploaded to the online database. All survey results can only be accessed and download via the username and password that are registered by the researcher. Completion of the questionnaire is anticipated to not exceed ten minutes.

4. Participants:

50 authoritative experts and scholars in the field of China are selected as the respondents of the questionnaire survey. All of the selected participants have background knowledge of urban planning and designing and obtain at least the bachelor degree from architecture school. Also, all selected respondents have rich experiences in the planning, management, and research of urban open space.

NO.	Age	Gender	Position	Company
1	35	Female	Project Manager	National development and reform commission cities and small towns reform and development centre
2	62	Male	Professor	Tongji University
3	36	Male	Project Director	Shanghai Jingke garden landscape planning and design co. LTD
4	36	Female	Project Director	DEUX Architectural Ltd
5	34	Female	Project Planner	Tongji Urban Planning and Design Institute
6	36	Male	Deputy Director	China Energy Engineering Group Co., Ltd.
7	36	Male	Lecturer	Tongji University

NO.	Age	Gender	Position	Company
8	35	Male	Project Director	Huaxia happy base industry investment development Limited by Share Ltd
9	35	Female	Director	Green Land Group
10	35	Female	Deputy Director	Shanghai Putuo District Town Planning Bureau
11	36	Female	Chief Planner	China Urban planning and design institute
12	36	Male	Chief Planner	Huazhong design (group) co. LTD
13	35	Female	Project Planner	Tongji Bite Design Co. LTD.
14	40	Female	Chief Planner	Shanghai Urban Planning and Design Institute
15	36	Male	Project Director	China urban planning and design institute
16	35	Female	Director	Shanghai Pudong Huamu Street Office
17	36	Male	Lecturer	Urban and Rural Planning Department of Zhejiang Normal University
18	35	Female	Office Manager	Shanghai Real Estate Group
19	35	Female	Deputy Director	Nanning Urban Planning Bureau
20	35	Female	Deputy Director	Shanghai Pudong Planning and Land Resource Management Bureau
21	38	Female	Director	Hangzhou Dajiang Qianjin Street Office
22	36	Male	Project Director	Tongji Urban Planning and Design Institute
23	40	Male	Project Director	New Space Design Consulting Ltd.
24	36	Female	Project manager	Shenyang Urban planning and Design Institute
25	35	Female	Deputy director	Shanghai Jingan district planning and land administration bureau
26	36	Male	Director	China Urban Construction Research Institute
27	35	Female	Director	Tianjin Municipal Part Committee
28	36	Male	Director	Shanghai South waterfront investment and development Co. LTD.
29	35	Female	Director	Pacific Design Group
30	35	Female	Director	Shanghai Jiading Planning Consulting service centre
31	36	Male	Chief Planner	Tongji Uran planning and design institute
32	37	Male	Project Architect	Tongji Urban planning and Design Institute
33	37	Male	CEO	Shanghai Yihui agricultural science and Technology Co., Ltd
34	35	Female	Editor	"Urban and Rural Planning" magazine
35	40	Female	Project Architect	Shanghai Huafang Architect Design Ltd.
36	38	Female	Project Planner	Tongji Urban Planning design institute
37	37	Male	Vice President	Shanghai Mai CE Data Technology Co., Ltd
38	35	Female	Lecturer	Changan University
39	35	Female	Project Manager	Shanghai Pudong Planning and Construction Co. LTD.
40	35	Female	Architect Director	Tongji Architectural design institute
41	35	Female	Chief Planner	Rectangular Stone Design
42	35	Female	Partner	Shanghai park real estate development co. LTD
43	35	Female	Lecturer	Shanghai Urban Construction Vocational College
44	35	Female	Ph.D.	Tongji University

NO.	Age	Gender	Position	Company
			candidate	
45	35	Male	Project Director	East China Architectural Design and Research Institute
46	35	Male	Project manager	SOM
47	35	Female	Chief Planner	AECOM Asia
48	35	Female	Chief Planner	Shanghai Pudong Urban planning and Design Institute
49	35	Male	Director	Shanghai Pudong Planning and Land Resource Management Bureau
50	35	Female	Chief Planner	Shanghai Urban Planning and Design Institute

5. Consent and participation information arrangements - please attached consent forms if they are to be used

The questionnaire survey does not pose a realistic risk of any participants experiencing either physical or psychological distress or discomfort. The questionnaire only contains items of purely informative character about the evaluation of sustainable streets. Furthermore, the project does not involve any kind of participant deception, manipulation, distraction or misleading information. No sensitive data will be collected that could trigger upset, anxieties or any other adverse emotional reactions. The information sheet provided with the questionnaire explicitly informs the participants about issues of confidentiality that participation is voluntary, and that participants can withdraw from the study at any time.

Besides, the invitation email also includes the information about data protection and voluntariness of participation. As soon as I receive the acceptable response, either by email, phone, or by other means, the online questionnaire link will be sent to them.

Therefore, I perceive the individual's acceptance and completion of the questionnaire, in combination with the information provided as implied consent to participate in the study.

6. A clear and concise statement of the ethical considerations raised by the project and how is dealt with them

Ethical considerations arise with the personal information of the questionnaire respondents. However, personal information, such as name, email address, and cell phone number, will only be used to contact and share the web link of online questionnaires. All these personal information will not be used in the research in any way. Also, the questionnaire answers downloaded from the Wenjuanxing (www.wjx.cn) do not contain any personal information. Also, all the survey results can only be accessed by the researchers via username and passwords.

7. Estimated start date and duration of project

The survey was conducted in September 2017.

Appendix D: Questionnaire Sample

Dear Sir/Madam,

This questionnaire is to survey your judgments of the importance of the following criterion in the sustainability evaluation system which is one part of my PhD research. Fifteen criterion are listed in the evaluation framework for sustainable streets as the table below. Please assess their importance from your judgment, and tick the box closest to your level of importance.

Sustainability	Evaluation Criteria		Importance				
	Criteria	Definition & Explanation	Very Important	Important	Medium	Unimportant	No Relationship
Environmental sustainability	Adaptability	Adaptation ability to the effect of climate change, such as rainstorm and extreme weather events					
	Mitigation UHI	Contribution to mitigation of Urban Heat Island effect					
	Pollution Reduction	Contribution to reducing pollution of air, noise, lighting, and waste					
	Ecological Balance	Minimizing impact to the environment and support a natural ecological balance in urban areas.					
	Green Life Promotion	Promotion and publicity of green lifestyle					
Social Sustainability	Equality	Providing accessibility and convenience for all kinds of people and supporting social equality.					
	Safety	Providing a safe and reliable street.					
	Accessibility	Providing high accessibility for various ways of arrival					
	Diversity	Encouraging a variety of activities and social life					
	Culture Inheritance	Coherent to the surroundings and positively displaying local characteristics and cultural identity					
Economic Sustainability	Intensive Land Utilization	Intensive land utilisation and promote mix-use within the streets					
	Efficiency	Promotion of traffic efficiency and mobility					
	Business Creation	Creation of various and vibrant business opportunities along the streets					
	Job Creation	Creation of various employment positions along the streets					
	Added-Value	Creation of the added value to the surrounding land, real estate, and business.					

Thank you so much for your time to participate in this questionnaire survey and support my PhD study.

Xuan SHEN
2017.9

您好，

由于博士研究的需要，真诚邀请您能够抽出宝贵的时间完成这项 “关于可持续街道评估体系权重”的问卷。在下面的表格中里，可持续街道的评估框架一共包含有 15 个相关的评价标准。请您根据您的判断，对这 15 个评价标准的重要性进行评估，并在最符合您判断的重要性一栏中打勾：

可持续性	评价标准		重要性				
	评价要素	定义&解释	很重要	重要	一般	不重要	没关系
环境可持续	变化适应性	对气候变化所带来的影响的适应性，例如暴雨和极端天气情况等。					
	城市热岛效应缓解性	对缓解城市热岛效应具有贡献					
	减少污染性	对减少包括空气、噪音、光线以及废物等方面的污染具有贡献					
	生态型平衡性	减少对环境的影响，并且促进自然和生态的平衡。					
	绿色生活促进性	在城市街道上帮助促进和宣扬绿色生活					
社会方面	公平性	给所有人群提供可达和方便并促进社会公平。					
	安全性	提供安全可靠的城市街道					
	可达性	提供各种到达街道的可能，并最大化其可达性					
	多样性	鼓励城市街道上的各种活动以及社会生活的发生					
	文化传承	城市街道与周围环境相辅相成，积极传承并发扬地方文化					
经济方面	土地集约型	集约化利用土地并促进街道用地的复合化利用					
	高效性	促进交通的高效流动性					
	商业创造性	沿路创造多种商业机会					
	就业创造性	沿路创造各种各样的就业机会					
	价值附加性	给沿路的土地、房地产以及商业创造附加值					

再次感谢您对本人博士研究的支持！

沈璇
2017.9

Appendix E: Invitation Email for Expert Questionnaire

Dear Sir/Madam,

I am writing to invite you to participate in the questionnaire survey on "the Importance of the Selected Criterion for Sustainability Evaluation Framework" that is one part of my Ph.D. research of "Towards Sustainable Streets: Theoretical Framework and Its Application in Shanghai, China".

The overall aim of the PhD research is to study the theoretical framework of sustainable streets and its application of sustainability evaluation to Shanghai streets. In order to build the indicator system of sustainability evaluation for Shanghai streets, the construction of the weighting system is a critical step. Therefore, the expert questionnaire is used to obtain a certain number of experts' judgments on the importance of fifteen criteria in the evaluation framework. Then based on the statistics of questionnaire results, the weighting system is worked out accordingly.

I hope that you can accept the survey and help me with the questionnaire. You are asked to judge the importance of 15 criterion for the evaluation of sustainable streets in the questionnaire. The questionnaire should not take longer than 10 minutes to complete.

Your participation in this project is entirely voluntary and you can withdraw from the survey at any time. The information you provide will be treated confidentially, and the data will be anonymised. Your name will not be used in the reporting or analysis in any way.

If you have any questions about the questionnaire survey, please do not hesitate to contact me. I am happy to respond to any queries you may have.

Thank you very much in advance for your help.

Xuan SHEN
Welsh School of Architecture
Cardiff University
Tel: 0086-13918064826
Email: ShenX8@cardiff.ac.uk

您好，

我的来信是邀请您参加一项“关于可持续评估框架标准重要性”的问卷调查，这是我的博士研究“通往可持续街道：理论框架及其在上海应用”的一部分工作。

整个博士课题的目的是研究可持续街道的理论框架以及在上海街道可持续性评估的实践。确定权重体系是构建上海街道可持续评估的指标体系过程中的重要一步。因此，本次专家问卷是用来搜集关于评估框架中的评估指标重要性的专家评价意见。并在问卷结果统计计算的基础上相应地计算出权重体系。

我希望您能够同意此次调查并帮助我完成这项问卷。问卷的主要内容是询问所列出的15个评估标准的重要性，并请您根据您的判断给出相应的评级。整个问卷的完成将不会超过10分钟。

您对于这次项目的参与完全是自愿的，您可以在调查的任何时候退出。您提供的所有信息都将是保密的，并且所有的数据都是匿名的。您的名字将不会以任何方式出现在研究的报告或者分析中。

如果您有任何关于本次问卷调查的问题，请不要有任何犹豫并联系我。我非常乐意回答您的任何疑问。

万分感谢您的帮助和支持。

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Project Three: Street Questionnaire

1. Title of Project

Street questionnaire: A survey of the appraisals of street sustainability from street users

2. Purpose of the project and its academic rationale

This project is one part of a PhD research of "Towards Sustainable Streets: Theoretical Framework and Its Application in Shanghai, China". The overall research aim is to study the theoretical framework of sustainable streets and its application of sustainability evaluation to Shanghai streets. The primary objectives of the street questionnaire are to obtain the appraisals of street sustainability from street users to compare with the results of the indicator system of sustainability evaluation, thereby refining the indicator system.

The questionnaire is widely used and is most common survey method in the world to collect the primary data about the users at a particular time and place (Saunders, et al., 2007; De Vaus, 2002). The questionnaire is also considered as a less costly, notably approach concerning large sample size and large extended geographic areas (De Vaus, 2002). Furthermore, it is also regarded as a valid and reliable technique because the data from questionnaires are easily examined and interpreted without middleman bias due to the uniformity of the questions and misinterpretation (Bernard, 2011).

3. Brief description of methods and measurements

Data is collected using the questionnaire (See Appendix G). The questionnaire consists of three parts: 1) A brief introduction to the research purpose. 2) 15 questions. The main body of the questionnaire to ask the respondents to judge the street's performance according to 15 evaluation criteria. Four appraisal levels, namely "Very Good", "Good", "Medium", and "bad", can be chosen for each criterion. 3) The gratitude of the respondents' time and devote.

The questionnaires are handed out by the researcher in the streets. After a brief introduction of the survey purpose and duration orally, the researcher is to ask politely if the respondent agree to participate in the survey. If the respondent agrees with this survey, one piece of questionnaire hardcopy and a pen are given to him/her to answer the questions. Completion of the questionnaire is anticipated to not exceed ten minutes.

4. Participants:

Three Shanghai streets, namely Madang Rd, Daxue Rd, Sujiatun Rd, are selected as the demonstrate cases for further evaluation of their sustainability. 50 respondents are randomly selected in each street. The only selection condition is that the respondent is using the street. The using pattern includes walking, sitting, jogging, dog walking, and other social activities in the street. Therefore, a total of 150 respondents will participate in this questionnaire survey.

5. Consent and participation information arrangements

The questionnaire survey does not pose a realistic risk of any participants experiencing either physical or psychological distress or discomfort. The questionnaire only contains items of purely informative character about the appraisal of sustainable streets. Furthermore, the project does not involve any kind of participant deception, manipulation, distraction or misleading information. No sensitive data will be collected that could trigger upset, anxieties or any other adverse emotional reactions. The information sheet provided with the questionnaire explicitly informs the participants about issues of confidentiality that participation is voluntary, and that participants can withdraw from the study at any time.

Besides, a brief introduction of the survey purpose, duration, data protection, and voluntariness of participation is introduced orally before the survey. The questionnaire is given to the respondent only if they agree to participate in the survey.

Therefore, I perceive the individual's acceptance and completion of the questionnaire, in combination with the information provided as implied consent to participate in the study.

6. A clear and concise statement of the ethical considerations raised by the project and how is dealt with them

No personal information of the questionnaire respondents is contained in the survey. The potential ethical considerations arise with the investigation photo that is took to record the questionnaire survey. However, all the photos do not show the faces of the respondents. Also, all the photos are taken with the consent of the respondents.

7. Estimated start date and duration of project

The dates and duration of the questionnaire survey in three selected streets are shown in the table below:

Location	**Duration**	**Specific Dates**
Madang Rd	2 days	3rd Nov. 2017 (Friday) 5th Nov. 2017 (Sunday)
Daxue Rd	2 days	27th Oct. 2017 (Friday) 28th Oct. 2017 (Saturday)
Sujiatun Rd	2 days	2nd Nov. 2017 (Thursday) 4th Nov. 2017 (Saturday)

Reference:

Bernard , H. R., 2011. *Research methods in anthropology: Qualitative and quantitative approaches.* 5th Edition ed. UK: Altamira Press.

De Vaus, D., 2002. *Survey in Social Research.* 5th Edition ed. London: Routledge.

Saunders, M., Lewis, P. & Thornhill, A., 2007. *Research Methods for Business Students.* London: Pearson.

Appendix G: Questionnaire Sample

Dear Sir/Madam,

I am conducting a PhD research on "Sustainable Urban Streets", and sincerely invite you to participate in this assessment questionnaire. According to your judgment, please rate on the following 15 sustainability evaluation criteria for this street:

Sustainability	Evaluation Criteria		Your Judgment			
	Criteria Title	Explanation	Very Good (3)	Good (2)	Medium (1)	Bad (0)
Environmental sustainability	Adaptability	*Please judge adaptation ability of this street to the effect of climate change, such as the rainstorm, snowstorm, and extreme hot/cold weather.*				
	Mitigation UHI	*Urban Heat Island (UHI) effect means the temperature of the city centre is normally higher than suburb areas. So please judge whether this street can contribute the mitigation of UHI.*				
	Pollution Reduction	*Please judge the street's contribution to reducing pollution of air, noise, lighting, and waste.*				
	Ecological Balance	*Please judge whether this street has low impact to the environment and promotes a natural and ecological balance in the urban area.*				
	Green Life Promotion	*Please judge if the street contributes to the promotion and publicity of a green lifestyle*				
Social sustainability	Equality	*Please judge whether the street is accessible and used convenient for all kinds of people and promotes social equality.*				
	Safety	*Please judge if the street is safe and reliable*				
	Accessibility	*Please judge if the street provides various ways of arrival, and all of them are convenient and reliable.*				
	Diversity	*Please judge if the street welcomes and encourages a variety of activities and social life in it.*				
	Culture Inheritance	*Please judge if the streetscape is coherent to the surroundings and positively display local characteristics and cultural identity.*				
Economic sustainability	Intensive Land Utilization	*Please judge if the street land is used efficiently and effectively, and each part of the land is utilized functionally and reasonably.*				
	Efficiency	*Please judge the mobility and efficiency of the street traffic efficiency and mobility*				
	Business Creation	*Please judge if the street helps to create various business opportunities along the streets.*				
	Job Creation	*Please judge if the street helps to create various employment positions along the streets*				
	Added-Value	*Please judge if the street helps to create added-value to the surrounding land, real estate, and business*				

Thank you very much for supporting my research, let's join our hands to push the development of sustainable street together!

Xuan SHEN
2017

您好，

我正在进行一项“关于可持续城市街道”的博士研究，真诚邀请您能抽出宝贵的时间完成本街道可持续性的评估问卷。请根据您的判断，对这条街道就以下 15 项“可持续性的评价要素”方面的表现进行打分：

可持续性	评价标准		您的评分			
	标准名称	解释说明	非常好	好	中等	差
环境可持续	气候变化适应性	请判断这条街道对气候变化所带来的影响例如暴雨、暴风或者极冷极热等恶劣天气情况的适应能力。				
	城市热岛缓解性	城市热岛效应是指中心区的温度往往要高于郊区。请判断这条街道在缓解这一效应中是否有积极作用				
	减少污染性	请判断这条街道在减少包括空气、噪音、光和废物等一系列污染中是否有积极的作用。				
	生态平衡性	请判断这条街道减少对环境的影响，并且促进城市中自然和生态的平衡。				
	绿色生活促进性	请判断这条街道是否对促进和宣扬绿色生活有积极的促进作用				
社会可持续	公平性	请判断这条街道是否对所有人群来说是方便可达的，并且促进并推动社会公平。				
	安全性	请判断这条街道是否是安全可靠的。				
	可达性	请判断这条街道是否提供了各种各样的到达方式，并且每一种到达方式都是方便且可靠的。				
	多样性	请判断这条街道是否欢迎并鼓励各种活动和社会生活在此发生。				
	文化传承性	请判断这条街道的景观是否与周围和谐一致，并且积极地展示地方特色和文化特质。				
经济可持续	土地集约型	请判断这条街道的土地是否被有效地使用，也就是说每一块土地都是有功能地合理地被利用起来了。				
	高效性	请判断这条街道是否高效流动				
	商业创造性	请判断这条街道是否给沿路创造了丰富的商业机会。				
	就业创造性	请判断这条街道是否给沿路创造了很多就业岗位。				
	价值附加性	请评价这条街道是否给周围的土地、房产和商业创造了附加值。				

非常感谢您对本人博士研究的支持，让我们共同努力推进城市街道的可持续发展！

沈璇
2017

Project Four: A Voluntary Task

1. Title of Project

A Voluntary Task: the Sustainability Assessment of 236 Shanghai Streets

2. Purpose of the project and its academic rationale

This project is one part of a PhD research of "Towards Sustainable Streets: Theoretical Framework and Its Application in Shanghai, China". The overall research aim is to study the theoretical framework of sustainable streets and its application of sustainability evaluation to Shanghai streets. One important part of this research is to assess the sustainability of 236 Shanghai streets based on a designed rating table.

Because the rating system of this stage is primarily a qualitative judgment, the personal influence is an inevitable factor in the judgment process. Therefore, in order to reduce the personal subjectivity and improve the rating mechanism, one volunteer is invited to participate in the rating task. Then, the assessment scores from the volunteer are combined with those from the researcher, thereby calculating the final assessment results.

3. Brief description of methods and measurements

The volunteer is well informed of the research purpose and survey objective, and get familiar with the rating standard (***See Appendix I***). Then the volunteer is asked to watching the streets' photos and comparing the street performance with the rating table, thereby filling the rating table (***See Appendix J***) and assessing 236 Shanghai streets. The street photos are taken by the researcher during the site visit.

Completion of the questionnaire is anticipated to not exceed 3 days.

4. Participants:

The participant in this study is one volunteer who has sufficient background knowledge and rich research experiences to complete the preliminary assessment. The volunteer has a master degree in architecture and a master degree in urban planning. Moreover, he has rich experience in urban researches, especially on public streets. Besides some published paper on urban streets, he also participated in a national research project on the retrofit of Shanghai streets as a leading researcher. The table below shows the detail description of the volunteer's information.

Gender	Age	Position	Company	Education background
Male	37	CEO	Shanghai Yihui Agricultural Science & Technology Co., Ltd	- MSc. Green Building. Wales School of Architecture. Cardiff University - MSc. Urban planning and design, College of Architecture and Urban Planning (CAUP), Tongji University - Bachelor, Urban Planning, CAUP. Tongji University

5. Consent and participation information arrangements

A signed consent form is attached in ***Appendix K***.

6. A clear and concise statement of the ethical considerations raised by the project and how is dealt with them

The ethical considerations arise with the personal information of the volunteer. However, all the personal information will only be used to contact and book working time. All these personal information will not be used in the research in any way.

7. Estimated start date and duration of project

The voluntary task was completed in August. 2017.

