A Study on the Spatial Composition and Characteristics of the Beijing Private Gardens during the Qing Dynasty of China

中国清代における

北京市の私家園林空間構成及び特徴に関する研究

August 2023

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（千葉大学審査学位論文）

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CONTENTS

Chapter 1

Preface

1 Background

China has a distant origin and a long development of building gardens. The construction of palaces and gardens began as early as three thousand years ago[1]. In addition, China has a vast territory, spanning multiple different climate zones, with winding and steep mountains, meander rivers and long coasts, and dense plants. Through the accumulation of historical culture, time and geographical environment, a broad and profound style system such as traditional Chinese gardens has been nurtured[2]. The overall style characteristics of traditional Chinese gardens can be summarized as follows: 1. Originating from nature but above nature, 2. The fusion of architectural and natural beauty; 3. The charm of poetry and painting; 4. The connotation of artistic conception[2]. It is a type of garden that artificially excavates water bodies, constructs mountains and rockeries, and is equipped with facilities such as corridors, pavilions and paths to enjoy the simulated natural scenery in a limited space.

As the last mature period of Chinese traditional gardens (CTGs), the Qing Dynasty witnessed the development of gardens from a prosperous period to a fully mature state full of creative and enterprising spirit. Most of the well-preserved gardens that we can see today were built or rebuilt during this period. From a geographical perspective, on the one hand, the royal gardens centered on different dynastic capitals such as Beijing, Chang'an, Luoyang, and Kaifeng are magnificent and unique, leading the trend. On the other hand, private gardens with different local styles, represented by Jiangnan, North China, Central China, Sichuan, and Lingnan, excel in their respective fields[3]. The imperial gardens, owned by the emperor and the royal family, tend to have grand scales, balanced layouts, symmetrical designs and luxurious decorations, reflecting a majestic and solemn atmosphere. Due to the personal political and economic limitations of

garden owners, private gardens are smaller in scale, more flexible in layout, and rich in spatial diversity.

Figure 1- 1 Comparison of Traditional Gardens in North and South (Left: Master of the Nets Garden, Center: Summer Palace, Right: Gongwangfu Garden)

Moreover, private gardens in northern and southern China exhibit significant differences due to variations in regional climate and living culture. The southern climate is humid and hot, with beautiful and delicate mountains and rivers, this make it's very easy to build a pool or pond. The garden style features winding spaces, simple and elegant colors, and slender buildings, exuding an overall delicate and exquisite temperament. Conversely, in the north, influenced by its dry and cold climate and grand mountains and rivers, gardens showcase spacious and tidy spaces, thick colors and simple layouts, evoking a dignified atmosphere[4)].

As the ancient capital of four dynasties, Beijing not only had a prosperous royal garden construction, but also gathered bureaucrats, nobles, literati, wealthy businessmen, and wealthy merchants, resulting in private gardens spreading all over the capital. Excellent gardening techniques from all over

the country were assembled, making it a representative of private gardens in the north. Bureaucrats and literati once built a large number of private gardens in Beijing, particularly Suzhou and Yangzhou[3)], resulting in a large number of distinct gardens with their unique characteristics in terms of mountain stacking, water management, architecture, and garden path configuration. These gardens are spacious, neat, and solemn in layout, yet friendly and pleasant in function, and embody local culture in a profound manner.