Appendix I: Rating Standard of Evaluation for Sustainable Streets

Evaluation Criteria				
	Code	Title	Definition	*Rating Standard*
ENVIRONMENT	C1	Adaptability	Adaptation ability to the effect of climate change, especially extreme weather events	*3: All street elements, including the choice of street plant, section layout, and all facilities, show strong adaptability to local climate type and extreme weather events. It can be a demonstration example.* *2: The street elements are designed according to the local climate, and it can adapt to extreme weather events to some extent.* *1: The street is neither able to adapt to the extreme weather events nor exacerbating the adverse effects of local climate and climate change;* *0: The street cannot adapt to local climate but exaggerate the effect of extreme weather events.*
	C2	Mitigation UHI	Contribution to mitigation of Urban Heat Island effect	*3: All street elements, including street plants, pavement, section design, shading facilities, show a significant consideration to UHI Mitigation and it can be easily felt the cooling effect when walking on it during the summer.* *2: All street elements, including street plants, pavement, section design, shading facilities, are considered to mitigate the effect of Urban Heat Island; but it cannot be felt when walking on it during summer.* *1: The street does not help to mitigate UHI, and there is no apparent difference regarding thermal comfort when walking on it during summer* *0: The street even aggravate the effect of UHI, and it is even hotter when walking on it during summer.*
	C3	Pollution Reduction	Contribution to reducing pollution of air, noise, lighting, and waste	*3: All street elements, including street plants, pavement, speed control facilities, garbage bins, and lighting system, help to reduce the pollution of air, noise, lighting, and waste. It is a tranquil and clean street without any lighting pollution during the night.* *2: The street elements help to mitigate the pollution of air, noise, lighting, and waste to some extent, but still some pollution, such as dust, noise, or rubbish, can found in the street.* *1: The street can neither help nor exaggerate the relevant pollutions.* *0: The street is unable to reduce pollution but becomes a significant source of pollution concerning noise, air, lighting, and waste.*
	C4	Ecological Balance	Minimizing impact to the environment and support a natural ecological corridor	*3: The street layout and all elements, including permeable pavement, the choice of street plant and rainwater collection facilities, can contribute to ecological balance concerning urban wind corridor, rainfall water permeability as well as urban ecological diversity. So it is a very natural and ecological street, and the traffic function cannot be felt obviously.* *2: The street layout and all elements can help to form urban wind corridors, rainfall water permeability or urban ecological diversity to some extent, but the traffic function is still dominant.* *1: The street layout and elements neither help to form a natural ecological corridor nor destroy the ecological environment.*

				0: The street has an apparent adverse effect on ecological balance concerning rainwater penetration, urban vegetation preservation, and ecological diversity.
	C5	Green Life Promotion	Promotion and publicity of green lifestyle	*3: The street not only fully supports and encourages green lifestyle, such as jogging, walking, cycling and using public transportation, but also actively promotes the significance of environmental protection and sustainable life by advertisement posting and various street campaigns.* *2: The street supports green life, including jogging, walking, cycling, and using public transportation.* *1: The street provides basic choices of transportation: walking, cycling, and public transportation system.* *0: The street does not support green life but even pushes people to drive due to lousy walking and cycling environment and inadequate public transportation service.*
SOCIETY	C6	Equality	Providing the street accessibility and convenience for all kinds of people and support social equality	*3: The street provides reliable and convenient blind-pavement and barrier-free facilities. The width of the sidewalk and height difference in intersections are considered the convenience of seniors as well as disabled people. This street can be used comfortably for all kinds of people.* *2: The street provides blind-pavement and barrier-free facilities, but some of them are blocked or out of service. The width of the sidewalk and height difference in the intersection is considered the usage of all kinds of people.* *1: The street provides blind-pavement, and most of them are blocked or unreliable. People with luggage or baby carriage are difficult to use this street.* *0: The street does not consider the usage of seniors and disabled people. People with luggage or baby carriage can even not walk on the sidewalk.*
	C7	Safety	Providing safety and reliability	*3: All street elements, including street signals, guide signs, safety islands, plants, street cameras, lighting system and section layout, help to guarantee street safety in each part of the street, especially the safety of pedestrian and cyclists. It can be called a very safe and reliable street.* *2: The most street elements help to create a safe street, but there are still some potential safety hazards in the intersection or some parts of the street. In general, it is a safe street.* *1: The street is equipped with the necessary safety facilities, but there are still many safety loopholes. So it cannot be called a safe street.* *0: There are many apparent safety hazards in the streets. So it is a very dangerous street.*
	C8	Accessibility	Providing high accessibility for various ways of arrival	*3: The street provides various ways of arrival, including walking, cycling, by bus, by railway as well as driving private cars. So all of the arrival ways are convenient and comfortable.* *2: The street provides all arrival ways, but some of them are not convenient. For example, the bus station is too far away, or there is no car parking nearby.* *1: The street provides 2-3 arrival ways, but still some of them are not convenient or comfortable.* *0: The street is hardly accessible. People can only drive there, but no car parking area is nearby.*
	C9	Diversity	Encouraging a variety of activities and social life	*3: The street encourages and meets the demand of various public activities. It often serves as many different functions, such as transportation corridor, social space, commercial space, cultural hub, public space and ecological corridors. So it can be called a very dynamic and diverse street.* *2: The street can meet the demand of many different social activities, but the place does not*

				encourage them to have more frequently. The street sometimes serves as the different function but not often. 1: Except for traffic and transportation, the street also serves as other functions and works as a place for optional activities, but the phenomenon is rare. 0: The street only serves as transportation space. Except for passing by, no other activity is observed.
	C10	Culture Inheritance	Coherent to the surroundings and displaying local characteristics and cultural identity	3: All street elements, including the plants, street furniture, pavement, signs, and signals, are well designed and dedicatedly constructed so as to form as a whole to display high aesthetic quality. The streetscape is consistent with the surroundings, and not only inherits but also highlights local culture and historical characteristics. 2: Most of the street elements look as a whole and show relatively high aesthetic quality. Also, the streetscape can reflect local culture or historical features to some extent. 1: The streetscape is not designed specially and similar to others, but do not harm local culture and surrounding landscape 0: The street and its streetscape damage and undermines the local culture or historical characters of the surrounding area.
ECONOMY	C11	Intensive Land Utilization	Intensive land utilisation and promote mix-use within the streets	3: The layout and usage of the street space, including the width of travel lanes, cycling lanes sidewalk, and intersection, are very reasonable and efficient. All street furniture and facilities are designed for multifunctional usage. All of the street lands is considered mixed usage, time/space sharing with the aim of intensive utilisation and land saving. 2: In general, most of layout and usage of the street space is relatively reasonable and efficient. Also, most of the street land and furniture are designed for multifunctional usage or time/space sharing. 1: Some of the layout and usage of street space is reasonable while the others are not. So a few of street furniture and facilities are designed for multifunctional usage while more of them are not. 0: The width of travel lanes, cycling lanes, sidewalk, and the intersection is unreasonable and wasteful. Many of the street space is designed and used for decoration and symbol rather than intensive usage and functional consideration.
	C12	Efficiency	Promotion of traffic efficiency and mobility	3: The traffic is in excellent condition. The average traffic density of the street is small, and the car speed is high. 2: The traffic condition is good. The average density of the street network is relatively small, and the car speed is relatively high. Only a small part of the street is congested or blocked. 1: the traffic condition is average. The average traffic density of the street network is large, and the car speed is not high. A remarkable proportion of the street is congested or blocked. 0: the traffic condition is very low or even blocked entirely. The congested part occupies a very high proportion of the street.
	C13	Business Creation	Creation of employment positions along the streets	3: There are various businesses along the whole street, including fixed businesses (stores and shops) and temporary businesses (like street vendors and mobile food station). 2: There are many businesses, including fixed businesses and temporary businesses, along with the majority of the street. 1: There are only a few businesses, fixed shops or temporary businesses, along with part of the street.

			0: There is no any business along the street.
C14	Job Creation	Creation of various business along the streets	*3: There are various jobs, such as salesmen, waitress, agent, craftsmen, officers, parking assistants, street vendors, created not only within the street space and the store on the first floor of the sided buildings but also on the upper floors of the buildings along the street* *2: There are many different jobs created within the street space and the store on the first floor of the sided buildings.* *1: There are some jobs created within the street space or the store on the first floor of the sided buildings.* *0: There are no any jobs created along the street*
C15	Added-Value	Increase of the value of land, real estate and business along the streets	*3: The street can bring considerable added value to the surrounding areas, including the increase of commercial leases and rent, the price of real estate transaction and market sales, as well as the rental prices of street advertising positions.* *2: The street can bring a certain of added value to the land, real estate, and business along the street.* *1: The street has neither positive nor negative influences on the value of the land, real estate, and business along the street.* *0: Poor performance of the street even reduces the value of surrounding buildings, especially the buildings next to the street.*

Appendix J: Rating table of sustainable street evaluation

Street Code & Name:

Evaluation Criteria

	Code	Title	Definition	Rating
Environment	*C1*	Adaptability	*Adaptation ability to the effect of climate change, especially extreme weather events*	
	C2	*Mitigation UHI*	*Contribution to mitigation of Urban Heat Island effect*	
	C3	Pollution Reduction	*Contribution to reducing pollution of air, noise, lighting, and waste*	
	C4	Ecological Balance	*Minimizing impact to the environment and support a natural ecological corridor*	
	C5	Green Life Promotion	*Promotion and publicity of green lifestyle*	
Society	*C6*	Equality	*Providing the street accessibility and convenience for all kinds of people and support social equality*	
	C7	Safety	*Providing safety and reliability*	
	C8	Accessibility	*Providing high accessibility for various ways of arrival*	
	C9	Diversity	*Encouraging a variety of activities and social life*	
	C10	Culture Inheritance	*Coherent to the surroundings and displaying local characteristics and cultural identity*	
Economy	*C11*	Intensive Land Utilization	*Intensive land utilisation and promote mix-use within the streets*	
	C12	Efficiency	*Promotion of traffic efficiency and mobility*	
	C13	Business Creation	*Creation of employment positions along the streets*	
	C14	Job Creation	*Creation of various business along the streets*	
	C15	Added-Value	*Increase of the value of land, real estate and business along the streets*	

Note:

Appendix K: Consent Form

CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD

Consent Form - Confidential Data

I understand that my participation in this project will involve a voluntary task in the sustainability evaluation of 236 Shanghai streets which will require approximately 3 days.

I understand that participation in this study is entirely voluntary and that I can withdraw from the study at any time without giving a reason.

I understand that I am free to ask any questions at any time. I am free to withdraw or discuss my concerns with Xuan SHEN.

I understand that the information provided by me will be held confidentially, such that only the Principal Investigator (Xuan SHEN) can trace this information back to me individually.

I understand that I can ask for the information I provide to be deleted/destroyed at any time and, in accordance with the Data Protection Act, I can have access to the information at any time.

I, Shuopu SHEN, consent to participate in the study conducted by Xuan SHEN, Welsh School of Architecture, Cardiff University with the supervision of Phillip Jones.

Signed: Shuopu Shen

Date: 2017. 7. 25

Appendix K: Evaluation results of M1-4 (Youyizhi Rd)

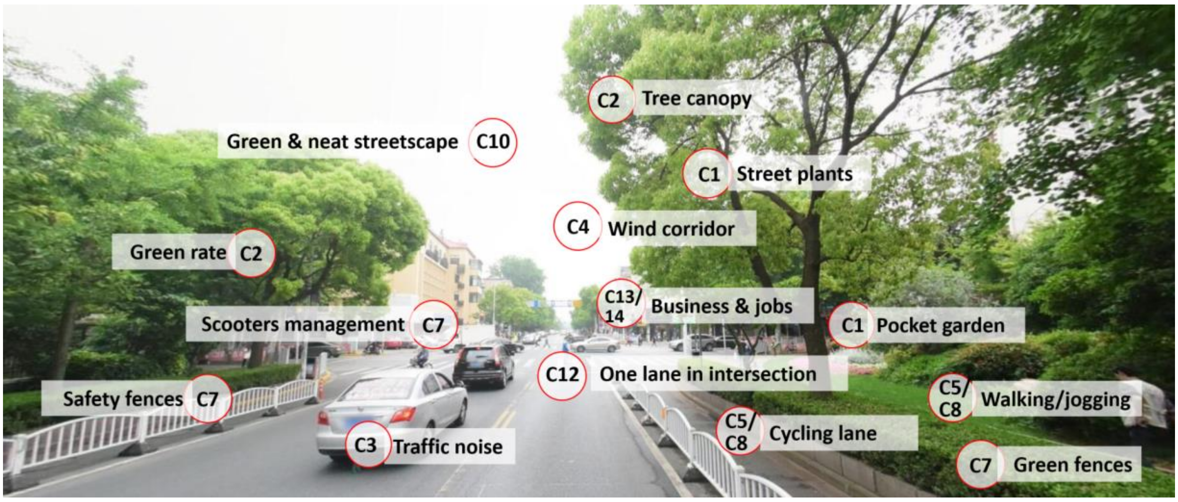

Figure I. 1: Evaluation Illustration on On-Site Photo of M1-4 (Youyizhi Rd)

Table I. 1: Sustainability Rating Results of M1-4 (Youyizhi Rd)

Evaluation Criteria				**Rating Results**	
	Code	***Title***	***Closest Rating Level***	***Score***	***Explanation***
Environment	***C1***	***Adaptability***	*2: The street elements are designed according to local climate, and it can adapt to extreme weather events to some extent.*	**1.8**	The street plants are designed according to local climate, and the pocket gardens can serve as rain garden during the rainstorm.
	C2	***Mitigation UHI***	*3: All street elements, including street plants, pavement, section design, shading facilities, show a great consideration to UHI Mitigation and it can be easily felt the cooling effect when walking on it during summer.*	**3.0**	The high green rate and big tree canopy contribute to the UHI mitigation. It can be easily felt the cooling effect when walking on it during summer site investigation.
	C3	***Pollution Reduction***	*2: The street elements help to mitigate the pollution of air, noise, lighting, and waste to some extent, but still some pollution, such as dust, noise, or rubbish, can found in the street.*	**2.0**	The street plants, speed control facilities, garbage bins and lighting system help to mitigate the pollution of air, noise, lighting, and waste to some extent, but the traffic noise still can be felt due to the pavement of travel lanes.
	C4	***Ecological Balance***	*2: The street layout and all elements can help to form urban wind corridor, rainfall water permeability or urban ecological diversity to some extent, but the traffic function is still dominant.*	**1.8**	The street can serve as a wind corridor, and promote permeability of rainfall water in pocket garden and street plants belt, but the promotional function of ecological diversity is limited.
	C5	***Green Life Promotion***	*3: The street not only fully supports and encourages green lifestyle, such as jogging, walking, cycling and using public transportation, but also actively promotes the significance of environmental*	**2.8**	The street supports green life, such as jogging, walking, cycling and using public transportation, and there is also some advertisement

			protection and sustainable life by advertisement posting and various street campaigns.		posting of green lifestyle in pocket gardens.
Society	***C6***	***Equality***	*2：The street provides blind-pavement and barrier-free facilities, but some of them are blocked or out of service. The width of sidewalk and height difference in the intersection is considered the usage of all kinds of people.*	**1.8**	The street provides blind-pavements, but some of them are blocked by cycling parking.
	C7	***Safety***	*2: The most street elements help to create a safe street, but there is still some potential safety hazard in the intersection or some parts of the street. In general, it is a safe street.*	**2.0**	The different types of fences help to create a safe street, but the scooters management in the intersection is poor which can cause some potential safety hazard.
	C8	***Accessibility***	*2: The street provides all arrival ways, but some of them are not convenient. For example, the bus station is too far away, or there is no car parking nearby.*	**1.8**	The street provides all arrival ways, but the bus station is not convenient and safe enough. There is also no car parking on or along the street.
	C9	***Diversity***	*2: The street can meet the demand of many different social activities, but the place does not encourage them to have more frequently. The street sometimes serves as the different function but not often.*	**1.8**	Many different activities are observed in part of this street, such as jogging, dog walking, meeting friends, shopping.
	C10	***Culture Inheritance***	*2: Most of the street elements look as a whole and show relatively high aesthetic quality. Also, the streetscape can reflect local culture or historical features to some extent.*	**1.8**	In general, the streetscape looks as a whole and show a green and neat feature.
Economics	***C11***	***Intensive Land Utilisation***	*2：In general, most of layout and usage of the street space is relatively reasonable and efficient. And most of the street land and furniture are designed for multifunctional usage or time/space sharing.*	**2.0**	In general, most of layout and usage of the street space is relatively reasonable and efficient.
	C12	***Efficiency***	*2: The traffic condition is good. The average density of the street network is relatively small, and the car speed is relatively high. Only a small part of the street is congested or blocked.*	**1.8**	Generally speaking, the traffic condition is good. However, part of the street is still congested during rush hour, especially near the intersections.
	C13	***Business Creation***	*2: There are various businesses, including fixed businesses and temporary businesses, along most of the street.*	**1.8**	There are some shops in part of the street.
	C14	***Job Creation***	*2: There are many different jobs created within the street space and the store on the first floor of the sided buildings.*	**1.8**	It can create some jobs on the first floor of buildings in part of the street.
	C15	***Added-Value***	*1: The street has neither positive nor negative influences on the value of the land, real estate, and business along the street.*	**1.0**	The added-value of this street to the surrounding land, real estate is limited according to published transaction data. *

**Data Source: Lianjia.com*

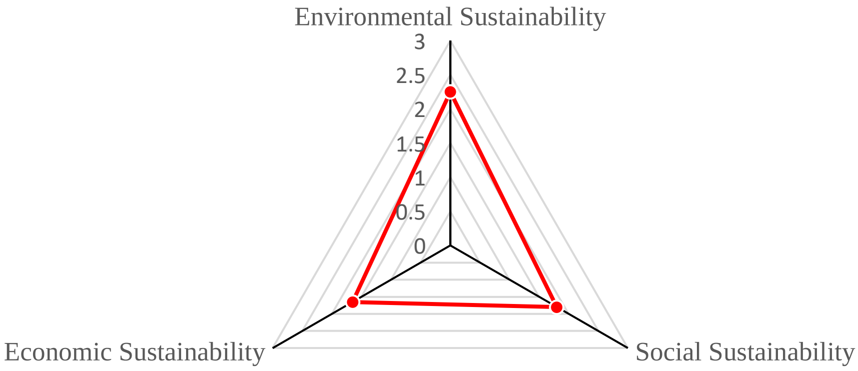

Figure I. 2: Radar Chart of M1-4 (Youyizhi Rd) Sustainability Evaluation

Appendix L: Evaluation results of M2-5 (Baode Rd)

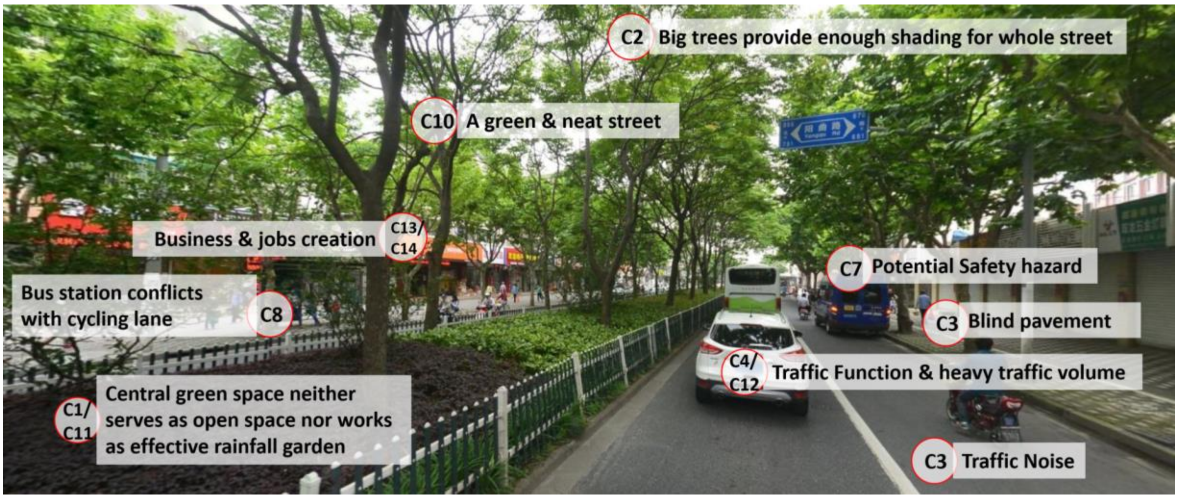

Figure K. 1: Evaluation Illustration on On-Site Photo of M2-5 (Baode Rd)

Table K. 1: Sustainability Rating results of M2-5 (Baode Rd)

Evaluation Criteria				Rating Results	
	Code	*Title*	*Closest Rating Level*	*Score*	*Explanation*
Environment	***C1***	***Adaptability***	*3: All street elements, including the choice of street plant, section layout, and all facilities, show strong adaptability to local climate and extreme weather events. It can be a demonstration example.*	**2.5**	The street plants are designed according to local climate, and the high green rate and central green space help to adapt to the extreme weather event, like the rainstorm. However, it is still no a demonstration example.
	C2	***Mitigation UHI***	*3: All street elements, including street plants, pavement, section design, shading facilities, show a significant consideration to UHI Mitigation and it can be easily felt the cooling effect when walking on it during summer.*	**2.5**	The high green rate and big tree canopy contribute to the UHI mitigation. It can be felt cooling effect when walking on it during summer site investigation.
	C3	***Pollution Reduction***	*2: The street elements help to mitigate the pollution of air, noise, lighting, and waste to some extent, but still some pollution, such as dust, noise, or rubbish, can found in the street.*	**1.8**	The street plants, garbage bins, and lighting system help to mitigate the pollution of air, noise, lighting, and waste to some extent, but the traffic noise is still annoying sometimes due to heavy traffic volume.
	C4	***Ecological Balance***	*2: The street layout and all elements can help to form urban wind corridor, rainfall water permeability or urban ecological diversity to some extent, but the traffic function is still dominant.*	**2.3**	The street can serve as a wind corridor, and promote permeability of rainfall water and ecological diversity to some extent, but the traffic function is still dominant.
	C5	***Green Life Promotion***	*3: The street not only fully supports and encourages*	**2.5**	The street supports green life, such as jogging,

			green lifestyle, such as jogging, walking, cycling and using public transportation, but also actively promotes the significance of environmental protection and sustainable life by advertisement posting and various street campaigns.		walking, cycling and using public transportation, but there is no advertisement posting or street activities for the promotion of the green lifestyle.
Society	***C6***	***Equality***	*3: The street provides reliable and convenient blind-pavement and barrier-free facilities. The width of sidewalk and height difference in intersections are considered the convenience of seniors as well as disabled people. This street can be used comfortably for all kinds of people.*	**2.5**	The street provides blind-pavement on both sides, but a few of them are damaged near intersections.
	C7	***Safety***	*2: The most street elements help to create a safe street, but there is still some potential safety hazard in the intersection or some parts of the street. In general, it is a safe street.*	**1.8**	In general, it is a relatively safe street, but there is still some potential safety hazard between travel lanes and cycling lanes.
	C8	***Accessibility***	*2: The street provides all arrival ways, but some of them are not convenient. For example, the bus station is too far away, or there is no car parking nearby.*	**1.5**	The street provides all arrival ways, but the layout of the bus station is not convenient and safe enough. There is also no car parking on or along the street.
	C9	***Diversity***	*2: The street can meet the demand of many different social activities, but the place does not encourage them to have more frequently. The street sometimes serves as the different function but not often.*	**1.5**	Some optional activities are observed in part of this street, such as jogging, dog walking, meeting friends, shopping.
	C10	***Culture Inheritance***	*2: Most of the street elements look as a whole and show relatively high aesthetic quality. Also, the streetscape can reflect local culture or historical features to some extent.*	**1.8**	In general, the streetscape looks as a whole and show a green and neat feature.
Economics	***C11***	***Intensive Land Utilisation***	*2：In general, most of layout and usage of the street space is relatively reasonable and efficient. Also, most of the street land and furniture are designed for multifunctional usage or time/space sharing.*	**1.5**	In general, most of layout and usage of the street space is relatively reasonable and efficient. However, the central green space neither serves as open space nor works as effective rain garden.
	C12	***Efficiency***	*2: The traffic condition is good. The average density of the street network is relatively small, and the car speed is relatively high. Only a small part of the street is congested or blocked.*	**1.8**	Generally speaking, the traffic condition is not bad. However, usually, the car speed in this street is relatively slow.
	C13	***Business Creation***	*2: There are various businesses, including fixed businesses and temporary businesses, along most of the street.*	**1.8**	There are some shops in part of the street.
	C14	***Job Creation***	*2: There are many different jobs created within the street space and the store on the first floor of the sided buildings.*	**1.8**	It can create some jobs on the first floor of buildings in part of the street.
	C15	***Added-Value***	*2: The street can bring a certain of added-value to the land, real*	**1.8**	The added-value of this street to the surrounding land, real estate is limited

	estate and business along the street.	according to published transaction data. *

**Data Source: Lianjia.Com*

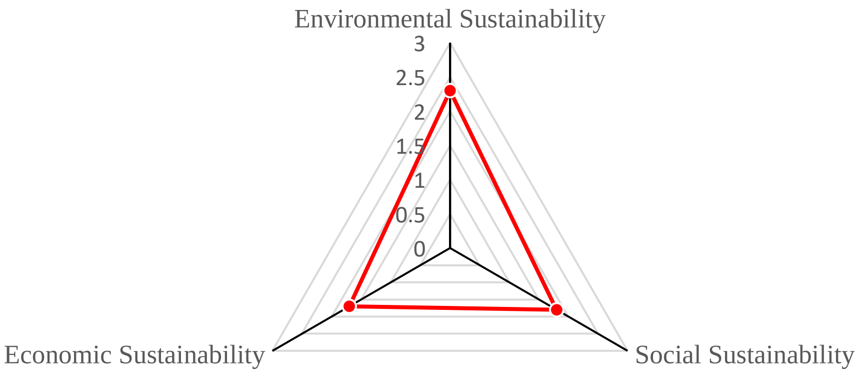

Figure K. 2: Radar Chart of M2-5 (Baode Rd) Sustainability Evaluation

Appendix M: Evaluation results of M3-1 (Daxue Rd)

Figure M. 1: Evaluation Illustration on On-Site Photo of M3-1 (Daxue Rd)

Table M. 1: Sustainability Rating results of M3-1 (Daxue Rd)

Evaluation Criteria				**Rating Results**	
	Code	***Title***	***Closest Rating Level***	***Score***	***Explanation***
Environment	***C1***	***Adaptability***	*2: The street elements are designed according to local climate, and it can adapt to extreme weather events to some extent.*	**1.8**	The street plants are designed according to local climate, but it does not show strong adaptability to extreme weather events.
	C2	***Mitigation UHI***	*2: All street elements, including street plants, pavement, section design, shading facilities, are considered to mitigate the effect of Urban Heat Island; but it cannot be felt when walking on it during summer.*	**2.0**	The layout of street plants and shading is considered UHI mitigation, but the effect is not apparent during summer site investigation.
	C3	***Pollution Reduction***	*2: The street elements help to mitigate the pollution of air, noise, lighting, and waste to some extent, but still some pollution, such as dust, noise, or rubbish, can found in the street.*	**2.0**	The street plants, garbage bins, and lighting system help to mitigate the pollution of air, noise, lighting, and waste to some extent, but there is still rubbish on the ground.
	C4	***Ecological Balance***	*2: The street layout and all elements can help to form urban wind corridor, rainfall water permeability or urban ecological diversity to some extent, but the traffic function is still dominant.*	**1.8**	The street can serve as a wind corridor and promote permeability to some extent, but the traffic function is still dominant.

	C5	***Green Life Promotion***	*3: The street not only fully supports and encourages green lifestyle, such as jogging, walking, cycling and using public transportation, but also actively promotes the significance of environmental protection and sustainable life by advertisement posting and various street campaigns.*	**2.8**	The street supports green life, such as jogging, walking, cycling and using public transportation, and there are often advertisement posting or street activities to promote the green lifestyle, such as organic food and daily gym.
Society	*C6*	***Equality***	*2: The street provides blind-pavement and barrier-free facilities, but some of them are blocked or out of service. The width of sidewalk and height difference in the intersection is considered the usage of all kinds of people.*	**1.8**	The street provides blind-pavement on both sides, but some of them are damaged or blocked, especially those near intersections.
	C7	***Safety***	*3: All street elements, including street signals, guide signs, safety islands, plants, street cameras, lighting system and section layout, help to guarantee street safety in each part of the street, especially the safety of pedestrian and cyclists. It can be called a very safe and reliable street.*	**2.8**	There are various ways to guarantee street safety, including guide signs, speed control of 30km/h, and street cameras. So, it can be called a safe street.
	C8	***Accessibility***	*2: The street provides all arrival ways, but some of them are not convenient. For example, the bus station is too far away, or there is no car parking nearby.*	**1.8**	The street provides many arrival ways, like walking, cycling, and driving. Also, it is linked with railway station by an underground path. However, there is no public bus within 500 meters.
	C9	***Diversity***	*3: The street encourages and meets the demand of various public activities. It often serves as many different functions, such as transportation corridor, social space, commercial space, cultural hub, public space and ecological corridors. So, it can be called a very dynamic and diverse street.*	**2.8**	The street does encourage various activities, such as meeting friends, shopping, café, photographing, and serve as many different functions, including a cultural hub, social space, and a commercial place.
	C10	***Culture Inheritance***	*3: All street elements, including the plants, street furniture, pavement, signs, and signals, are well designed and dedicatedly constructed so as to form as a whole to display high aesthetic quality. The streetscape is consistent with the surroundings, and not only inherits but also highlights local culture and historical characteristics.*	**2.8**	All street elements and the façade of sided buildings are designed as a whole and show aesthetic quality, which highlights the local culture of youth, diversity, and innovation.

Economics	*C11*	***Intensive Land Utilisation***	*3： The layout and usage of the street space, including the width of travel lanes, cycling lanes sidewalk, and intersection, are very reasonable and efficient. All street furniture and facilities are designed for multifunctional usage. All of the street lands are considered mixed usage, time/space sharing with an aim of intensive utilisation and land saving.*	**2.8**	The layout and usage of the street space are pretty intensive. The sided shops are sharing sidewalks during weekends for pavement café and product display without influencing pedestrians. Many facilities, like cycling parking, flower beds, and street seats, are sharing space and considered multifunctional usage.
	C12	***Efficiency***	*2: The traffic condition is good. The average density of the street network is relatively small, and the car speed is relatively high. Only a small part of the street is congested or blocked.*	**2.0**	The traffic condition is good, and the car speed is at the control speed of 30 km/h. Only some parts near intersections are slightly congested due to car parking.
	C13	***Business Creation***	*3: There are various businesses along the whole street, including fixed business (stores and shops) and temporary business (like street vendors and mobile food station).*	**3.0**	There are various businesses along the whole street, including fixed business and temporary business.
	C14	***Job Creation***	*3: There are various jobs, such as salesmen, waitress, agent, craftsmen, officers, parking assistants, street vendors, are created not only within the street space and the store on the first floor of the sided buildings but also on the upper floors of the buildings along the street*	**2.8**	There are various jobs created not only within the street space and the store on the first floor of the sided buildings but also on the upper floors of the buildings along the street.
	C15	***Added-Value***	*3: The street can bring considerable added-value to the surrounding areas, including the increase of commercial leases and rent, the price of real estate transaction and market sales, as well as the rental prices of street advertising positions.*	**3.0**	The street can bring considerable added-value to the surrounding areas. The price of commercial leases and real estate is obviously higher along the street according to published transaction data. *

**Data Source: Lianjia.Com*

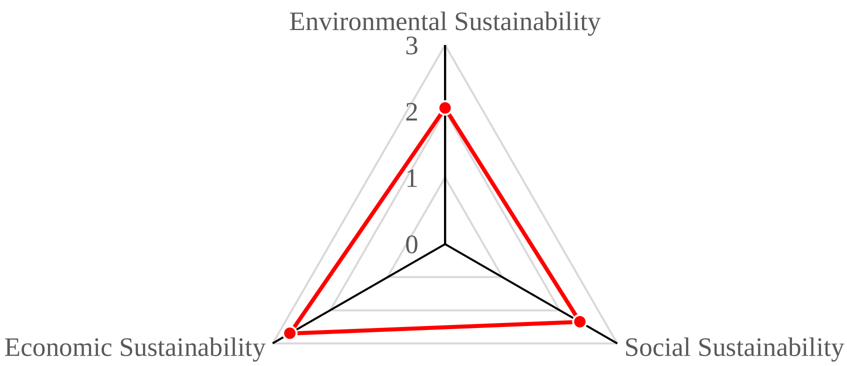

Figure M. 2: Radar Chart of M3-1 (Daxue Rd) Sustainability Evaluation

Appendix N: Evaluation results of M4-10 (Sujiatun Rd)

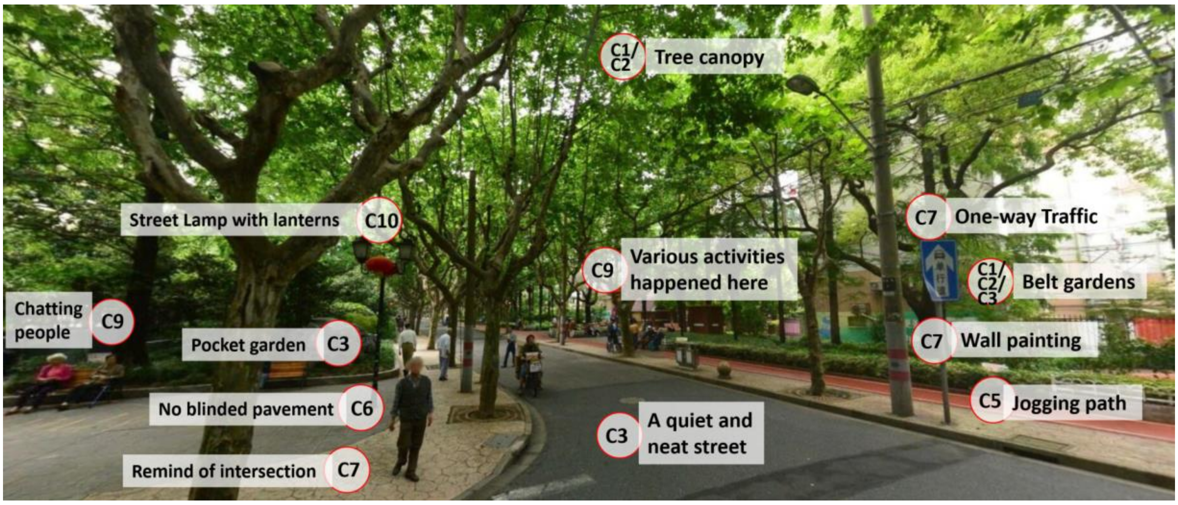

Figure O. 1: Evaluation Illustration on On-Site Photo of M4-10 (Sujiatun Rd)

Table O. 1: Sustainability Rating results of M4-10 (Sujiatun Rd)

Evaluation Criteria				**Rating Results**	
	Code	***Title***	***Closest Rating Level***	***Score***	***Explanation***
Environment	***C1***	***Adaptability***	*3: All street elements, including the choice of street plant, section layout, and all facilities, show strong adaptability to local climate and extreme weather events. It can be a demonstration example.*	**2.8**	High green rate, penetrated pavement, and various gardens all show strong adaptability to both Shanghai climate and extreme weather events.
	C2	***Mitigation UHI***	*3: All street elements, including street plants, pavement, section design, shading facilities, show a significant consideration to UHI Mitigation and it can be easily felt the cooling effect when walking on it during summer.*	**2.8**	Very high green rate and pleasant tree canopy do help to mitigate the effect of UHI, and the cooling effect is evident in summer site investigation.
	C3	***Pollution Reduction***	*3: All street elements, including street plants, pavement, speed control facilities, garbage bins, and lighting system, help to reduce the pollution of air, noise, lighting, and waste. It is a tranquil and clean street without any lighting pollution during the night.*	**2.8**	The street plants, belt gardens, garbage bins, and lighting system help to mitigate the pollution of air, noise, lighting, and waste to some extent, so it can be called as s a peaceful and clean street.
	C4	***Ecological Balance***	*3: The street layout and all elements, including permeable pavement, the*	**2.8**	The street layout and all elements contribute to ecological balance. The

			choice of street plant and rainwater collection facilities, can contribute to ecological balance concerning urban wind corridor, rainfall water permeability as well as urban ecological diversity. So, it is a very natural and ecological street, and the traffic function cannot be felt obviously.		street is so natural that its traffic function cannot be felt obviously.
	C5	***Green Life Promotion***	*3: The street not only fully supports and encourages green lifestyle, such as jogging, walking, cycling and using public transportation, but also actively promotes the significance of environmental protection and sustainable life by advertisement posting and various street campaigns.*	**2.8**	The street supports green life, such as jogging, walking, and cycling. There is a jogging path along the street. Also, there are often advertisement posting or street activities to promote the green lifestyle, such as daily exercise and healthy knowledge.
Society	***C6***	***Equality***	*2: The street provides blind-pavement and barrier-free facilities, but some of them are blocked or out of service. The width of sidewalk and height difference in the intersection is considered the usage of all kinds of people.*	**2.0**	The street does not provide blind-pavement, but it considers the convenient usage of seniors and disabled people.
	C7	***Safety***	*3: All street elements, including street signals, guide signs, safety islands, plants, street cameras, lighting system and section layout, help to guarantee street safety in each part of the street, especially the safety of pedestrian and cyclists. It can be called a very safe and reliable street.*	**2.8**	There are various ways to guarantee street safety, including guide signs, ground marks, one-way traffic control, and street cameras. So, it can be called a safe street.
	C8	***Accessibility***	*2: The street provides all arrival ways, but some of them are not convenient. For example, the bus station is too far away, or there is no car parking nearby.*	**2.0**	The street provides all basic arrival ways, like walking, cycling, and driving. However, there is no public bus within 500 meters.
	C9	***Diversity***	*3: The street encourages and meets the demand of various public activities. It often serves as many different functions, such as transportation corridor, social space, commercial space, cultural hub, public space and ecological corridors. So, it can be called as a very dynamic and diverse street.*	**2.8**	The street encourages and meets the demand of various public activities all the time, like jogging, meeting with friends, physical exercises, kids playing, chess playing. The street is an important social place for local people.
	C10	***Culture Inheritance***	*3: All street elements, including the plants, street furniture, pavement, signs, and signals, are well designed and dedicatedly constructed so as to form as a whole to display high aesthetic quality. The streetscape is consistent with the surroundings, and not only inherits but also highlights local culture and historical characteristics.*	**2.8**	All street elements are designed as a whole, and all street furniture, like sculptures, seats, lamps, wall painting and bins, show high aesthetic quality. All of these reflect and highlight the local culture of a mature community.

Economics	***C11***	***Intensive Land Utilisation***	*3：The layout and usage of the street space, including the width of travel lanes, cycling lanes sidewalk, and intersection, are very reasonable and efficient. All street furniture and facilities are designed for multifunctional usage. All of the street lands are considered mixed usage, time/space sharing with the aim of intensive utilisation and land saving.*	**2.8**	The layout and usage of the street space are intensive. It is a one-way sharing street, and more street space is used for green space and open plaza. One jogging path covered in red plastic runway is added on the side of footway for multifunctional usage. Also, many seats are added along the street.
	C12	***Efficiency***	*3: The traffic is in excellent condition. The average traffic density of the street is small, and the car speed is high.*	**2.8**	The traffic condition is good, and the average traffic density of the street is small.
	C13	***Business Creation***	*1: There are only a few businesses, fixed shops or temporary businesses, along with part of the street.*	**1.0**	There are only a few restaurants at the beginning of this street where is opposite to a market
	C14	***Job Creation***	*1: There are some jobs created within the street space or the store on the first floor of the sided buildings.*	**1.0**	There are only a few jobs created along the street.
	C15	***Added-Value***	*2: The street can bring a certain of added-value to the land, real estate and business along the street.*	**1.8**	The street can bring a certain of added-value to the surrounding areas. The price of real estate along the street is a bit higher because of its pleasant environment according to published transaction data. *

**Data Source: Lianjia.com*

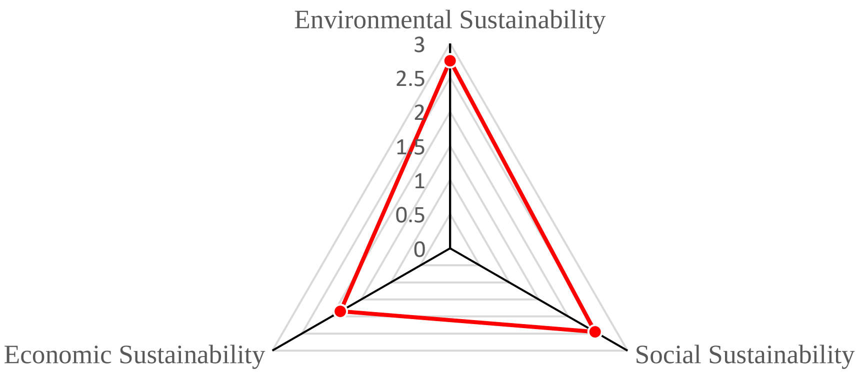

Figure O. 2: Radar Chart of M4-10 (Sujiatun Rd) Sustainability Evaluation

Appendix O: Evaluation results of M5-4 (Meilinbei Rd)

Figure Q. 1: Evaluation Illustration on On-Site Photo of M5-4 (Meilinbei Rd)

Table Q. 1: Sustainability Rating results of M5-4 (Meilinbei Rd)

Evaluation Criteria				Rating Results	
	Code	***Title***	***Closest Rating Level***	***Score***	***Explanation***
Environment	***C1***	***Adaptability***	*2: The street elements are designed according to local climate, and it can adapt to extreme weather events to some extent.*	**1.8**	The street elements, like trees, pavements, are designed to local climate, and it can somehow adapt to rainstorms and windstorms.
	C2	***Mitigation UHI***	*2: All street elements, including street plants, pavement, section design, shading facilities, are considered to mitigate the effect of Urban Heat Island; but it cannot be felt when walking on it during summer.*	**2.3**	The street trees can create a pleasant canopy in summer, and its shading can cover the majority of the street. So, the UHI mitigation effect is noticeable.
	C3	***Pollution Reduction***	*2: The street elements help to mitigate the pollution of air, noise, lighting, and waste to some extent, but still some pollution, such as dust, noise, or rubbish, can found in the street.*	**1.8**	The street plants, garbage bins, and lighting system help to mitigate the pollution of air, noise, lighting, and waste to some extent, but the traffic noise and vehicle emission are still annoying due to poor management.
	C4	***Ecological Balance***	*2: The street layout and all elements can help to form urban wind corridor, rainfall water permeability or urban ecological diversity to some extent, but the traffic function is still dominant.*	**1.5**	The street layout and all elements can help to form an urban wind corridor. But the effect of ecological balance is limited.
	C5	***Green Life Promotion***	*1: The street provides basic choices of transportation: walking, cycling, and public transportation system.*	**0.8**	The street provides basic choices of transportation. However, part of cycling lanes and footway are occupied by car parking.
Soci	***C6***	***Equality***	*1: The street provides blind-pavement, and most of them are blocked or unreliable.*	**1.0**	The street provides blind-pavement, but most of them are blocked or damaged by

			People with luggage or baby carriage are difficult to use this street.		cars. People with luggage or baby carriage are difficult to use this street.
	C7	***Safety***	*2: The most street elements help to create a safe street, but there is still some potential safety hazard in the intersection or some parts of the street. In general, it is a safe street.*	**1.8**	The most street elements help to create a safe street, but the phenomenon of parked cars in sidewalk causes the significant safety hazard.
	C8	***Accessibility***	*2: The street provides all arrival ways, but some of them are not convenient. For example, the bus station is too far away, or there is no car parking nearby.*	**1.8**	The street provides all basic arrival ways, like walking, cycling, and driving. But the lack of continuous safe cycling lane is a big issue
	C9	***Diversity***	*2: The street can meet the demand of many different social activities, but the place does not encourage them to have more frequently. The street sometimes serves as the different function but not often.*	**1.5**	The street can meet the demand for many different social activities. The sidewalks are initially wide but are often occupied by cars, which mainly influence social activities in the street.
	C10	***Culture Inheritance***	*2: Most of the street elements look as a whole and show relatively high aesthetic quality. Also, the streetscape can reflect local culture or historical features to some extent.*	**1.8**	In general, the streetscape is neat and green building façade, and street furniture can reflect the local feature of the mature community. However, too many cars on sidewalks are the biggest problem.
Economics	***C11***	***Intensive Land Utilisation***	*2: In general, most of layout and usage of the street space is relatively reasonable and efficient. Also, most of the street land and furniture are designed for multifunctional usage or time/space sharing.*	**2.0**	The layout and usage of the street space are intensive. The cycling lanes are sharing with car parking.
	C12	***Efficiency***	*2: The traffic condition is good. The average density of the street network is relatively small and the car speed is relatively high. Only a small part of the street is congested or blocked.*	**1.8**	The traffic condition is good. Only a small part of the street near intersections is congested in rush hour.
	C13	***Business Creation***	*2: There are various businesses, including fixed businesses and temporary businesses, along most of the street.*	**1.8**	There are different businesses along the street.
	C14	***Job Creation***	*2: There are many different jobs created within the street space and the store on the first floor of the sided buildings.*	**1.5**	There are many different jobs created within the street space and the store on the first floor of the sided buildings.
	C15	***Added-Value***	*2: The street can bring a certain of added-value to the land, real estate and business along the street.*	**1.5**	The street can bring a certain of added-value to the surrounding areas. The price of real estate along the street is a bit higher because of the commercial convenience according to published transaction data. *

**Data Source: Lianjia.Com*

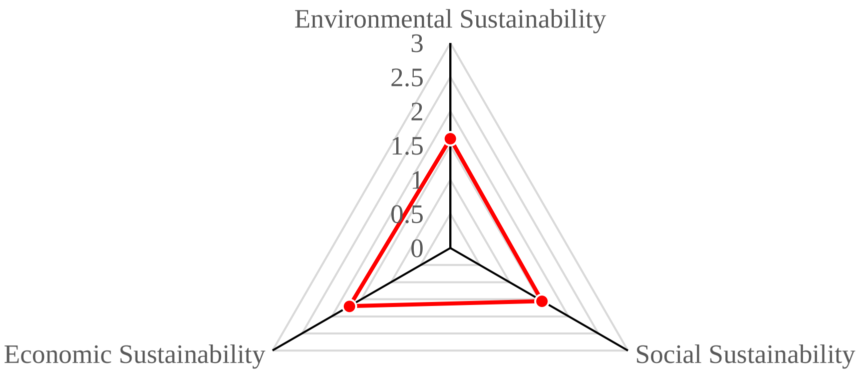

Figure Q. 2: Radar Chart of M5-4 (Meilinbei Rd) Sustainability Evaluation

Appendix P: Evaluation results of M6-9 (Pingtang Rd)