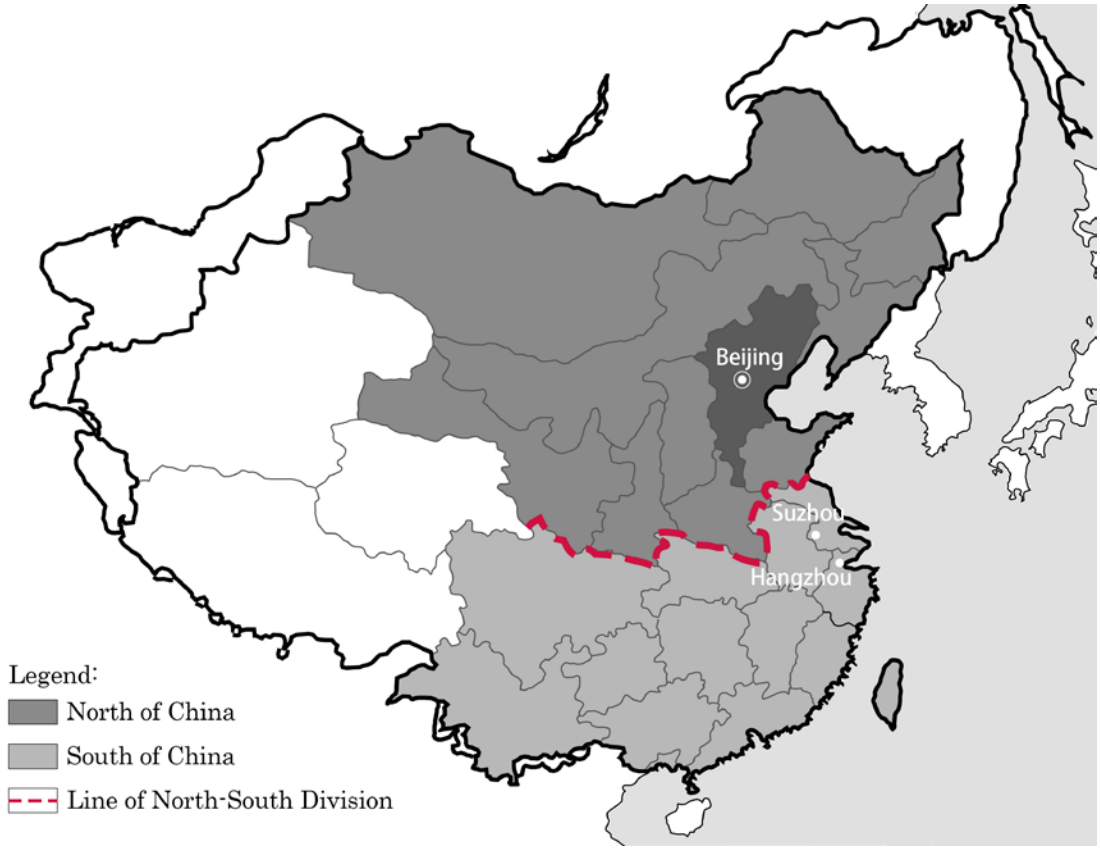

Figure 1- 2 The Location of Beijing in the Qing Dynasty

2 Review of Beijing's Traditional Private Gardens

Currently, most research on traditional Chinese gardens focuses on the royal gardens in the north and the private gardens in the south, while relatively few studies have been conducted on the equally prosperous private gardens in Beijing, and the research findings are relatively

fragmented. Overall, the study of Beijing's traditional private gardens (BTPGs) has undergone a process from shallow to deep. Initially, the focus was on exploring the characteristics of the gardens, followed by surveys and photography in the middle period, and later on the preliminary exploration of the formal characteristics and causes of the gardens.

In 1937, scholar Han Xi compiled the *Yandu Famous Garden Records*, which sorted out the private gardens in Beijing during the Yuan, Ming, and Qing dynasties[5]. In 1940, Chinese scholar Chen published an article titled *Prince Kung's Palace and Its Adjoining Garden in Peking*, which was the first to discuss in detail the historical evolution and artistic features of the Gongwangfu Garden in Beijing [6]. Then in 1949, Osvald Siren's *Gardens of China* systematically introduced the naturalness, landscape, architecture, garden paths, plants, and other elements of traditional Chinese gardens, including several private gardens in Beijing. However, research on private gardens in Beijing has since developed from basic exploration to in-depth studies of formal characteristics and causes of these gardens[7].

Since then, the BTPGs have continued to receive attention from local government and industry scholars. From 1954 to 1964, authoritative organizations such as the Beijing Municipal Planning Administration and the China Academy of Building Research conducted simple renovations on existing gardens in the urban area of Beijing, such as Chunwangfu Garden, Guichunzhai Garden, Zhenbeizifu Garden, and Banmu Garden. They conducted photography and surveying, but many precious photos and images were lost due to political turmoil and personnel changes. In 1978, academician Wang Juyuan, the founder of the Chinese gardening profession, conducted research on seven private gardens including Gongwangfu Garden, Najia Garden, and Ke Garden, and drew a schematic diagram[8]. In 1988, Hou Renzhi conducted a textual research on the gardens of princes and aristocrats in the Qing Dynasty on the campus of Peking University,

and included it in the book *Yanyuan Historical Tales* [9].