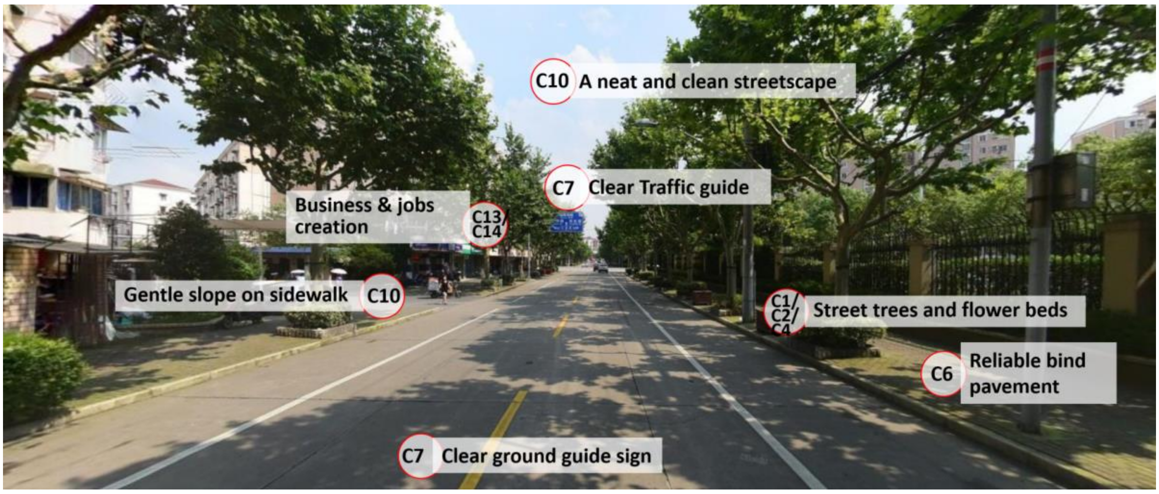

Figure S. 1: Evaluation Illustration on On-Site Photo of M6-9 (Pingtang Rd)

Table S. 1: Sustainability Rating results of M6-9 (Pingtang Rd)

Evaluation Criteria				**Rating Results**	
	Code	***Title***	***Closest Rating Level***	***Score***	***Explanation***
Environment	***C1***	***Adaptability***	*2: The street elements are designed according to local climate, and it can adapt to extreme weather events to some extent.*	**1.8**	The street plants, sidewalk's pavement, and flower beds are designed according to local climate, but it does not show strong adaptability to extreme weather events.
	C2	***Mitigation UHI***	*2: All street elements, including street plants, pavement, section design, shading facilities, are considered to mitigate the effect of Urban Heat Island; but it cannot be felt when walking on it during summer.*	**1.5**	The layout of street elements shows the consideration of UHI mitigation, but the effect is not apparent during summer site investigation.
	C3	***Pollution Reduction***	*2: The street elements help to mitigate the pollution of air, noise, lighting, and waste to some extent, but still some pollution, such as dust, noise, or rubbish, can found in the street.*	**1.8**	The street plants, garbage bins, and lighting system help to mitigate the pollution of air, noise, lighting, and waste to some extent, but the traffic noise is still apparent.
	C4	***Ecological Balance***	*2: The street layout and all elements can help to form urban wind corridor, rainfall water permeability or urban ecological diversity to some extent, but the traffic function is still dominant.*	**1.5**	The street can serve as a wind corridor and promote permeability to some extent, but the traffic function is still dominant.
	C5	***Green Life Promotion***	*2: The street supports green life, including jogging, walking, cycling and using public transportation.*	**1.5**	The street supports green life, but the specific promotion methods are not apparent.
Soci	***C6***	***Equality***	*3: The street provides reliable and convenient blind-pavement and barrier-free facilities. The width*	**2.5**	The street provides blind-pavement, and barrier-free facilities on both sides,

			of sidewalk and height difference in intersections are considered the convenience of seniors as well as disabled people. This street can be used comfortably for all kinds of people.		the width of sidewalk and height difference in intersections are considered the convenience of seniors as well as disabled people.
	C7	***Safety***	*2: The most street elements help to create a safe street, but there is still some potential safety hazard in the intersection or some parts of the street. In general, it is a safe street.*	**1.8**	The most street elements help to create a safe street though there are still some safety loopholes in intersections regarding cycling and pedestrians
	C8	***Accessibility***	*3: The street provides various ways of arrival, including walking, cycling, by bus, by railway as well as driving private cars. So, all of the arrival ways are convenient and comfortable.*	**2.5**	The street provides many arrival ways, like walking, cycling, taking buses and driving. So, in general, all are convenient and comfortable. However, there is no parking space nearby.
	C9	***Diversity***	*2: The street can meet the demand of many different social activities, but the place does not encourage them to have more frequently. The street sometimes serves as the different function but not often.*	**1.5**	The street can meet the demand of some basic street activities, like jogging, dog walking, and shopping. However, there is no appropriate facility, like the seat or exercise equipment, to create a more dynamic public space.
	C10	***Culture Inheritance***	*2: Most of the street elements look as a whole and show relatively high aesthetic quality. Also, the streetscape can reflect local culture or historical features to some extent.*	**1.8**	Most of layout and usage of the street space is relatively reasonable and efficient. However, it lacks mix-use consideration within street space.
Economics	***C11***	***Intensive Land Utilisation***	*2: In general, most of layout and usage of the street space is relatively reasonable and efficient. Also, most of the street land and furniture are designed for multifunctional usage or time/space sharing.*	**1.8**	Most of layout and usage of the street space is relatively reasonable and efficient. But it lacks mix-use consideration within street space.
	C12	***Efficiency***	*2: The traffic condition is good. The average density of the street network is relatively small and the car speed is relatively high. Only a small part of the street is congested or blocked.*	**1.8**	The traffic condition is good, and Only some parts near intersections are slightly congested during rush hours.
	C13	***Business Creation***	*2: There are various businesses, including fixed businesses and temporary businesses, along most of the street.*	**1.5**	There are some businesses along part of the street.
	C14	***Job Creation***	*2: There are many different jobs created within the street space and the store on the first floor of the sided buildings.*	**1.5**	There are some jobs created not on the first floor of the sided building.
	C15	***Added-Value***	*2: The street can bring a certain of added-value to the land, real estate and business along the street.*	**1.5**	The street can bring a certain of added-value according to published transaction data. *

**Data source: Lianjia.com*

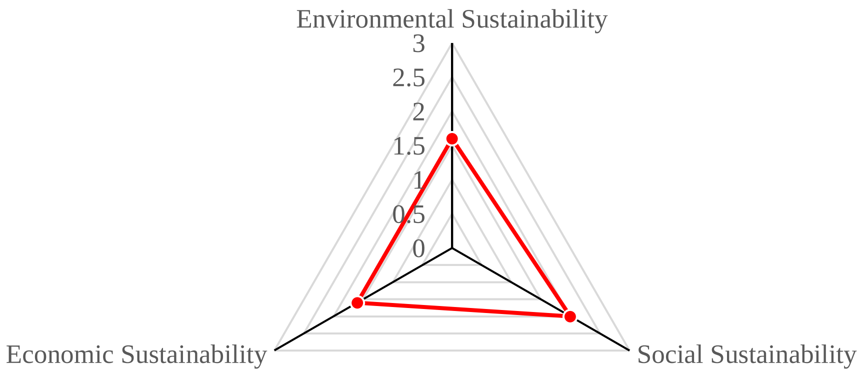

Figure S. 2: Radar Chart of M6-9 (Pingtang Rd) Sustainability Evaluation

Appendix Q: Evaluation results of M7-9 (Yishan Rd)

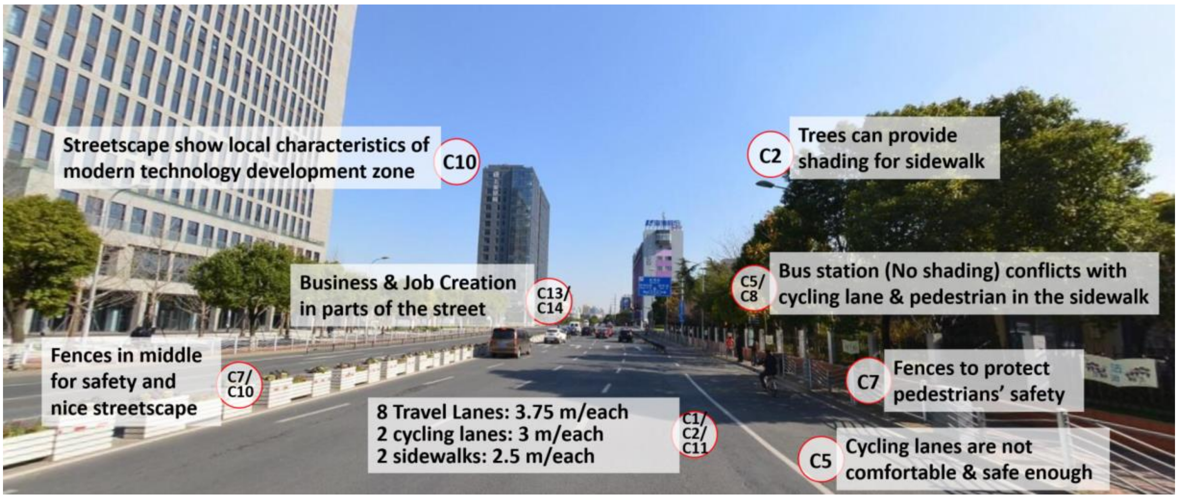

Figure U. 1: Evaluation Illustration on On-Site Photo of M7-9 (Yishan Rd)

Table U. 1: Sustainability Rating results of M7-9 (Yishan Rd)

Evaluation Criteria				Rating Results	
	Code	***Title***	***Closest Rating Level***	***Score***	***Explanation***
Environment	***C1***	***Adaptability***	*1: The street is neither able to adapt to the extreme weather event nor exacerbating the adverse effects of local climate and Climate Change;*	**1.0**	The street is renovated recently, and its storm-water system, pavement, and street trees are all upgraded too. So, in general, the street can neither help but worsen the situation in Climate Change.
	C2	***Mitigation UHI***	*1: The street does not help to mitigate UHI, and there is no apparent difference regarding thermal comfort when walking on it during summer*	**0.8**	The street trees can create shading on both sidewalks, but the street is so broad that the heat absorbed by the asphalt in travel lanes is considerable. So, in general, it is still hot in summer when walking on it.
	C3	***Pollution Reduction***	*2: The street elements help to mitigate the pollution of air, noise, lighting, and waste to some extent, but still some pollution, such as dust, noise, or rubbish, can found in the street.*	**1.8**	The street trees, garbage bins, and lighting system help to mitigate the pollution of air, noise, lighting, and waste to some extent, but the traffic noise and vehicle emission are still quite noticeable.
	C4	***Ecological Balance***	*1: The street layout and elements neither help to form a natural ecological corridor nor destroy the ecological environment.*	**0.8**	In general, the street is more artificial, all hard surface and low green rate. Except for urban wind corridor, the contribution to ecological balance is limited.
	C5	***Green Life Promotion***	*2: The street supports green life, including jogging, walking, cycling and using public transportation.*	**1.5**	The street provides basic choices of transportation. But the cycling lanes are not comfortable and safe enough, and the bus station has the conflict with cycling lanes.
Society	***C6***	***Equality***	*3: The street provides reliable and convenient blind-pavement and barrier-free facilities. The width of sidewalk and height difference in intersections are*	**2.5**	The street provides blind-pavement, and the width of sidewalk and height difference in intersections are considered the convenience of all kinds of

			considered the convenience of seniors as well as disabled people. This street can be used comfortably for all kinds of people.		people. But there is no barrier-free facilities or consideration in bus stations.
	C7	***Safety***	*3: All street elements, including street signals, guide signs, safety islands, plants, street cameras, lighting system and section layout, help to guarantee street safety in each part of the street, especially the safety of pedestrian and cyclists. It can be called a very safe and reliable street.*	**2.8**	The majority of street elements, like fences in the middle of the street and on sidewalks, help to create a safe street. The guide signs and traffic signals are clear and efficient. So, it can be called a safe and street.
	C8	***Accessibility***	*3: The street provides various ways of arrival, including walking, cycling, by bus, by railway as well as driving private cars. So, all of the arrival ways are convenient and comfortable.*	**3.0**	The street provides various ways of arrival, including walking, cycling, by bus, by railway as well as driving private cars.
	C9	***Diversity***	*2: The street can meet the demand of many different social activities, but the place does not encourage them to have more frequently. The street sometimes serves as the different function but not often.*	**1.5**	In some parts of this street, some commercial activities also happened because of the sided shops, but in general, only walking are observed on sidewalks.
	C10	***Culture Inheritance***	*2: Most of the street elements look as a whole and show relatively high aesthetic quality. Also, the streetscape can reflect local culture or historical features to some extent.*	**2.3**	Most of the street elements look as a whole. The streetscape is neat and shows local characteristics of modern technology development zone.
Economics	***C11***	***Intensive Land Utilisation***	*1: Some of layout and usage of street space is reasonable while the others are not. So, a few of street furniture and facilities are designed for multifunctional usage while more of them are not.*	**0.8**	Some of layout and usage of street space is reasonable. But compared with a total of 28 meters' travel lanes, a 2.5-meter-wide sidewalk is a bit too narrow especially when it also needs to share the space with the bus station.
	C12	***Efficiency***	*2: The traffic condition is good. The average density of the street network is relatively small, and the car speed is relatively high. Only a small part of the street is congested or blocked.*	**2.3**	The traffic condition is good. Only a small part of the street near intersections is congested in rush hour.
	C13	***Business Creation***	*2: There are various businesses, including fixed businesses and temporary businesses, along most of the street.*	**1.5**	There are some businesses, including fixed business and temporary business, in parts of the street.
	C14	***Job Creation***	*2: There are many different jobs created within the street space and the store on the first floor of the sided buildings.*	**1.5**	There are some jobs created within and along the street space.
	C15	***Added-Value***	*2: The street can bring a certain of added-value to the land, real estate and business along the street.*	**1.8**	The street can bring a certain of added-value to the surrounding areas. The price of real estate along the street is a bit higher according to published transaction data. *

**Data Source: Lianjia.Com*

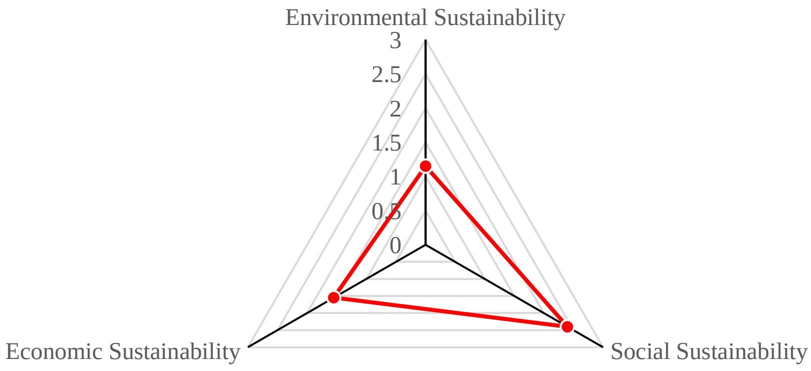

Figure U. 2: Radar Chart of M7-9 (Yishan Rd) Sustainability Evaluation

Table U. 2: Statistics of M7-9 (Yishan Rd) Sustainability Evaluation

Street	Environmental sustainability					Social sustainability					Economic sustainability					Final
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	
M7-9 *Yishani Rd*	1.0	0.8	1.8	0.8	1.5	2.5	2.8	3.0	1.5	2.3	0.8	2.3	1.5	1.5	1.8	**25.5**
	1.15					2.40					1.55					
236 streets Average	*1.4*	*1.4*	*1.6*	*1.3*	*1.5*	*1.5*	*2.0*	*1.9*	*1.5*	*1.6*	*1.5*	*1.8*	*1.4*	*1.4*	*1.3*	***23.0***
	1.43					*1.69*					*1.49*					

Appendix R: Evaluation results of M8-6 (Shuiqing Rd)

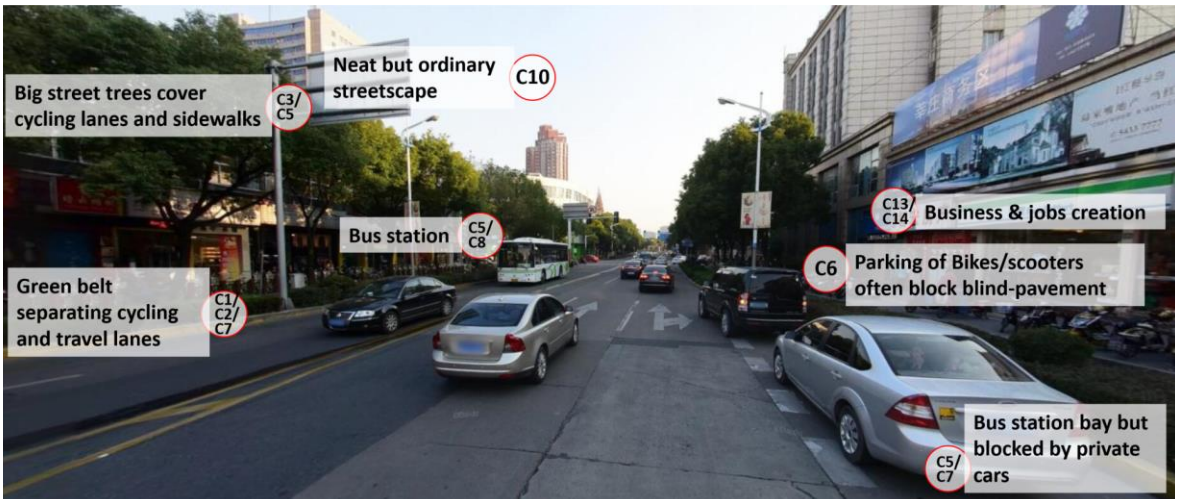

Figure W. 1: Evaluation Illustration on On-Site Photo of M8-6 (Shuiqing Rd)

Table W. 1: Sustainability Rating results of M8-6 (Shuiqing Rd)

Evaluation Criteria				**Rating Results**	
	Code	*Title*	*Closest Rating Level*	*Score*	*Explanation*
Environment	***C1***	***Adaptability***	*2: The street elements are designed according to local climate, and it can adapt to extreme weather events to some extent.*	**1.8**	The street plants and green belts are designed according to Shanghai climate. But it does not show strong adaptability to extreme weather events.
	C2	***Mitigation UHI***	*2: All street elements, including street plants, pavement, section design, shading facilities, are considered to mitigate the effect of Urban Heat Island; but it cannot be felt when walking on it during summer.*	**1.5**	Some street elements show the consideration of UHI mitigation, but the effect is not apparent during summer site investigation.
	C3	***Pollution Reduction***	*2: The street elements help to mitigate the pollution of air, noise, lighting, and waste to some extent, but still some pollution, such as dust, noise, or rubbish, can found in the street.*	**1.8**	The street plants, garbage bins, and lighting system help to mitigate relevant pollution to some extent, but the traffic noise is still apparent.
	C4	***Ecological Balance***	*2: The street layout and all elements can help to form urban wind corridor, rainfall water permeability or urban ecological diversity to some extent, but the traffic function is still dominant.*	**1.5**	The street can serve as a wind corridor and promote permeability to some extent, but the traffic function is still dominant.
	C5	***Green Life Promotion***	*2: The street supports green life, including jogging, walking, cycling and using public transportation.*	**1.5**	The street supports green life, and street provides relatively comfortable and safe environment for walking, cycling and taking public buses.
	C6	***Equality***	*2: The street provides blind-pavement and barrier-free*	**1.5**	The street provides blind-pavement and barrier-

			facilities, but some of them are blocked or out of service. The width of sidewalk and height difference in the intersection is considered the usage of all kinds of people.		free facilities on both sides, but many of them are blocked by bike parking or damaged.
	C7	***Safety***	*2: The most street elements help to create a safe street, but there is still some potential safety hazard in the intersection or some parts of the street. In general, it is a safe street.*	**2.0**	The most street elements help to create a safe street though there are still some safety loopholes in intersections regarding cycling and pedestrians.
	C8	***Accessibility***	*3: The street provides various ways of arrival, including walking, cycling, by bus, by railway as well as driving private cars. So, all of the arrival ways are convenient and comfortable.*	**2.5**	The street provides many arrival ways, like walking, cycling, taking buses and driving. So, in general, all are convenient and comfortable. However, the bus station bay is blocked by private cars.
	C9	***Diversity***	*2: The street can meet the demand of many different social activities, but the place does not encourage them to have more frequently. The street sometimes serves as the different function but not often.*	**1.5**	The street can meet the demand of some basic street activities, and people like buying something in the stores along the street. But the optional activates are not diverse.
	C10	***Culture Inheritance***	*2: Most of the street elements look as a whole and show relatively high aesthetic quality. Also, the streetscape can reflect local culture or historical features to some extent.*	**1.8**	Most of the street elements look as a whole. In general, the streetscape is neat but ordinary.
Economics	***C11***	***Intensive Land Utilisation***	*2: In general, most of layout and usage of the street space is relatively reasonable and efficient. Also, most of the street land and furniture are designed for multifunctional usage or time/space sharing.*	**1.8**	Most of layout and usage of the street space is relatively reasonable and efficient. But it lacks mix-use consideration within street space.
	C12	***Efficiency***	*2: The traffic condition is good. The average density of the street network is relatively small, and the car speed is relatively high. Only a small part of the street is congested or blocked.*	**2.0**	The traffic condition is good, and Only some parts near intersections are slightly congested in rush hours.
	C13	***Business Creation***	*3: There are various businesses along the whole street, including fixed business (stores and shops) and temporary business (like street vendors and mobile food station).*	**2.5**	There are various businesses along part of the street.
	C14	***Job Creation***	*3: There are various jobs, such as salesmen, waitress, agent, craftsmen, officers, parking assistants, street vendors, are created not only within the street space and the store on the first floor of the sided buildings but also on the upper floors of the buildings along the street*	**2.5**	There are many jobs created not only on the first floor of the sided buildings but also on the upper floors of the buildings along the street.
	C15	***Added-Value***	*2: The street can bring a certain of added-value to the land, real estate and business along the street.*	**1.8**	The street can bring a certain of added-value according to published transaction data. *

**Data Source: Lianjia.Com*

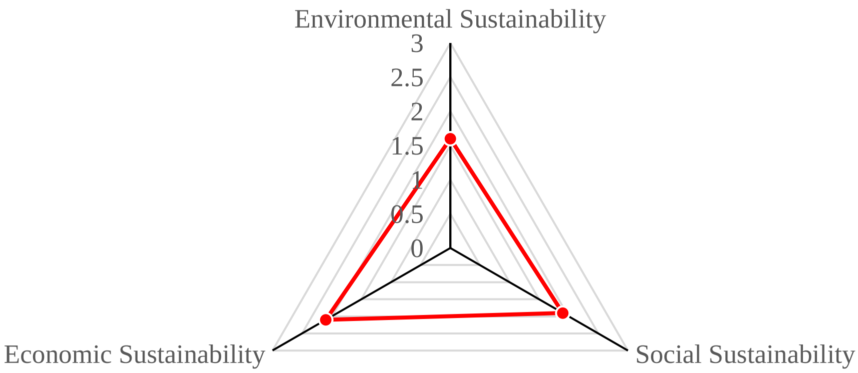

Figure W. 2: Radar Chart of M8-6 (Shuiqing Rd) Sustainability Evaluation

Appendix S: Evaluation results of M9-1 (Zhangyang Rd)