Since the 1980s, the study of traditional private gardens in Beijing has been greatly advanced. Both *History of Ancient Chinese Gardens* and *History of Chinese Classical Gardens* by Wang Juyuan and Zhou Weiquan have separate chapters on the history of private gardens in Beijing, analyzing their characteristics[2, 10]. This greatly promoted research on private gardens in Beijing at that time. Professor Jia Jun has also contributed significantly to the study of private gardens in Beijing, publishing over 30 articles in core Chinese publications such as Chinese Landscape Architecture, and authoring the book *Record of Private Garden in Beijing*. This book not only analyzes the historical origin, gardening ideas, garden life, cultural connotation, and protection measures of private gardens in Beijing but also conducts detailed textual research on 29 typical garden examples from the Ming, Qing, and Ming dynasties. Overall, the research on BTPGs has high academic value and important reference significance[3].

During this period, scholars such as Wang Yue and Wang Wei analyzed the characteristics of plants in five private gardens in Beijing[11, 12]. Zhang conducted a quantitative study on the scale, accessibility, and topological network characteristics of the garden paths in eight private gardens in Beijing[13]. Lei sorted out the protection process and current situation of private gardens in the urban area of Beijing, finding that most of the gardens have been damaged and there are many problems in their protection and management[14]. Zhang, Huang, Hao used Wangfu Garden as an example to summarize the spatial form, plant characteristics, and Fengshui theory in the garden[15-17]. Wang Yao focused on the historical overview, gardening art, and evolution process of the gardens on the campus of Peking University[18]. These studies have greatly enriched the understanding of BTPGs and their characteristics.

3 Research Purpose and Significance

While previous scholars have made valuable contributions, overall the research on private gardens in Beijing has been relatively weak in terms of depth and breadth. There are many gaps in the research methods, content, and results. Much of the research has relied on summarizing and sorting out characteristics based on previous studies, and the results are often determined subjectively by researchers without the support of mathematical analysis. As a result, it is difficult to compare with the research on royal gardens and private gardens in the south, and the research on private gardens in Beijing does not reflect their historical significance and artistic achievements.

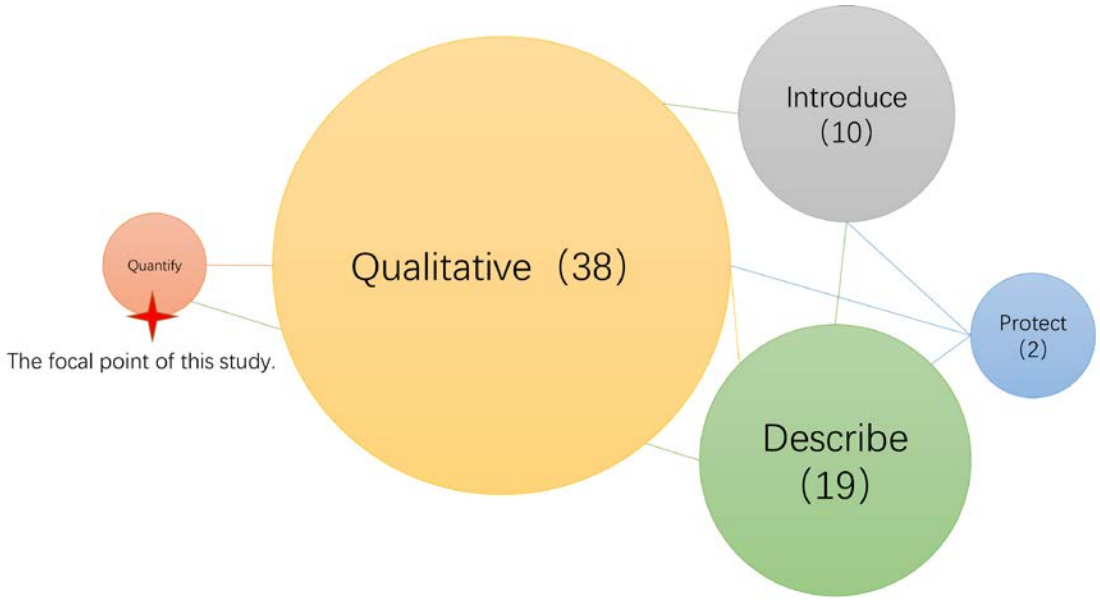

Figure 1- 3 The Location of This Study in Relevant Studies

Based on the aforementioned research status, this study aims to achieve the following three objectives:

1. Develop indicators, methods, and systems that can quantify the private gardens in Beijing during the Qing Dynasty.

2. Clarify the spatial composition characteristics of private gardens in Beijing during the Qing Dynasty based on the quantitative results obtained

from the gardens.