Figure Y. 1: Evaluation Illustration on On-Site Photo of M9-1 (Zhangyang Rd)

Table Y. 1: Sustainability Rating results of M9-1 (Zhangyang Rd)

Evaluation Criteria				Rating Results	
	Code	***Title***	***Closest Rating Level***	***Score***	***Explanation***
Environment	***C1***	***Adaptability***	*2: The street is neither able to adapt to the extreme weather events nor exacerbating the adverse effects of local climate and Climate Change;*	**2.0**	The street plants are designed according to local climate, and there is a wide green belt in the street central. So, it can adapt to extreme weather events to some extent.
	C2	***Mitigation UHI***	*2: All street elements, including street plants, pavement, section design, shading facilities, are considered to mitigate the effect of Urban Heat Island; but it cannot be felt when walking on it during summer.*	**1.8**	The layout of street plants is considered UHI mitigation, but the effect is not apparent during summer site investigation.
	C3	***Pollution Reduction***	*3: All street elements, including street plants, pavement, speed control facilities, garbage bins, and lighting system, help to reduce the pollution of air, noise, lighting, and waste. It is a tranquil and clean street without any lighting pollution during the night.*	**2.5**	The high green rata, big street trees, and garbage bins help to mitigate the pollution of air, noise, lighting, and waste to some extent.
	C4	***Ecological Balance***	*3: The street layout and all elements, including*	**2.5**	The street can serve as a wind corridor and

			permeable pavement, the choice of street plant and rainwater collection facilities, can contribute to ecological balance concerning urban wind corridor, rainfall water permeability as well as urban ecological diversity. So, it is a very natural and ecological street, and the traffic function cannot be felt obviously.		promote permeability to some extent. It can be called a natural and green street, but the traffic function is still dominant.
	C5	***Green Life Promotion***	*3: The street not only fully supports and encourages green lifestyle, such as jogging, walking, cycling and using public transportation, but also actively promotes the significance of environmental protection and sustainable life by advertisement posting and various street campaigns.*	**2.5**	The street supports green life, such as jogging, walking, cycling and using public transportation. However, there are no relevant advertising boards or campaigns for the green lifestyle on this street.
Society	***C6***	***Equality***	*3: The street provides reliable and convenient blind-pavement and barrier-free facilities. The width of sidewalk and height difference in intersections are considered the convenience of seniors as well as disabled people. This street can be used comfortably for all kinds of people.*	**2.5**	The street provides blind-pavement on both sides, and the width of sidewalk and height difference in intersections are considered the convenience of seniors and disabled people. But there is no barrier-free facility in the height difference of sided shops.
	C7	***Safety***	*3: All street elements, including street signals, guide signs, safety islands, plants, street cameras, lighting system and section layout, help to guarantee street safety in each part of the street, especially the safety of pedestrian and cyclists. It can be called a very safe and reliable street.*	**2.8**	There are various ways to guarantee street safety, including guide signs, speed control cameras, green belt garden, and safety fences. So, it can be called a safe street.
	C8	***Accessibility***	*3: The street provides various ways of arrival, including walking, cycling, by bus, by railway as well as driving private cars. So, all of the arrival ways are convenient and comfortable.*	**3.0**	The street provides many arrival ways, like walking, cycling, taking public buses and driving. Also, all of the arrival ways are convenient and comfortable.
	C9	***Diversity***	*2: The street can meet the demand of many different social activities, but the place does not encourage them to have more frequently. The street sometimes serves as the*	**1.5**	There are some commercial activities in part of this street, but in general, this street does not encourage optional activities due to the

			different function but not often.		scale and street furniture.
	C10	***Culture Inheritance***	*2: Most of the street elements look as a whole and show relatively high aesthetic quality. Also, the streetscape can reflect local culture or historical features to some extent.*	**2.3**	Most of the street elements look as a whole, and the streetscape can reflect local culture of a newly-developed community.
Economics	***C11***	***Intensive Land Utilisation***	*2: In general, most of layout and usage of the street space is relatively reasonable and efficient. Also, most of the street land and furniture are designed for multifunctional usage or time/space sharing.*	**1.5**	The bus-only lane is time-sharing with all vehicles. However, the central green belt can be designed and used for more functions, like the accessible open garden or green rain garden.
	C12	***Efficiency***	*2: The traffic condition is good. The average density of the street network is relatively small, and the car speed is relatively high. Only a small part of the street is congested or blocked.*	**2.3**	The traffic condition is good. Only some parts near intersections are slightly congested in rush hour.
	C13	***Business Creation***	*2: There are various businesses, including fixed businesses and temporary businesses, along most of the street.*	**1.8**	There are some businesses along part of the street.
	C14	***Job Creation***	*2: There are many different jobs created within the street space and the store on the first floor of the sided buildings.*	**1.5**	There are some jobs created in part of this street.
	C15	***Added-Value***	*2: The street can bring a certain of added-value to the land, real estate, and business along the street.*	**1.8**	The street can bring a certain of added-value to the land, real estate, and business according to published transaction data. *

*Data Source: Lianjia.Com

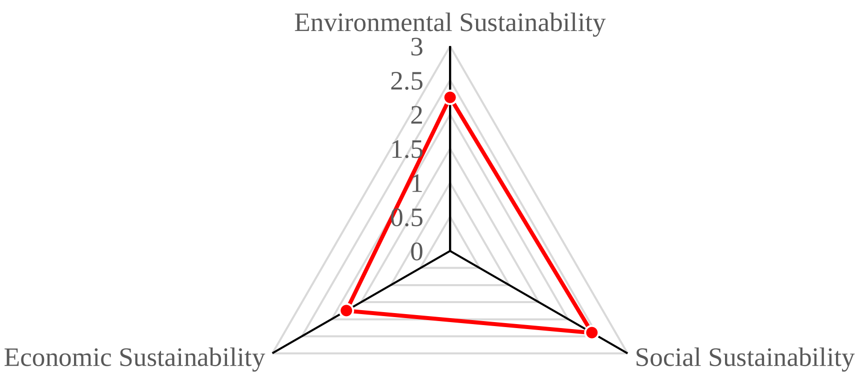

Figure Y. 2: Radar Chart of M9-1 (Zhangyang Rd) Sustainability Evaluation

Appendix T: Evaluation results of M10-3 (Meihua Rd)

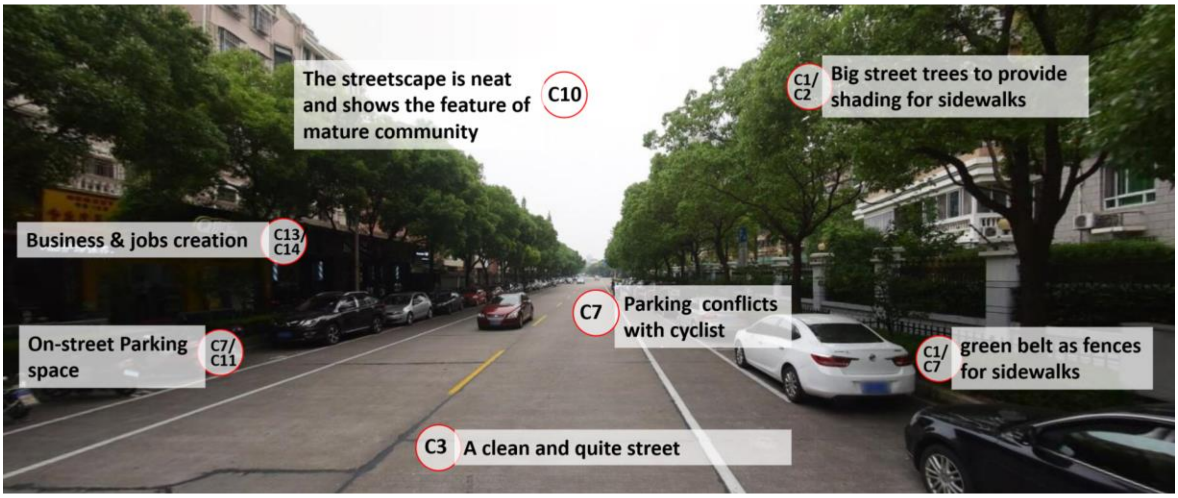

Figure AA. 1: Evaluation Illustration on On-Site Photo of M10-3 (Meihua Rd)

Table AA. 1: Sustainability Rating results of M10-3 (Meihua Rd)

Evaluation Criteria				Rating Results	
	Code	***Title***	***Closest Rating Level***	***Score***	***Explanation***
Environment	***C1***	***Adaptability***	*2: The street elements are designed according to local climate, and it can adapt to extreme weather events to some extent.*	**1.8**	The street trees and other elements are designed according to local climate, a it can adapt to extreme weat events to some extent.
	C2	***Mitigation UHI***	*2: All street elements, including street plants, pavement, section design, shading facilities, are considered to mitigate the effect of Urban Heat Island; but it cannot be felt when walking on it during summer.*	**1.5**	The street trees can create shading on both sidewalks, but the cooling effect is not apparent in summer site visit.
	C3	***Pollution Reduction***	*3: All street elements, including street plants, pavement, speed control facilities, garbage bins, and lighting system, help to reduce the pollution of air, noise, lighting, and waste. It is a tranquil and clean street without any lighting pollution during the night.*	**2.5**	The street trees, garbage bins, and lighting system help to mitigate the pollution. It can be called a quiet and clean street.
	C4	***Ecological Balance***	*2: The street layout and all elements can help to form urban wind corridor, rainfall water permeability or urban ecological diversity to some extent, but the traffic function is still dominant.*	**1.5**	The street can serve as an urban wind corridor. The street trees and flower beds help water penetration. However, the overall function of ecological balance is limited.
	C5	***Green Life Promotion***	*2: The street supports green life, including jogging, walking, cycling and using public transportation.*	**1.5**	The street provides basic choices of transportation. However, there is no bus lane on this street.

Society	***C6***	***Equality***	*3: The street provides reliable and convenient blind-pavement and barrier-free facilities. The width of sidewalk and height difference in intersections are considered the convenience of seniors as well as disabled people. This street can be used comfortably for all kinds of people.*	**2.5**	The street provides blind-pavement, and the width of sidewalk and height difference in intersections are considered the convenience of all kinds of people. But some part of sidewalks is a bit narrow for disable chair.
	C7	***Safety***	*3: All street elements, including street signals, guide signs, safety islands, plants, street cameras, lighting system and section layout, help to guarantee street safety in each part of the street, especially the safety of pedestrian and cyclists. It can be called a very safe and reliable street.*	**2.8**	The majority of street elements, like green fences in sidewalks, help to create a safe street. The guide signs and traffic signals are clear and efficient. So, it can be called a safe and street.
	C8	***Accessibility***	*2: The street provides all arrival ways, but some of them are not convenient. For example, the bus station is too far away, or there is no car parking nearby.*	**1.8**	The street provides various ways of arrival. There is also on-street parking space. But there is no public bus line and bus station in this street.
	C9	***Diversity***	*2: The street can meet the demand of many different social activities, but the place does not encourage them to have more frequently. The street sometimes serves as the different function but not often.*	**2.3**	There are shops and commercial activities on one side of this street. There are some optional activities happened here, but it cannot be called a diverse street
	C10	***Culture Inheritance***	*2: Most of the street elements look as a whole and show relatively high aesthetic quality. Also, the streetscape can reflect local culture or historical features to some extent.*	**1.8**	Most of the street elements look as a whole. The streetscape is neat and shows local characteristics of the mature community.
Economics	***C11***	***Intensive Land Utilisation***	*2：In general, most of layout and usage of the street space is relatively reasonable and efficient. And most of the street land and furniture are designed for multifunctional usage or time/space sharing.*	**2.0**	In general, most of layout and usage of the street space is relatively reasonable and efficient.
	C12	***Efficiency***	*2: The traffic condition is good. The average density of the street network is relatively small, and the car speed is relatively high. Only a small part of the street is congested or blocked.*	**1.8**	The traffic condition is good in general. But it is slightly congested during rush hours.
	C13	***Business Creation***	*2: There are various businesses, including fixed businesses and temporary businesses, along most of the street.*	**2.0**	There are many businesses, including fixed businesses and temporary businesses, along the street.
	C14	***Job Creation***	*2: There are many different jobs created within the street space and the store on the first floor of the sided buildings.*	**1.8**	There are many different jobs created and the store on the first floor of the sided buildings.
	C15	***Added-Value***	*2: The street can bring a certain of added-value to the land, real estate and business along the street.*	**1.8**	The street can bring a certain of added-value to the surrounding areas. The price of real estate along the street is a bit higher according to

	published transaction data. *

**Data Source: Lianjia.Com*

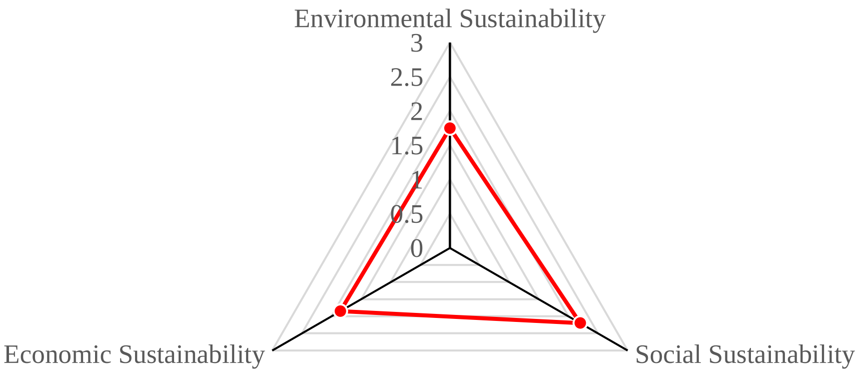

Figure AA. 2: Radar Chart of M10-3 (Meihua Rd) Sustainability Evaluation

Appendix U: Evaluation results of M11-10 (Zuzhongzhi Rd)

Figure CC. 1: Evaluation Illustration on On-Site Photo of M11-10 (Zuzhongzhi Rd)

Table CC. 1: Sustainability Rating results of M11-10 (Zuzhongzhi Rd)

Evaluation Criteria				**Rating Results**	
	Code	***Title***	***Closest Rating Level***	***Score***	***Explanation***
Environment	***C1***	***Adaptability***	*2: The street elements are designed according to local climate, and it can adapt to extreme weather events to some extent.*	**1.8**	The street plants and other elements are designed according to local climate, and there is also green space along sidewalks. So, it can adapt to extreme weather events to some extent.
	C2	***Mitigation UHI***	*2: All street elements, including street plants, pavement, section design, shading facilities, are considered to mitigate the effect of Urban Heat Island; but it cannot be felt when walking on it during summer.*	**1.5**	The layout of street plants is considered UHI mitigation, but the effect is not apparent in summer site investigation.
	C3	***Pollution Reduction***	*2: The street elements help to mitigate the pollution of air, noise, lighting, and waste to some extent, but still some pollution, such as dust, noise, or rubbish, can found in the street.*	**1.5**	The street trees and other green belts help to reduce relevant pollution. But the traffic noise, both from cars and from the horns of scoters, is still very obvious.
	C4	***Ecological Balance***	*2: The street layout and all elements can help to form urban wind corridor, rainfall water permeability or urban ecological diversity to some extent, but the traffic function is still dominant.*	**1.5**	The street can serve as a wind corridor and promote permeability to some extent. But the street plants are not diverse enough to promote ecological balance and the traffic function is still dominant.
	C5	***Green Life Promotion***	*2: The street supports green life, including jogging, walking,*	**2.3**	The street supports green life, such as jogging,

			cycling and using public transportation.		walking, cycling and using public transportation.
Society	*C6*	***Equality***	*3: The street provides reliable and convenient blind-pavement and barrier-free facilities. The width of sidewalk and height difference in intersections are considered the convenience of seniors as well as disabled people. This street can be used comfortably for all kinds of people.*	**2.5**	The street provides blind-pavement on both sides, and the width of sidewalk and height difference in intersections are considered the convenience of all kinds of people. However, the height difference between sidewalks and commercial complex is not convenient for disabled people.
	C7	***Safety***	*3: All street elements, including street signals, guide signs, safety islands, plants, street cameras, lighting system and section layout, help to guarantee street safety in each part of the street, especially the safety of pedestrian and cyclists. It can be called a very safe and reliable street.*	**2.8**	There are various ways to guarantee street safety, including guide signs, speed control cameras, green belts, and safety fences. So, it can be called a safe street.
	C8	***Accessibility***	*3: The street provides various ways of arrival, including walking, cycling, by bus, by railway as well as driving private cars. So, all of the arrival ways are convenient and comfortable.*	**2.8**	The street provides many arrival ways, like walking, cycling, taking public buses and driving. So, all of the arrival ways are convenient and comfortable.
	C9	***Diversity***	*3: The street encourages and meets the demand of various public activities. It often serves as many different functions, such as transportation corridor, social space, commercial space, cultural hub, public space and ecological corridors. So, it can be called as a very dynamic and diverse street.*	**2.5**	The street encourages and meets the demand of various public activities, like shopping, meeting friends, jogging, and dog walking. It can be called a dynamic street.
	C10	***Culture Inheritance***	*3: All street elements, including the plants, street furniture, pavement, signs, and signals, are well designed and dedicatedly constructed so as to form as a whole to display high aesthetic quality. The streetscape is consistent with the surroundings, and not only inherits but also highlights local culture and historical characteristics.*	**2.5**	Most of the street elements look as a whole, and the streetscape can reflect the local feature of Hi-Tech Park.
Economics	*C11*	***Intensive Land Utilisation***	*2: In general, most of layout and usage of the street space is relatively reasonable and efficient. Also, most of the street land and furniture are designed for multifunctional usage or time/space sharing.*	**1.8**	In general, most of layout and usage of the street space is relatively reasonable and efficient. However, the parking of scooters and bikes occupy nearly the whole sidewalks.
	C12	***Efficiency***	*2: The traffic condition is good. The average density of the street network is relatively small, and the car speed is relatively high. Only a small part of the street is congested or blocked.*	**1.8**	The traffic condition is good. But some parts near intersections is slightly congested in rush hour.

C13	***Business Creation***	*3: There are various businesses along the whole street, including fixed businesses (stores and shops) and temporary businesses (like street vendors and mobile food station).*	**2.8**	There are various businesses along the whole street.
C14	***Job Creation***	*3: There are various jobs, such as salesmen, waitress, agent, craftsmen, officers, parking assistants, street vendors, created not only within the street space and the store on the first floor of the sided buildings, but also on the upper floors of the buildings along the street*	**2.8**	There are various jobs created along this street.
C15	***Added-Value***	*2: The street can bring a certain of added-value to the land, real estate, and business along the street.*	**2.0**	The street can bring a certain of added-value to the land, real estate, and business because of its vibrant commercial atmosphere and convenient traffic condition according to published transaction data. *

**Data Source: Lianjia.Com*

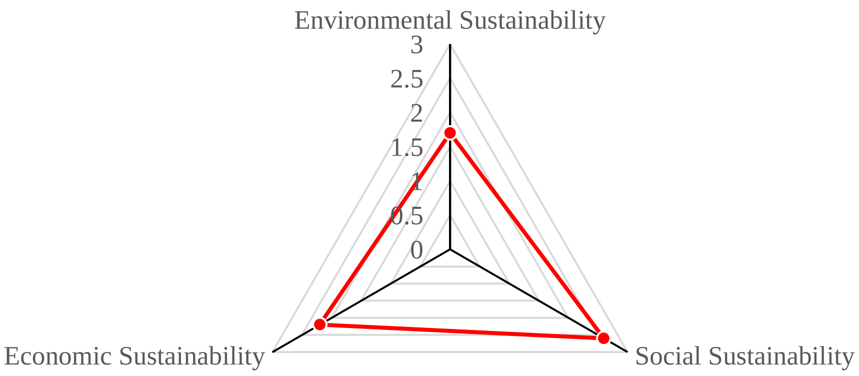

Figure CC. 2: Radar Chart of M11-10 (Zuzhongzhi Rd) Sustainability Evaluation

Appendix V: Evaluation results of M12-6 (Xinde Rd)

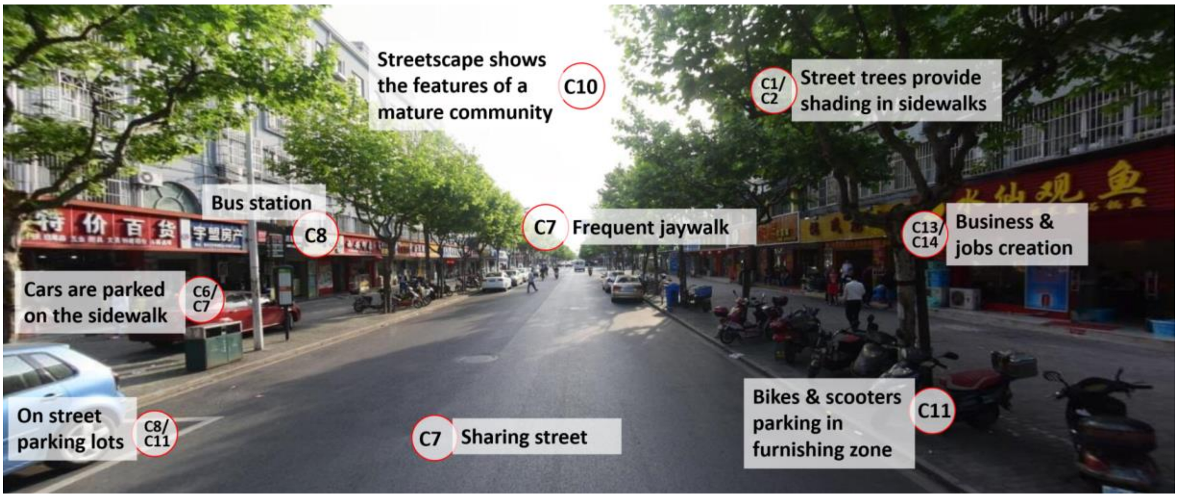

Figure EE. 1: Evaluation Illustration on On-Site Photo of M12-6 (Xinde Rd)

Table EE. 1: Sustainability Rating results of M12-6 (Xinde Rd)

Evaluation Criteria				**Rating Results**	
	Code	***Title***	***Closest Rating Level***	***Score***	***Explanation***
Environment	***C1***	***Adaptability***	*1: The street is neither able to adapt to the extreme weather events nor exacerbating the adverse effects of local climate and Climate Change;*	**1.0**	The street is neither able to adapt to the extreme weather event nor exacerbating the negative effects of extreme weather events;
	C2	***Mitigation UHI***	*2: All street elements, including street plants, pavement, section design, shading facilities, are considered to mitigate the effect of Urban Heat Island; but it cannot be felt when walking on it during summer.*	**1.5**	The street trees can create shading on both sidewalks, but in general, it is still hot in summer when walking on it.
	C3	***Pollution Reduction***	*2: The street elements help to mitigate the pollution of air, noise, lighting, and waste to some extent, but still some pollution, such as dust, noise, or rubbish, can found in the street.*	**1.5**	The street trees, garbage bins, and lighting system help to mitigate pollutions, but the traffic noise is still quite apparent.
	C4	***Ecological Balance***	*1: The street layout and elements neither help to form a natural ecological corridor nor destroy the ecological environment.*	**0.8**	The street does not help a lot for ecological balance.
	C5	***Green Life Promotion***	*2: The street supports green life, including jogging, walking, cycling, and using public transportation.*	**1.5**	The street provides the basic condition for walking, cycling, and public transportation.

Society	***C6***	***Equality***	*2: The street provides blind-pavement and barrier-free facilities, but some of them are blocked or out of service. The width of sidewalk and height difference in the intersection is considered the usage of all kinds of people.*	**1.8**	The street provides blind-pavement, and the width of sidewalk and height difference in intersections are considered the convenience of all kinds of people. But some part blind-pavements are blocked by parking.
	C7	***Safety***	*2: The most street elements help to create a safe street, but there are still some potential safety hazards in the intersection or some parts of the street. In general, it is a safe street.*	**2.0**	In general, the street is safe because of low traffic flow. However, there are still some potential safety hazard, like parking on sidewalks and jaywalk.
	C8	***Accessibility***	*3: The street provides various ways of arrival, including walking, cycling, by bus, by railway as well as driving private cars. So, all of the arrival ways are convenient and comfortable.*	**2.5**	The street provides various ways of arrival, including walking, cycling, by bus, and driving private cars. All are relatively convenient.
	C9	***Diversity***	*2: The street can meet the demand of many different social activities, but the place does not encourage them to have more frequently. The street sometimes serves as the different function but not often.*	**1.5**	There are commercial and some social activities. But it cannot be described as diverse.
	C10	***Culture Inheritance***	*2: Most of the street elements look as a whole and show relatively high aesthetic quality. Also, the streetscape can reflect local culture or historical features to some extent.*	**1.8**	Most of the street elements look as a whole. The streetscape is neat and shows local characteristics of a mature community.
Economics	***C11***	***Intensive Land Utilisation***	*2：In general, most of layout and usage of the street space is relatively reasonable and efficient. Also, most of the street land and furniture are designed for multifunctional usage or time/space sharing.*	**1.8**	As a community street, the street space is shared with diver, cyclists, and scooters, and there are on-street parking lots. So, in general, the street land is used intensively.
	C12	***Efficiency***	*2: The traffic condition is good. The average density of the street network is relatively small, and the car speed is relatively high. Only a small part of the street is congested or blocked.*	**1.8**	The traffic condition is pretty good in general. Only a small part of the street near intersections is congested in rush hour.
	C13	***Business Creation***	*3: There are various businesses along the whole street, including fixed businesses (stores and shops) and temporary businesses (like street venders and mobile food station).*	**2.5**	There are various businesses along the whole street.
	C14	***Job Creation***	*3: There are various jobs, such as salesmen, waitress, agent, craftsmen, officers, parking assistants, street vendors, created not only within the street space and the store on the first floor of the sided buildings but also on the upper floors of the buildings along the street t*	**2.5**	There are various jobs created on the first floor of the buildings along the street.

C15	***Added-Value***	*2: The street can bring a certain of added-value to the land, real estate and business along the street.*	**1.5**	The price of real estate along the street is a bit higher according to published transaction data. *

**Data Source: Lianjia.Com*

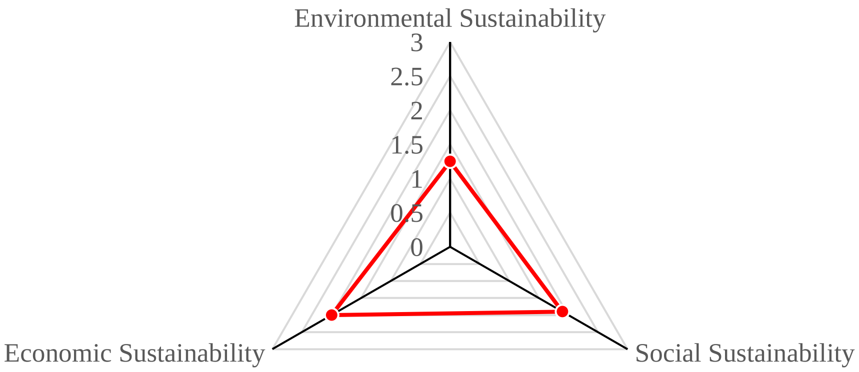

Figure EE. 2: Radar Chart of M12-6 (Xinde Rd) Sustainability Evaluation

Appendix W: Evaluation results of C1-4 (Xizangzhong Rd)

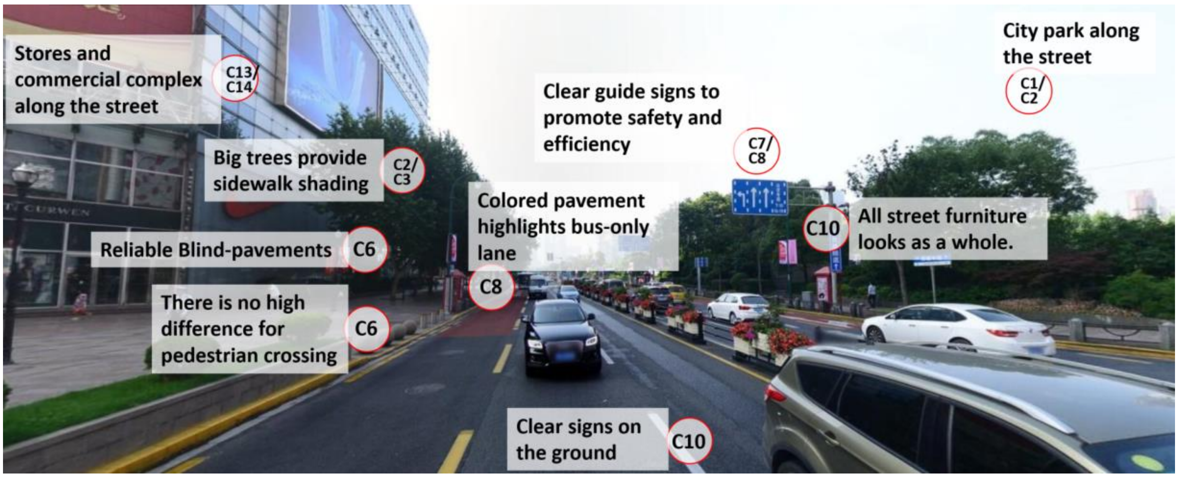

Figure GG. 1: Evaluation Illustration on On-Site Photo of C1-4 (Xizangzhong Rd)

Table GG. 1: Sustainability Rating results of C1-4 (Xizangzhong Rd)

Evaluation Criteria			Rating Results		
	Code	***Title***	***Closest Rating Level***	***Score***	***Explanation***
Environment	***C1***	***Adaptability***	*1: The street is neither able to adapt to the extreme weather event nor exacerbating the adverse effects of local climate and Climate Change;*	**1.3**	As the main street in the city centre, all street plants, pavements, and drainage system are designed according to Shanghai climate, and it can adapt to extreme weather events to some extent.
	C2	***Mitigation UHI***	*2: All street elements, including street plants, pavement, section design, shading facilities, are considered to mitigate the effect of Urban Heat Island; but it cannot be felt when walking on it during summer.*	**2.0**	The layout of street plants is considered UHI mitigation, but the effect is not apparent during summer site investigation.
	C3	***Pollution Reduction***	*2: The street elements help to mitigate the pollution of air, noise, lighting, and waste to some extent, but still some pollution, such as dust, noise, or rubbish, can found in the street.*	**1.8**	The big street trees, garbage bins, and city park along the street help to mitigate relevant pollution to some extent. But traffic noise is still apparent.
	C4	***Ecological Balance***	*1: The street layout and elements neither help to form a natural ecological corridor nor destroy the ecological environment.*	**1.0**	The street cannot help to promote ecological balance.
	C5	***Green Life Promotion***	*2: The street supports green life, including jogging, walking, cycling and using public transportation.*	**1.8**	The street supports walking and using public transportation. Cycling is forbidden in this street. Also, sometimes there are campaigns or street shows for green lifestyle in this street.
Soci	***C6***	***Equality***	*3: The street provides reliable and convenient blind-pavement and barrier-free facilities. The*	**2.8**	The street provides blind-pavement on both sides, and the width of

			width of sidewalk and height difference in intersections are considered the convenience of seniors as well as disabled people. This street can be used comfortably for all kinds of people.		sidewalk and height difference in intersections are considered the convenience of all kinds of people.
	C7	***Safety***	*3: The most street elements help to create a safe street, but there are still some potential safety hazards in the intersection or some parts of the street. In general, it is a safe street.*	**2.8**	There are various ways to guarantee street safety, including guide signs, speed control cameras, green belt garden, and safety fences. So, it can be called a safe street.
	C8	***Accessibility***	*3: The street provides various ways of arrival, including walking, cycling, by bus, by railway as well as driving private cars. So, all of the arrival ways are convenient and comfortable.*	**2.8**	The street provides many arrival ways, like walking, cycling, taking public buses, subway and driving. And all are convenient and comfortable.
	C9	***Diversity***	*3: The street encourages and meets the demand of various public activities. It often serves as many different functions, such as transportation corridor, social space, commercial space, cultural hub, public space and ecological corridors. So, it can be called a very dynamic and diverse street.*	**2.8**	As a street in the city center, there are lots of commercial and tourism activates. Also, this street encourages and meets the demand for these activities. It is also a significant social space in Shanghai.
	C10	***Culture Inheritance***	*3: All street elements, including the plants, street furniture, pavement, signs, and signals, are well designed and dedicatedly constructed so as to form as a whole to display high aesthetic quality. The streetscape is consistent with the surroundings, and not only inherits but also highlights local culture and historical characteristics.*	**2.5**	All street elements and furniture look as a whole and show high aesthetic quality. The pavement, central flower fences, and building façade along street reflect Shanghai characteristics to some extent.
Economics	***C11***	***Intensive Land Utilisation***	*3: The layout and usage of the street space, including the width of travel lanes, cycling lanes sidewalk, and intersection, are very reasonable and efficient. All street furniture and facilities are designed for multifunctional usage. All of the street lands are considered mixed usage, time/space sharing with the aim of intensive utilisation and land saving.*	**2.8**	The street space is used intensively. The layout and space usage are reasonable and efficient. Some street furniture, like sculptures, seats and garbage bins, is designed for multifunctional usage and safe land.
	C12	***Efficiency***	*2: The traffic condition is good. The average density of the street network is relatively small, and the car speed is relatively high. Only a small part of the street is congested or blocked.*	**2.0**	The traffic condition is ok except for rush hours.
	C13	***Business Creation***	*3: There are various businesses along the whole street, including fixed businesses*	**3.0**	There are various businesses along the street, including different

		(stores and shops) and temporary businesses (like street vendors and mobile food station).		stores and commercial complex, as well as some mobile vendors and food stations.
C1 4	***Job Creation***	*3: There are various jobs, such as salesmen, waitress, agent, craftsmen, officers, parking assistants, street vendors, are created not only within the street space and the store on the first floor of the sided buildings but also on the upper floors of the buildings along the street*	**3.0**	There are various jobs created in this street.
C1 5	***Added-Value***	*3: The street can bring considerable added-value to the surrounding areas, including the increase of commercial leases and rent, the price of real estate transaction and market sales, as well as the rental prices of street advertising positions.*	**3.0**	The street can bring considerable added-value to the surrounding areas according to published transaction data. *

**Data Source: Lianjia.Com*

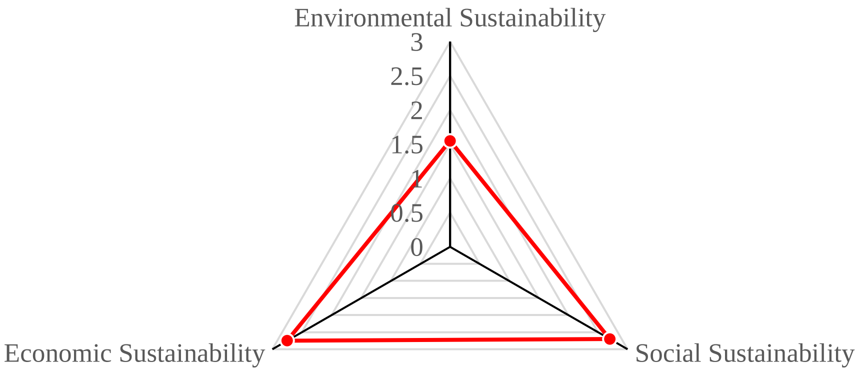

Figure GG. 2: Radar Chart of C1-4 (Xizangzhong Rd) Sustainability Evaluation

Appendix X: Evaluation results of C2-6 (Century Avenue)

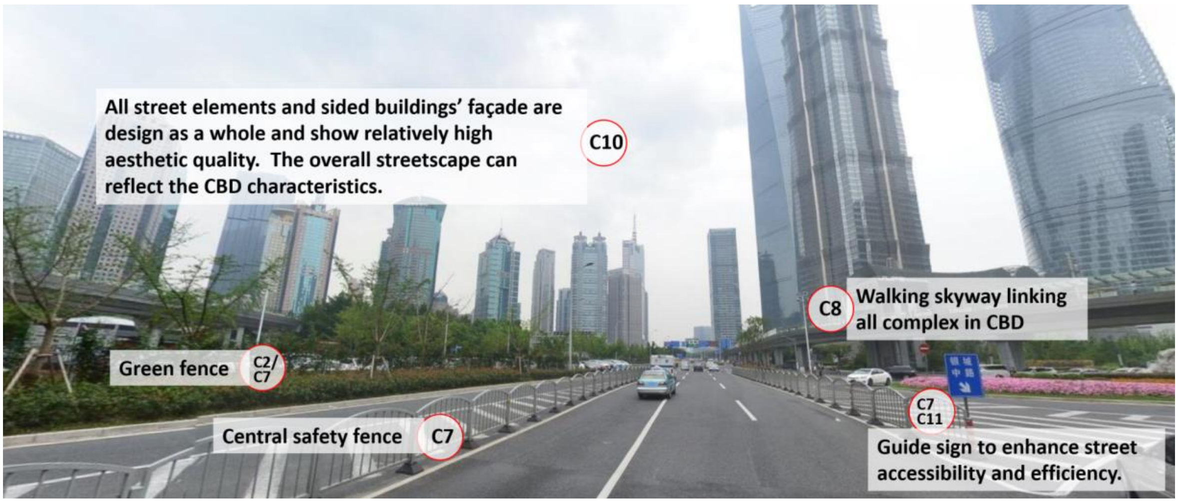

Figure II. 1: Evaluation Illustration on On-Site Photo of C2-6 (Century Avenue)

Table II. 1: Sustainability Rating results of C2-6 (Century Avenue)

Evaluation Criteria				**Rating Results**	
	Code	***Title***	***Closest Rating Level***	***Score***	***Explanation***
Environment	***C1***	***Adaptability***	*2: The street elements are designed according to local climate, and it can adapt to extreme weather events to some extent.*	**2.0**	The street green, drainage system, all pavements and street vertical are designed according to Shanghai climate, and it can adapt to extreme weather event to some extent.
	C2	***Mitigation UHI***	*2: All street elements, including street plants, pavement, section design, shading facilities, are considered to mitigate the effect of Urban Heat Island; but it cannot be felt when walking on it during summer.*	**2.0**	The layout of street plants is considered UHI mitigation, but the effect is not apparent during summer site investigation.
	C3	***Pollution Reduction***	*2: The street elements help to mitigate the pollution of air, noise, lighting, and waste to some extent, but still some pollution, such as dust, noise, or rubbish, can found in the street.*	**2.0**	The high green rata, big street trees, and garbage bins help to mitigate the pollution of air, noise, lighting, and waste to some extent.
	C4	***Ecological Balance***	*2: The street layout and all elements can help to form urban wind corridor, rainfall water permeability or urban ecological diversity to some extent, but the traffic function is still dominant.*	**2.0**	The street can serve as a wind corridor and promote permeability to some extent, but the traffic function is still dominant.
	C5	***Green Life Promotion***	*1: The street provides basic choices of transportation: walking, cycling, and public transportation system.*	**1.3**	The street supports green life to some extent. But the vehicle traffic is still dominated.
Socie	***C6***	***Equality***	*3: The street provides reliable and convenient blind-pavement and barrier-free facilities. The width of*	**2.8**	The street provides blind-pavement on both sides, and the width of sidewalk

			sidewalk and height difference in intersections are considered the convenience of seniors as well as disabled people. This street can be used comfortably for all kinds of people.		and height difference in intersections are considered the convenience of seniors and disabled people.
	C7	***Safety***	*3: All street elements, including street signals, guide signs, safety islands, plants, street cameras, lighting system and section layout, help to guarantee street safety in each part of the street, especially the safety of pedestrian and cyclists. It can be called a very safe and reliable street.*	**2.8**	There are various ways to guarantee street safety, including guide signs, speed control cameras, green belt garden, and safety fences. So, it can be called a safe street.
	C8	***Accessibility***	*3: The street provides various ways of arrival, including walking, cycling, by bus, by railway as well as driving private cars. So, all of the arrival ways are convenient and comfortable.*	**3.0**	The street provides many arrival ways, like walking, cycling, taking public buses and subway, and driving.
	C9	***Diversity***	*2: The street can meet the demand of many different social activities, but the place does not encourage them to have more frequently. The street sometimes serves as the different function but not often.*	**2.0**	As the main street in CBD, there are lots of activities, like shopping, meeting friends, taking photos and sightseeing. Also, this street also serves for multiple functions.
	C10	***Culture Inheritance***	*3: All street elements, including the plants, street furniture, pavement, signs, and signals, are well designed and dedicatedly constructed so as to form as a whole to display high aesthetic quality. The streetscape is consistent with the surroundings, and not only inherits but also highlights local culture and historical characteristics.*	**2.5**	All street elements and sided buildings' façade are designed as a whole and show relatively high aesthetic quality. The overall streetscape can reflect the CBD characteristics.
Economics	***C11***	***Intensive Land Utilisation***	*1: Some of layout and usage of street space is reasonable while the others are not. So, a few of street furniture and facilities are designed for multifunctional usage while more of them are not.*	**1.3**	Century Avenue is 100 meters wide with10 travel lanes, spacious sidewalk and broad green belts. The overall land usage is not intensive.
	C12	***Efficiency***	*2: The traffic condition is good. The average density of the street network is relatively small, and the car speed is relatively high. Only a small part of the street is congested or blocked.*	**2.3**	The traffic condition is good in general.
	C13	***Business Creation***	*2: There are various businesses, including fixed businesses and temporary businesses, along most of the street.*	**2.3**	There are many businesses along the street.
	C14	***Job Creation***	*2: There are many different jobs created within the street space and the store on the first floor of the sided buildings.*	**2.3**	There are many jobs created in this street, not only limited the first floor of sided buildings.

C15	***Added-Value***	*2: The street can bring a certain of added-value to the land, real estate and business along the street.*	**2.3**	The street can bring considerable added-value to the land, real estate, and business according to published transaction data. *

**Data Source: Lianjia.Com*

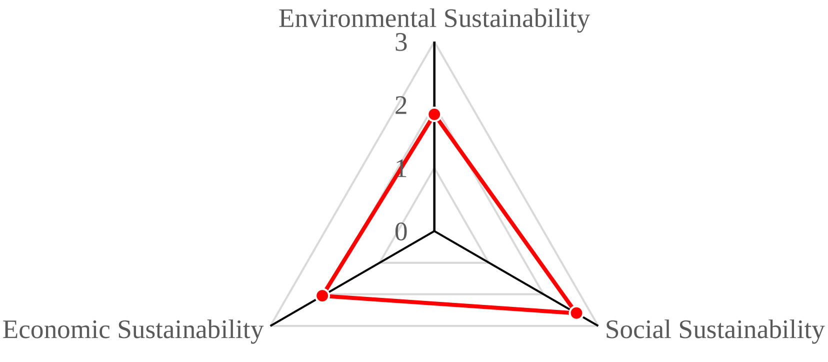

Figure II. 2: Radar Chart of C2-6 (Century Avenue) Sustainability Evaluation

Appendix Y: Evaluation Results of C3-8(Madang Rd)

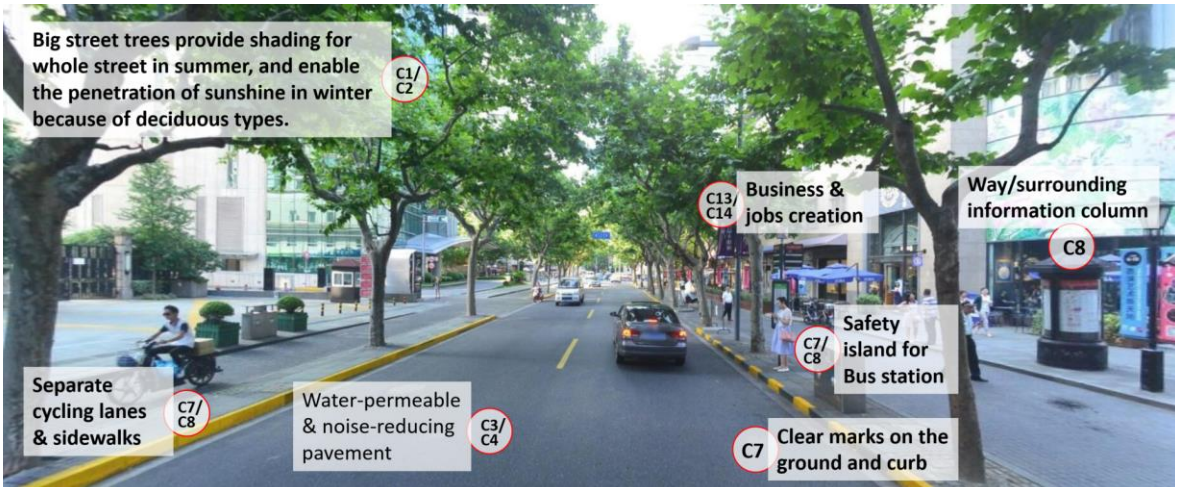

Figure KK. 1: Evaluation Illustration on On-Site Photo of C3-8(Madang Rd)

Table KK. 1: Sustainability Rating results of C3-8(Madang Rd)

Evaluation Criteria				Rating Results	
	Code	***Title***	***Closest Rating Level***	***Score***	***Explanation***
Environment	***C1***	***Adaptability***	*2: The street elements are designed according to local climate, and it can adapt to extreme weather events to some extent.*	**1.8**	The street plants are designed according to local climate, but it does not show strong adaptability to extreme weather events.
	C2	***Mitigation UHI***	*2: All street elements, including street plants, pavement, section design, shading facilities, are considered to mitigate the effect of Urban Heat Island; but it cannot be felt when walking on it during summer.*	**1.5**	The layout of street plants and shading is considered UHI mitigation, but the effect is not apparent during summer site investigation.
	C3	***Pollution Reduction***	*2: The street elements help to mitigate the pollution of air, noise, lighting, and waste to some extent, but still some pollution, such as dust, noise, or rubbish, can found in street.*	**1.8**	The street plants, garbage bins, and lighting system help to mitigate relevant pollution to some extent.
	C4	***Ecological Balance***	*2: The street layout and all elements can help to form urban wind corridor, rainfall water permeability or urban ecological diversity to some extent, but the traffic function is still dominant.*	**1.8**	The street can serve as a wind corridor and promote permeability to some extent, but the traffic function is still dominant.
	C5	***Green Life Promotion***	*2: The street supports green life, including jogging, walking, cycling and using public transportation.*	**1.5**	The street supports green life, and also sometimes there are posters or street activities to promote the green lifestyle.
Soci	***C6***	***Equality***	*3: The street provides reliable and convenient blind-pavement and barrier-free facilities. The width*	**2.8**	The street provides blind-pavement. Also, the width of sidewalk and height

			of sidewalk and height difference in intersections are considered the convenience of seniors as well as disabled people. This street can be used comfortably for all kinds of people.		difference in intersections are considered the convenience of all kinds of people.
	C7	***Safety***	*3: All street elements, including street signals, guide signs, safety islands, plants, street cameras, lighting system and section layout, help to guarantee street safety in each part of the street, especially the safety of pedestrian and cyclists. It can be called a very safe and reliable street.*	**2.8**	There are various ways to guarantee street safety, including guide signs, speed control, safety islands and street cameras. So, it can be called as a safe street.
	C8	***Accessibility***	*3: The street provides various ways of arrival, including walking, cycling, by bus, by railway as well as driving private cars. So, all of the arrival ways are convenient and comfortable.*	**3.0**	The street provides many arrival ways, like walking, cycling, driving, taking bus and subway. Also, all of the arrival ways are convenient and comfortable.
	C9	***Diversity***	*3: The street encourages and meets the demand of various public activities. It often serves as many different functions, such as transportation corridor, social space, commercial space, cultural hub, public space and ecological corridors. So, it can be called a very dynamic and diverse street.*	**3.0**	The street encourages various activities, such as meeting friends, shopping, café, photographing, and serve as many different functions, including a cultural hub, social space, and a commercial place.
	C10	***Culture Inheritance***	*3: All street elements, including the plants, street furniture, pavement, signs, and signals, are well designed and dedicatedly constructed so as to form as a whole to display high aesthetic quality. The streetscape is consistent with the surroundings, and not only inherits but also highlights local culture and historical characteristics.*	**3.0**	All street elements and the façade of sided buildings are designed as a whole and show aesthetic quality, which inherits and demonstrates the historical and cultural value of Shikumen as the traditional residential building in Shanghai
Economics	***C11***	***Intensive Land Utilisation***	*2：In general, most of layout and usage of the street space is relatively reasonable and efficient. Also, most of the street land and furniture are designed for multifunctional usage or time/space sharing.*	**2.0**	The layout and usage of the street space are relatively intensive and reasonable. The sided shops are sharing sidewalks during weekends for pavement café and product display without influencing pedestrians.
	C12	***Efficiency***	*2: The traffic condition is good. The average density of the street network is relatively small, and the car speed is relatively high. Only a small part of the street is congested or blocked.*	**2.3**	The traffic condition is good in general, but the intersections are often congested during rush hours.
	C13	***Business Creation***	*3: There are various businesses along the whole street, including fixed businesses (stores and shops) and temporary businesses (like street vendors and mobile food station).*	**3.0**	There are various businesses along the whole street

C14	***Job Creation***	*3: There are various jobs, such as salesmen, waitress, agent, craftsmen, officers, parking assistants, street vendors, are created not only within the street space and the store on the first floor of the sided buildings but also on the upper floors of the buildings along the street*	**3.0**	There are various jobs created not only within the street space and the store on the first floor of the sided buildings but also on the upper floors of the buildings along the street.
C15	***Added-Value***	*3: The street can bring considerable added-value to the surrounding areas, including the increase of commercial leases and rent, the price of real estate transaction and market sales, as well as the rental prices of street advertising positions.*	**3.0**	The street can bring considerable added-value to the surrounding areas. The price of commercial leases and real estate is higher along the street according to published transaction data. *

**Data Source: Lianjia.Com*

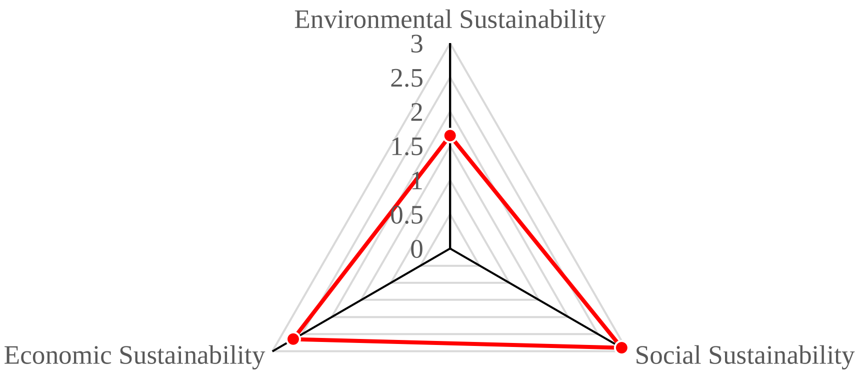

Figure KK. 2: Radar Chart of C3-8(Madang Rd) Sustainability Evaluation

Appendix Z: Evaluation Results of C4-7 (Xinhua Rd)

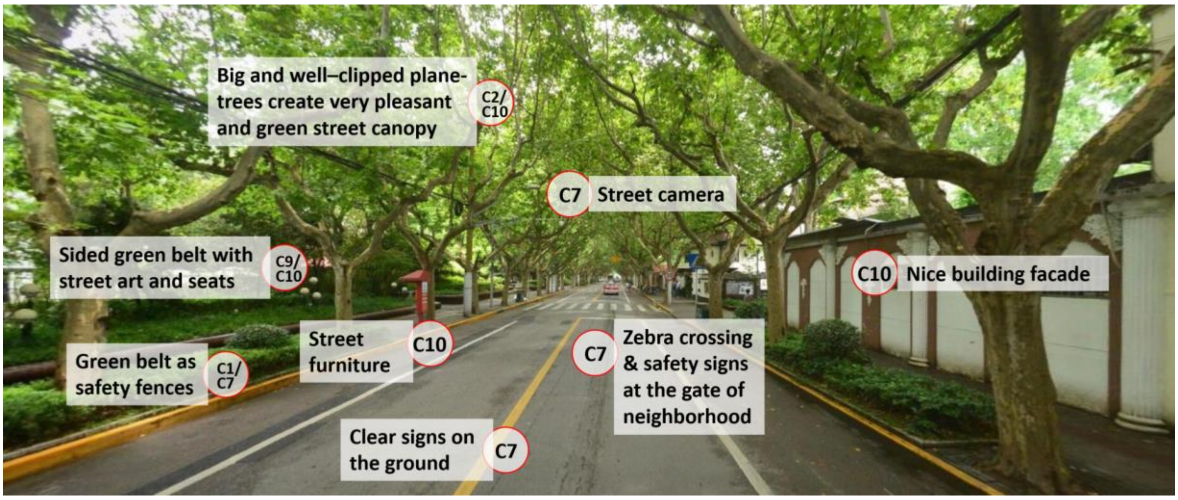

Figure MM. 1: Evaluation Illustration on On-Site Photo of C4-7 (Xinhua Rd)

Table MM. 1: Sustainability Rating results of C4-7 (Xinhua Rd)

Evaluation Criteria				**Rating Results**	
	Code	***Title***	***Closest Rating Level***	***Score***	***Explanation***
Environment	***C1***	***Adaptability***	*3: All street elements, including the choice of street plant, section layout, and all facilities, show strong adaptability to local climate type and extreme weather events. It can be a demonstration example.*	**2.5**	The street green, drainage system, all pavements and street vertical are designed according to Shanghai climate, and it can adapt to extreme weather event to some extent.
	C2	***Mitigation UHI***	*3: All street elements, including street plants, pavement, section design, shading facilities, show a significant consideration to UHI Mitigation and it can be easily felt the cooling effect when walking on it during summer.*	**2.8**	The layout of street plants is considered UHI mitigation, and it can be easily felt the cooling effect in summer during the site investigation.
	C3	***Pollution Reduction***	*3: All street elements, including street plants, pavement, speed control facilities, garbage bins, and lighting system, help to reduce the pollution of air, noise, lighting, and waste. It is a very quiet and clean street without any lighting pollution during the night.*	**2.8**	The high green rata, big street trees, and garbage bins help to mitigate relevant pollution. It is an elegant, quiet and peaceful street.
	C4	***Ecological Balance***	*3: The street layout and all elements, including permeable pavement, the choice of street plant and rainwater collection facilities, can contribute to ecological balance concerning urban wind corridor, rainfall water permeability as well as urban ecological diversity. So, it is a very natural and ecological street, and the traffic function cannot be felt obviously.*	**2.8**	The street layout, plants, and sided green space can contribute to ecological balance. It is a very natural and ecological street.

	C5	***Green Life Promotion***	*3: The street not only fully supports and encourages green lifestyle, such as jogging, walking, cycling and using public transportation, but also actively promotes the significance of environmental protection and sustainable life by advertisement posting and various street campaigns.*	**2.5**	The street supports green life. People would like to have jogging, cycling and physical exercises here. And sometimes there are also posters and campaigns for green life promotion.
Society	***C6***	***Equality***	*3: The street provides reliable and convenient blind-pavement and barrier-free facilities. The width of sidewalk and height difference in intersections are considered the convenience of seniors as well as disabled people. This street can be used comfortably for all kinds of people.*	**2.5**	The street provides blind-pavement on both sides, and the width of sidewalk and height difference in intersections are designed for the convenience of all kinds of people.
	C7	***Safety***	*3: All street elements, including street signals, guide signs, safety islands, plants, street cameras, lighting system and section layout, help to guarantee street safety in each part of the street, especially the safety of pedestrian and cyclists. It can be called a very safe and reliable street.*	**2.8**	There are various ways to guarantee street safety, including guide signs, speed control cameras, green belt garden and safety fences. So, it can be called a safe street.
	C8	***Accessibility***	*2: The street provides all arrival ways, but some of them are not convenient. For example, the bus station is too far away, or there is no car parking nearby.*	**1.8**	The street provides basic arrival ways.
	C9	***Diversity***	*2: The street can meet the demand of many different social activities, but the place does not encourage them to have more frequently. The street sometimes serves as the different function but not often.*	**1.5**	The street can meet the demand for various social activities. Taking a walk is the most common activities in this street.
	C10	***Culture Inheritance***	*3: All street elements, including the plants, street furniture, pavement, signs, and signals, are well designed and dedicatedly constructed so as to form as a whole to display high aesthetic quality. The streetscape is consistent with the surroundings, and not only inherits but also highlights local culture and historical characteristics.*	**2.8**	All street elements and sided buildings' façade are designed as a whole and show relatively high aesthetic quality. The overall streetscape can reflect the historical characteristics of French Concession.
Economics	***C11***	***Intensive Land Utilisation***	*2: In general, most of layout and usage of the street space is relatively reasonable and efficient. Also, most of the street land and furniture are designed for multifunctional usage or time/space sharing.*	**1.5**	In general, most of layout and usage of the street space is relatively reasonable and efficient.
	C12	***Efficiency***	*2: The traffic condition is good. The average density of the street network is relatively small and the car speed is relatively high. Only a small part of the street is congested or blocked.*	**2.0**	The traffic condition is good in general. But it is slightly congested during rush hours.
	C13	***Business Creation***	*2: There are various businesses, including fixed businesses and*	**1.5**	There are some businesses along the street.

		temporary businesses, along most of the street.		
C14	***Job Creation***	*2: There are many different jobs created within the street space and the store on the first floor of the sided buildings.*	**1.5**	There are some jobs created in this street, not only limited the first floor of sided buildings.
C15	***Added-Value***	*2: The street can bring a certain of added-value to the land, real estate and business along the street.*	**1.8**	The street can bring a certain of added-value to the land, real estate, and business according to published transaction data. *

**Data Source: Lianjia.Com*

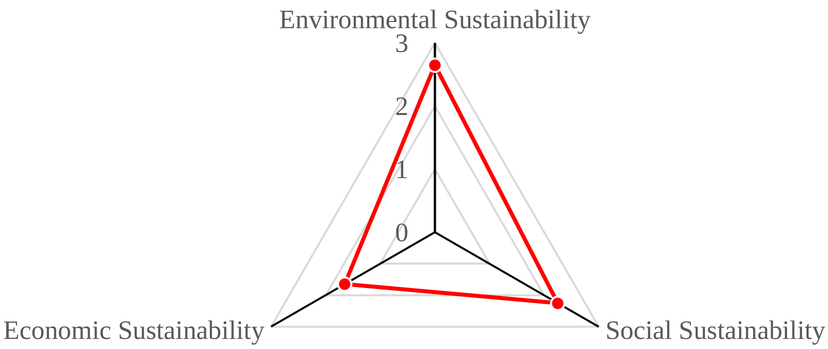

Figure MM. 2: Radar Chart of C4-7 (Xinhua Rd) Sustainability Evaluation

Appendix AA: Evaluation Results of C5-1 (Mengzi Rd)

Figure OO. 1: Evaluation Illustration on On-Site Photo of C5-1 (Mengzi Rd)

Table OO. 1: Sustainability Rating results of C5-1 (Mengzi Rd)

Evaluation Criteria				**Rating Results**	
	Code	***Title***	***Closest Rating Level***	***Score***	***Explanation***
Environment	***C1***	***Adaptability***	*2: The street elements are designed according to local climate, and it can adapt to extreme weather events to some extent.*	**1.8**	The street plants are designed according to Shanghai climate. However, it does not show strong adaptability to extreme weather events.
	C2	***Mitigation UHI***	*2: All street elements, including street plants, pavement, section design, shading facilities, are considered to mitigate the effect of Urban Heat Island; but it cannot be felt when walking on it during summer.*	**1.5**	Some street elements show the consideration of UHI mitigation, but the effect is not apparent during summer site investigation.
	C3	***Pollution Reduction***	*2: The street elements help to mitigate the pollution of air, noise, lighting, and waste to some extent, but still some pollution, such as dust, noise, or rubbish, can found in the street.*	**1.8**	The street plants, garbage bins, and lighting system help to mitigate relevant pollution to some extent, but the traffic noise is still apparent.
	C4	***Ecological Balance***	*2: The street layout and all elements can help to form urban wind corridor, rainfall water permeability or urban ecological diversity to some extent, but the traffic function is still dominant.*	**1.5**	The street can serve as a wind corridor and promote permeability to some extent, but the traffic function is still dominant.
	C5	***Green Life Promotion***	*2: The street supports green life, including jogging, walking, cycling and using public transportation.*	**1.5**	The street supports green life, and street provides relatively comfortable and safe environment for

					walking, cycling and taking public buses.
Society	***C6***	***Equality***	*2: The street provides blind-pavement and barrier-free facilities, but some of them are blocked or out of service. The width of sidewalk and height difference in the intersection is considered the usage of all kinds of people.*	**1.8**	The street provides blind-pavements and barrier-free facilities on both sides, but some are blocked by bike parking or damaged.
	C7	***Safety***	*3: All street elements, including street signals, guide signs, safety islands, plants, street cameras, lighting system and section layout, help to guarantee street safety in each part of the street, especially the safety of pedestrian and cyclists. It can be called a very safe and reliable street.*	**2.8**	Most of the street elements help to create a safe street, like guild signs, street cameras, and safety fences. It can be called a safe and reliable street.
	C8	***Accessibility***	*2: The street provides all arrival ways, but some of them are not convenient. For example, the bus station is too far away, or there is no car parking nearby.*	**1.8**	The street provides many arrival ways, like walking, cycling, taking buses and driving. But cycling lanes are often blocked by parked cars.
	C9	***Diversity***	*2: The street can meet the demand of many different social activities, but the place does not encourage them to have more frequently. The street sometimes serves as the different function but not often.*	**2.3**	The street can meet the demand of many street activities, and people like buying something in the stores along the street.
	C10	***Culture Inheritance***	*2: Most of the street elements look as a whole and show relatively high aesthetic quality. Also, the streetscape can reflect local culture or historical features to some extent.*	**1.8**	Most of the street elements look as a whole. In general, the streetscape is neat but ordinary.
Economics	***C11***	***Intensive Land Utilisation***	*2: In general, most of layout and usage of the street space is relatively reasonable and efficient. Also, most of the street land and furniture are designed for multifunctional usage or time/space sharing.*	**1.8**	Most of layout and usage of the street space is relatively reasonable and efficient. But it lacks the consideration of mix-use within street space.
	C12	***Efficiency***	*2: The traffic condition is good. The average density of the street network is relatively small and the car speed is relatively high. Only a small part of the street is congested or blocked.*	**1.8**	The traffic condition is good in general. Only some parts near intersections are slightly congested during rush hours.
	C13	***Business Creation***	*3: There are various businesses along the whole street, including fixed businesses (stores and shops) and temporary businesses (like street vendors and mobile food station).*	**2.5**	There are various businesses along part of the street.
	C14	***Job Creation***	*3: There are various jobs, such as salesmen, waitress, agent, craftsmen, officers, parking assistants, street vendors, are created not only within the street space and the store on the first floor of the sided buildings, but also on the upper floors of the buildings along the street*	**2.5**	There are many jobs created along the street.
	C15	***Added-Value***	*1: The street has neither positive nor negative influences on the value of*	**1.0**	The street has neither obviously positive nor negative influences on

	the land, real estate, and business along the street.	the sided commercial and residential buildings according to published transaction data. *

**Data Source: Lianjia.Com*

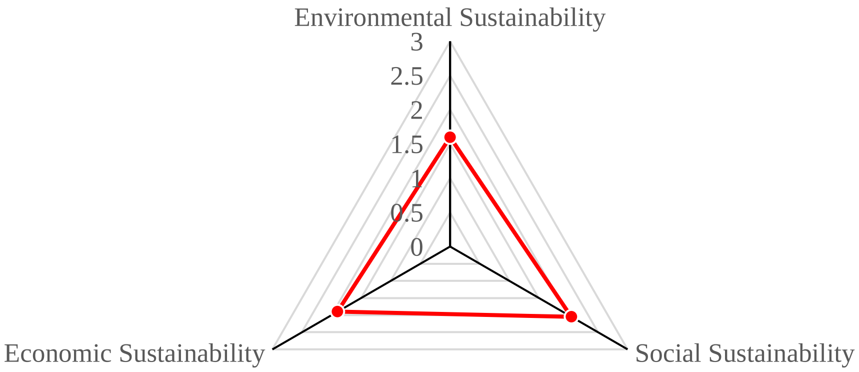

Figure OO. 2: Radar Chart of C5-1 (Mengzi Rd) Sustainability Evaluation

Appendix BB: Evaluation Results of C6-12 (Wanping Rd)

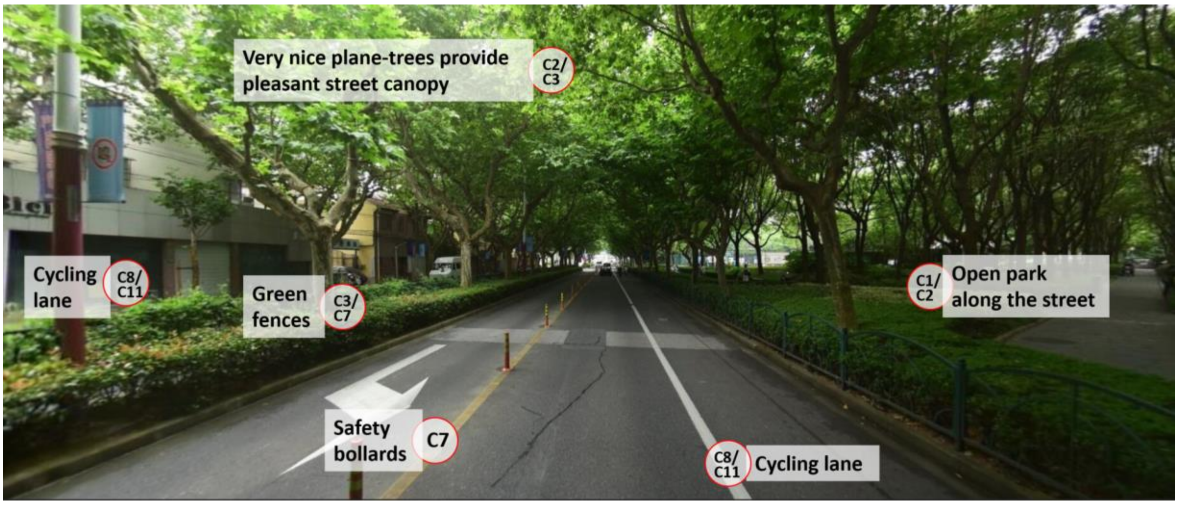

Figure QQ. 1: Evaluation Illustration on On-Site Photo of C6-12 (Wanping Rd)

Table QQ. 1: Sustainability Rating results of C6-12 (Wanping Rd)

Evaluation Criteria				Rating Results	
	Code	***Title***	***Closest Rating Level***	***Score***	***Explanation***
Environment	***C1***	***Adaptability***	*3: All street elements, including the choice of street plant, section layout, and all facilities, show strong adaptability to local weather and extreme weather events. It can be a demonstration example.*	**2.5**	The street green, drainage system, all pavements and street vertical are designed according to Shanghai climate, and it can adapt to extreme weather event to some extent.
	C2	***Mitigation UHI***	*3: All street elements, including street plants, pavement, section design, shading facilities, show a significant consideration to UHI Mitigation and it can be easily felt the cooling effect when walking on it during summer.*	**3.0**	The layout of street plants is considered UHI mitigation, and it can be easily felt the cooling effect in summer during the site investigation.
	C3	***Pollution Reduction***	*3: All street elements, including street plants, pavement, speed control facilities, garbage bins, and lighting system, help to reduce the pollution of air, noise, lighting, and waste. It is a tranquil and clean street without any lighting pollution during the night.*	**3.0**	The high green rata, big street trees, and garbage bins help to mitigate relevant pollution. It is an elegant, quiet and peaceful street.
	C4	***Ecological Balance***	*3: The street layout and all elements, including permeable pavement, the choice of street plant and rainwater collection facilities, can contribute to ecological balance concerning urban wind corridor, rainfall water permeability as well as urban ecological diversity. So, it is a very natural and ecological street, and the traffic function cannot be felt obviously.*	**3.0**	The street layout, plants, and sided green space can contribute to ecological balance. It is a very natural and ecological street.
	C5	***Green Life Promotion***	*3: The street not only fully supports and encourages green life, such as jogging, walking, cycling and*	**2.8**	The street supports the green lifestyle. People would like to have

			using public transportation, but also actively promotes the significance of environmental protection and sustainable life by advertisement posting and various street campaigns.		jogging, cycling and physical exercises here. And sometimes there are also posters and campaigns for green life promotion.
Society	***C6***	***Equality***	*3: The street provides reliable and convenient blind-pavement and barrier-free facilities. The width of sidewalk and height difference in intersections are considered the convenience of seniors as well as disabled people. This street can be used comfortably for all kinds of people.*	**2.8**	The street provides blind-pavement on both sides, and the width of sidewalk and height difference in intersections are designed for the convenience of all kinds of people.
	C7	***Safety***	*3: All street elements, including street signals, guide signs, safety islands, plants, street cameras, lighting system and section layout, help to guarantee street safety in each part of the street, especially the safety of pedestrian and cyclists. It can be called a very safe and reliable street.*	**2.8**	There are various ways to guarantee street safety, including guide signs, speed control cameras, green belt garden and safety fences. So, it can be called a safe street.
	C8	***Accessibility***	*3: The street provides various ways of arrival, including walking, cycling, by bus, by railway as well as driving private cars. So, all of the arrival ways are convenient and comfortable.*	**2.5**	The street provides various arrival ways, and all are convenient and comfortable.
	C9	***Diversity***	*2: The street can meet the demand of many different social activities, but the place does not encourage them to have more frequently. The street sometimes serves as the different function but not often.*	**2.0**	The street can meet the demand of many social activities.
	C10	***Culture Inheritance***	*3: All street elements, including the plants, street furniture, pavement, signs, and signals, are well designed and dedicatedly constructed so as to form as a whole to display high aesthetic quality. The streetscape is consistent with the surroundings, and not only inherits but also highlights local culture and historical characteristics.*	**2.5**	The overall streetscape is green and neat, which can both reflect the historical characteristics of this area and show the promotion of green life.
Economics	***C11***	***Intensive Land Utilisation***	*2: In general, most of layout and usage of the street space is relatively reasonable and efficient. Also, most of the street land and furniture are designed for multifunctional usage or time/space sharing.*	**1.8**	In general, most of layout and usage of the street space is reasonable and efficient.
	C12	***Efficiency***	*2: The traffic condition is good. The average density of the street network is relatively small and the car speed is relatively high. Only a small part of the street is congested or blocked.*	**1.8**	The traffic condition is good in normal time, but it is often congested during rush hours.
	C13	***Business Creation***	*1: There are only a few businesses, fixed shops or temporary businesses, along with part of the street.*	**0.8**	There are some businesses along the street.
	C14	***Job Creation***	*1: There are some jobs created within the street space or the store on the first floor of the sided buildings.*	**0.8**	There are some jobs created in this street.

C15	***Added-Value***	*2: The street can bring a certain of added-value to the land, real estate and business along the street.*	**1.8**	The street can bring a certain of added-value to the land, real estate, and business according to published transaction data. *

**Data Source: Lianjia.Com*

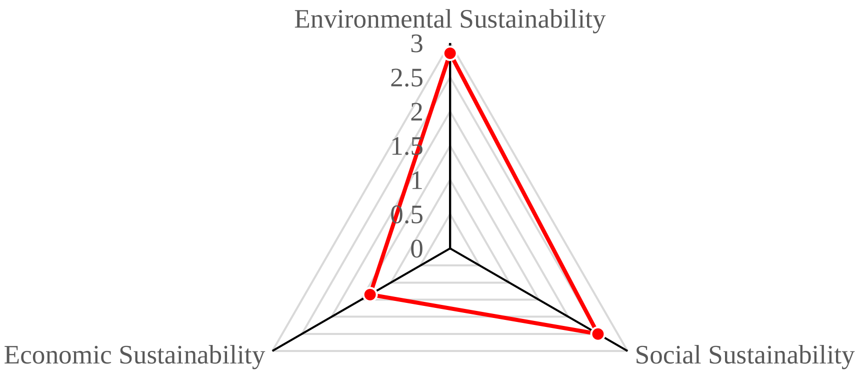

Figure QQ. 2: Radar Chart of C6-12 (Wanping Rd) Sustainability Evaluation

Appendix CC: Evaluation Results of C7-8 (Yunjin Rd)

Figure SS. 1: Evaluation Illustration on On-Site Photo of C7-8 (Yunjin Rd)

Table SS. 1: Sustainability Rating results of C7-8 (Yunjin Rd)

Evaluation Criteria				Rating Results	
	Code	***Title***	***Closest Rating Level***	***Score***	***Explanation***
Environment	***C1***	***Adaptability***	*3: All street elements, including the choice of street plant, section layout, and all facilities, show strong adaptability to local weather and extreme weather events. It can be a demonstration example.*	**2.8**	The street trees and other elements are designed according to local climate, and it can adapt to extreme weather events to some extent.
	C2	***Mitigation UHI***	*3: All street elements, including street plants, pavement, section design, shading facilities, show a significant consideration to UHI Mitigation and it can be easily felt the cooling effect when walking on it during summer.*	**2.8**	The high green rate within this street trees can help for UHI mitigation, but the cooling effect is not apparent in summer site visit.
	C3	***Pollution Reduction***	*2: The street elements help to mitigate the pollution of air, noise, lighting, and waste to some extent, but still some pollution, such as dust, noise, or rubbish, can found in the street.*	**1.8**	The street plants, garbage bins, and lighting system help to mitigate the pollution to some extent.
	C4	***Ecological Balance***	*3: The street layout and all elements, including permeable pavement, the choice of street plant and rainwater collection facilities, can contribute to ecological balance concerning urban wind corridor, rainfall water permeability as well as urban ecological diversity. So, it is a very natural and ecological street, and the traffic function cannot be felt obviously.*	**2.5**	The street can serve as an urban wind corridor. The street trees, flower beds, and rain gardens help for water penetration.
	C5	***Green Life Promotion***	*3: The street not only fully supports and encourages green lifestyle, such as jogging,*	**2.5**	The street provides support for the green lifestyle, such as jogging,

			walking, cycling and using public transportation, but also actively promotes the significance of environmental protection and sustainable life by advertisement posting and various street campaigns.		walking, and cycling. There is also some demonstration garden for publicity of rain garden.
Society	***C6***	***Equality***	*2: The street provides blind-pavement and barrier-free facilities, but some of them are blocked or out of service. The width of sidewalk and height difference in the intersection is considered the usage of all kinds of people.*	**1.8**	The street provides blind-pavement on the sidewalk, and the width of sidewalk and height difference in intersections are considered the convenience of all kinds of people. But some part of sidewalks is a bit narrow for disable chair.
	C7	***Safety***	*3: All street elements, including street signals, guide signs, safety islands, plants, street cameras, lighting system and section layout, help to guarantee street safety in each part of the street, especially the safety of pedestrian and cyclists. It can be called a very safe and reliable street.*	**2.8**	The majority of street elements, like green fences in sidewalks, help to create a safe street. The guide signs and traffic signals are clear and efficient. So, it can be called a safe and street.
	C8	***Accessibility***	*3: The street provides various ways of arrival, including walking, cycling, by bus, by railway as well as driving private cars. So, all of the arrival ways are convenient and comfortable.*	**2.8**	The street provides various ways of arrival. But there is no public bus line and bus station in this street.
	C9	***Diversity***	*2: The street can meet the demand of many different social activities, but the place does not encourage them to have more frequently. The street sometimes serves as the different function but not often.*	**1.5**	The street can meet the demand of many social activities, and there is also some open space along the street. But there are few people in this street due to its location and no houses nearby.
	C10	***Culture Inheritance***	*2: Most of the street elements look as a whole and show relatively high aesthetic quality. Also, the streetscape can reflect local culture or historical features to some extent.*	**1.5**	Most of the street elements look as a whole. The streetscape is neat but lifeless. It shows a newly-constructed feature.
Economics	***C11***	***Intensive Land Utilisation***	*1: Some of layout and usage of street space is reasonable while the others are not. So, a few of street furniture and facilities are designed for multifunctional usage while more of them are not.*	**1.0**	In general, some of layout and usage of the street space is reasonable.
	C12	***Efficiency***	*2: The traffic condition is good. The average density of the street network is relatively small, and the car speed is relatively high. Only a small part of the street is congested or blocked.*	**2.3**	The traffic condition is good in general.
	C13	***Business Creation***	*1: There are only a few businesses, fixed shops or temporary business, along with part of the street.*	**0.8**	There are very few businesses along the street.
	C14	***Job Creation***	*1: There are some jobs created within the street space or the*	**0.8**	There are few jobs created along this street.

		store on the first floor of the sided buildings.		
C15	***Added-Value***	*1: The street has neither positive nor negative influences on the value of the land, real estate, and business along the street.*	**1.0**	The street has neither positive nor negative influences on the value of the land, real estate and business along the street according to published transaction data. *

**Data Source: Lianjia.Com*

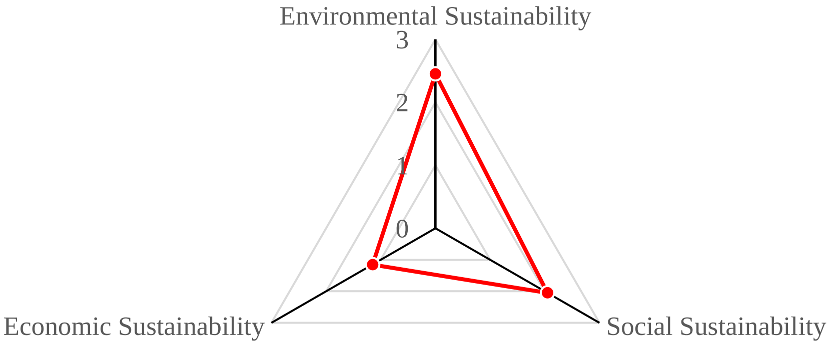

Figure SS. 2: Radar Chart of C7-8 (Yunjin Rd) Sustainability Evaluation

Appendix DD: Statistics of 236 streets Evaluation

Evaluation Items	C1- Adaptability	C2-Mitigation UHI	C3- Pollution Reduction	C4- Ecological Balance	C5- Green Life Promotion	C6- Equality	C7- Safety	C8- Accessibility	C9-Diversity	C10-Culture Inheritance	C11-Intensive land utilisation	C12-Efficiency	C13-Business Creation	C14- Job Creation	C15-Added-Value	*SSI*
	EnSI					***ScSI***					***EcSI***					
Average of 236 Streets	1.42	1.41	1.61	1.25	1.45	1.51	1.95	1.90	1.49	1.59	1.55	1.83	1.41	1.37	1.32	**23.06**
	1.43					***1.69***					***1.49***					
Average of 24 BEST streets	1.94	2.02	2.17	1.85	2.02	2.41	2.64	2.41	2.16	2.45	1.91	2.05	2.11	2.08	2.28	**32.49**
	2.00					***2.41***					***2.09***					
Average of 24 WORST streets	0.56	0.36	0.50	0.43	0.65	0.57	1.15	1.26	0.83	0.79	1.05	1.61	0.85	0.81	0.53	**11.97**
	0.50					***0.92***					***0.97***					
Best Case (C3-8 Madang Rd)	1.75	1.50	1.75	1.75	1.50	2.75	2.75	3.00	3.00	3.00	2.00	2.25	3.00	3.00	3.00	**36.00**
	1.65					***2.90***					***2.650***					
Worst Case (C7-2 Jichangxi Rd)	0.00	0.75	0.75	0.75	0.00	0.00	0.00	0.00	0.00	0.00	1.25	0.00	0.00	0.00	0.00	**3.50**
	0.45					***0.00***					***0.25***					
M1	1.65	1.87	1.98	1.62	1.40	1.65	1.96	1.79	1.46	1.60	1.60	1.75	1.29	1.25	1.15	**24.02**
	1.70					***1.69***					***1.41***					
M2	1.50	1.46	1.52	1.27	1.52	1.19	1.40	1.77	1.38	1.33	1.35	1.75	1.52	1.40	1.15	**21.50**
	1.45					***1.41***					***1.43***					
M3	1.20	1.09	1.14	0.91	1.32	1.14	1.86	1.59	1.29	1.16	1.29	1.86	0.91	0.77	0.86	**18.38**
	1.13					***1.41***					***1.14***					
M4	1.39	1.46	1.72	1.25	1.61	1.53	2.01	1.82	1.54	1.72	1.60	1.85	1.46	1.40	1.38	**23.74**
	1.49					***1.73***					***1.54***					
M5	1.23	0.91	0.98	0.75	0.95	0.55	1.57	2.07	1.36	1.39	1.45	1.68	1.75	1.64	1.34	**19.61**

Evaluation Items	C1- Adaptability	C2-Mitigation UHI	C3- Pollution Reduction	C4- Ecological Balance	C5- Green Life Promotion	C6- Equality	C7- Safety	C8- Accessibility	C9-Diversity	C10-Culture Inheritance	C11-Intensive land utilisation	C12-Efficiency	C13-Business Creation	C14- Job Creation	C15-Added-Value	*SSI*
			EnSI					***ScSI***					***EcSI***			
			0.96					***1.39***					***1.57***			
M6	1.30	1.11	1.50	1.05	1.32	1.52	1.73	1.80	1.50	1.55	1.48	1.77	1.61	1.52	1.32	**22.07**
			1.25					***1.62***					***1.54***			
M7	1.19	1.27	1.56	1.10	1.21	1.33	2.06	1.85	1.04	1.37	1.38	1.94	0.83	0.85	0.98	**19.94**
			1.27					***1.53***					***1.20***			
M8	1.52	1.42	1.77	1.20	1.57	1.65	2.00	2.40	1.50	1.53	1.57	1.90	1.37	1.33	1.35	**24.07**
			1.49					***1.82***					***1.50***			
M9	1.68	1.68	1.90	1.53	1.71	1.76	1.99	1.84	1.31	1.53	1.53	1.81	1.06	1.04	1.38	**23.74**
			1.70					***1.69***					***1.36***			
M10	1.63	1.56	1.88	1.42	1.44	1.79	2.08	1.92	1.56	1.63	1.58	1.90	1.19	1.17	1.60	**24.33**
			1.58					***1.80***					***1.49***			
M11	1.73	1.48	2.02	1.65	1.62	2.08	2.31	1.94	1.42	1.69	1.46	1.81	1.00	1.00	1.48	**24.69**
			1.70					***1.89***					***1.35***			
M12	0.90	0.90	0.95	0.60	1.20	0.70	1.48	1.90	1.50	1.38	1.65	1.78	1.98	1.95	1.38	**20.23**
			0.91					***1.39***					***1.75***			
M Avg.	1.43	1.38	1.61	1.22	1.43	1.44	1.89	1.89	1.40	1.50	1.50	1.82	1.30	1.25	1.28	**22.34**
			1.41					***1.63***					***1.43***			
C1	1.20	1.21	1.43	1.11	1.46	1.79	2.14	1.84	1.98	2.04	2.09	1.84	1.91	1.88	1.66	**25.57**
			1.28					***1.96***					***1.88***			
C2	1.65	1.45	1.75	1.55	1.38	2.28	2.40	2.40	1.65	1.80	1.50	2.00	1.78	1.78	1.88	**27.23**
			1.56					***2.11***					***1.79***			
C3	1.67	1.69	1.85	1.46	1.79	1.87	2.15	2.23	1.90	2.15	1.92	1.90	2.12	2.12	1.88	**28.71**

Evaluation Items	C1- Adaptability	C2-Mitigation UHI	C3- Pollution Reduction	C4- Ecological Balance	C5- Green Life Promotion	C6- Equality	C7- Safety	C8- Accessibility	C9-Diversity	C10-Culture Inheritance	C11-Intensive land utilisation	C12-Efficiency	C13-Business Creation	C14- Job Creation	C15-Added-Value	*SSI*
	EnSI					***ScSI***					***EcSI***					
	1.69					***2.06***					***1.99***					
C4	1.50	1.75	1.83	1.50	1.64	1.53	1.83	1.86	1.78	1.94	1.58	1.81	1.47	1.47	1.22	**24.72**
	1.64					***1.79***					***1.51***					
C5	1.05	1.38	1.43	0.90	1.35	1.18	1.90	1.63	1.28	1.25	1.48	1.75	1.43	1.40	0.73	**20.10**
	1.22					***1.45***					***1.36***					
C6	1.44	1.58	1.52	1.35	1.60	1.60	2.08	1.94	1.67	1.94	1.52	1.83	1.52	1.50	1.46	**24.56**
	1.50					***1.85***					***1.57***					
C7	1.44	1.22	1.44	1.28	1.19	1.25	1.94	1.56	1.17	1.06	1.22	1.67	0.81	0.81	0.67	**18.72**
	1.32					***1.39***					***1.03***					
C Avg.	1.42	1.47	1.60	1.31	1.50	1.66	2.08	1.94	1.67	1.78	1.66	1.83	1.62	1.61	1.41	**24.56**
	1.46					***1.82***					***1.63***					

Appendix EE: Data Sheet of Questionnaire Results

Questionnaire NO.		Answer Time (Sec.)	Environmental Sustainability					Social Sustainability					Economic Sustainability				
			C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
Raw data	1	120	4	4	4	5	4	5	5	5	5	5	5	5	5	4	4
	2	259	4	4	5	4	5	5	4	5	5	5	3	4	4	4	5
	3	78	4	4	3	3	4	4	5	5	5	5	4	4	5	4	4
	4	106	4	4	5	4	4	5	4	4	4	4	4	4	4	4	4
	5	65	5	3	3	3	5	5	5	5	4	4	4	4	4	3	3
	6	214	3	4	4	4	4	4	5	5	5	5	4	4	4	4	4
	7	114	5	4	4	4	3	5	5	5	4	4	3	4	3	2	2
	8	330	3	3	3	5	5	5	5	5	5	4	4	4	3	2	4
	9	135	2	5	5	2	5	5	5	5	5	4	3	2	4	4	4
	10	152	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	11	103	5	3	4	5	4	5	5	5	5	4	5	3	5	3	5
	12	155	3	4	5	4	4	4	5	4	4	4	2	2	4	2	2
	13	108	5	5	5	5	4	5	5	4	4	5	4	5	4	4	3
	14	164	4	4	5	5	5	3	4	3	4	4	5	5	4	4	3
	15	357	5	4	3	3	4	4	5	4	5	4	5	4	4	3	4
	16	141	5	3	5	5	5	5	5	4	5	4	5	5	5	5	5
	17	158	3	3	4	4	4	5	4	4	4	4	4	2	4	5	4
	18	64	4	4	4	4	4	4	4	4	4	4	4	5	4	5	4
	19	104	4	5	4	4	4	5	3	4	4	4	4	4	4	4	3
	20	89	5	4	5	5	5	5	5	5	5	5	5	4	5	5	5
	21	141	4	5	5	3	3	4	5	5	3	3	3	4	4	4	3
	22	526	3	3	3	4	3	5	5	5	5	4	5	5	4	4	4
	23	278	5	4	3	5	5	4	5	5	5	5	5	5	3	3	5
	24	192	4	4	5	5	5	5	5	5	4	5	3	4	3	4	4
	25	96	5	5	5	5	3	5	5	5	4	5	3	1	4	4	2
	26	93	4	3	4	4	5	5	4	3	4	4	5	4	3	2	3
	27	60	4	3	4	3	5	5	5	4	4	4	4	4	4	4	4
	28	59	5	5	5	4	4	4	5	4	4	4	4	3	3	3	3

Questionnaire NO.		Answer Time (Sec.)	Environmental Sustainability					Social Sustainability					Economic Sustainability				
			C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
Raw data	*29*	*181*	*5*	*5*	*4*	*4*	*4*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*2*	*3*
	30	*60*	*5*	*4*	*5*	*5*	*5*	*5*	*5*	*5*	*4*	*4*	*5*	*5*	*5*	*4*	*4*
	31	*251*	*4*	*3*	*3*	*3*	*3*	*4*	*5*	*5*	*5*	*4*	*3*	*5*	*5*	*5*	*3*
	32	*67*	*3*	*4*	*2*	*4*	*5*	*5*	*5*	*4*	*5*	*3*	*3*	*4*	*4*	*1*	*1*
	33	*163*	*4*	*5*	*5*	*4*	*5*	*5*	*4*	*5*	*5*	*5*	*5*	*3*	*4*	*4*	*4*
	34	*167*	*4*	*4*	*5*	*4*	*5*	*5*	*4*	*4*	*4*	*5*	*4*	*3*	*4*	*4*	*4*
	35	*88*	*4*	*5*	*5*	*4*	*2*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*
	36	*128*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*
	37	*145*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*
	38	*65*	*4*	*3*	*3*	*4*	*4*	*4*	*5*	*5*	*5*	*5*	*4*	*4*	*4*	*3*	*5*
	39	*64*	*4*	*4*	*4*	*4*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*4*	*4*
	40	*117*	*4*	*4*	*4*	*3*	*3*	*5*	*5*	*5*	*4*	*4*	*4*	*3*	*4*	*3*	*4*
	41	*80*	*4*	*2*	*4*	*3*	*3*	*4*	*5*	*5*	*5*	*4*	*5*	*5*	*4*	*3*	*4*
	42	*78*	*5*	*3*	*3*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*4*	*5*
	43	*109*	*4*	*2*	*4*	*4*	*4*	*5*	*5*	*3*	*4*	*5*	*3*	*3*	*4*	*3*	*3*
	44	*69*	*3*	*4*	*4*	*4*	*4*	*4*	*4*	*5*	*5*	*5*	*3*	*4*	*4*	*5*	*5*
	45	*79*	*3*	*3*	*3*	*3*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*
	46	*130*	*5*	*3*	*4*	*4*	*4*	*4*	*5*	*5*	*4*	*3*	*4*	*3*	*4*	*2*	*4*
	47	*373*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*
	48	*80*	*3*	*3*	*3*	*4*	*4*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*
	49	*83*	*1*	*2*	*1*	*1*	*1*	*1*	*1*	*1*	*2*	*2*	*1*	*1*	*2*	*2*	*1*
	50	*82*	*5*	*3*	*4*	*3*	*3*	*5*	*5*	*5*	*5*	*5*	*4*	*3*	*5*	*4*	*4*
Descriptive Analysis	**Average**	142.40	**4.08**	**3.82**	**4.06**	**4.00**	**4.16**	**4.60**	**4.68**	**4.54**	**4.50**	**4.38**	**4.12**	**3.98**	**4.18**	**3.72**	**3.84**
	Median	111.5	4	4	4	4	4	5	5	5	5	4	4	4	4	4	4
	Statistical Mode	78	4	4	5	4	5	5	5	5	5	5	5	5	4	4	4
	Standard Deviation	94.65	0.90	0.87	0.93	0.88	0.91	0.73	0.71	0.79	0.65	0.70	0.94	1.08	0.72	1.05	1.04
	Variance	8780.24	0.79	0.75	0.86	0.76	0.81	0.52	0.50	0.61	0.41	0.48	0.87	1.14	0.51	1.08	1.05
	Kurtosis	5.15	1.52	-0.70	0.87	1.49	1.70	11.33	14.16	7.37	3.02	1.41	1.04	0.76	0.41	-0.34	0.69
	Skewness	2.05	-1.01	-0.20	-0.88	-0.91	-1.14	-2.75	-3.22	-2.28	-1.37	-1.03	-0.99	-1.05	-0.61	-0.60	-0.90
	Max.	526	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Questionnaire NO.		Answer Time (Sec.)	Environmental Sustainability					Social Sustainability					Economic Sustainability				
			C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
	Min.	59	1	2	1	1	1	1	1	1	2	2	1	1	2	1	1
	Sum	7120	204	191	203	200	208	230	234	227	225	219	206	199	209	186	192