3. Create a spatial model of private gardens in Beijing during the Qing Dynasty, analyze the causes and differences based on the social background at that time, and summarize the findings.

The quantitative approach adopted in this study provides a more objective and scientific way to summarize the spatial characteristics and genetic mechanisms of Beijing's private gardens in Qing Dynasty, thus avoiding the potential bias of the researcher's subjective perspective. Moreover, the use of quantitative indicators in this research draws on the findings of studies on traditional Chinese and Japanese gardens, modern parks, and urban green spaces, among others. This comprehensive quantification and evaluation of garden characteristics offers a more complete and diverse perspective on the topic. Finally, the graphic representation of the spatial characteristics of gardens is an innovative approach that effectively summarizes the spatial forms of private gardens in Beijing, making it easy for readers to understand and disseminate. Overall, this research is of significant importance in promoting the publicity, protection, and research of Beijing's private gardens in Qing Dynasty.

4 Research Objects

Currently, there is no clear and widely accepted definition of private gardens, and the categories are often determined based on the scope of royal gardens. For instance, Zhou proposed that private gardens refer to those that belong to folk nobles, bureaucrats and gentry, and can be called gardens, garden pavilions, garden villas, pool pavilions, mountain villas, thatched cottages, etc[2)]. Similarly, Jia provided a similar definition, stating that private gardens originally refer to gardens owned by private individuals. Alternatively, it may be mansion gardens or villa gardens used and lived in by private individuals and their families for a long time, not

limited to property rights in a narrow sense[3)].

This study adopts the definition of private gardens proposed by Zhou and Jia, which includes gardens owned by folk nobles, bureaucrats, and gentry, such as garden pavilions, garden villas, pool pavilions, mountain villas and thatched cottages, etc. The scope of private gardens in this study is not limited to property rights in a narrow sense. In the Qing Dynasty, many gardens of princes and nobles were rewarded by the emperor, and although the property rights still belonged to the emperor, the construction, repair, and use of the gardens were decided by the princes and nobles. These gardens are also regarded as private gardens in this study. However, small and simple internal gardens in courtyard houses in the Beijing area are not included in the study because they are part of the residence and not strictly considered a garden（Figure 1- 2）.

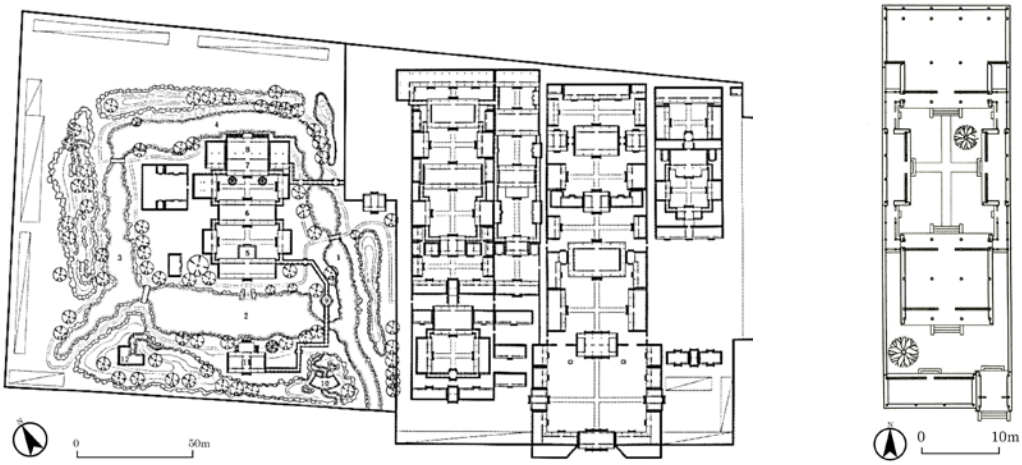

Figure 1- 4 The Plan of Chunwangfu Garden (Left) and Yuewei Caotang Garden (right)

According to the above definition of the scope of private gardens in Beijing and the garden information, this study establishes the research objects based on the following three principles:

① Need to comply with the research scope of private gardens in Beijing during the Qing Dynasty;

② The construction or rebuild period of the garden was during the Qing

Dynasty, with a style that reflects the garden craftsmen of the Qing Dynasty;

③ Basic information (garden size, owner's identity, garden period, location and utilization) is detailed and reliable.

Finally, 14 gardens were established as the final research objects (Table 1-1). And their owners status / occupation, construction Ways, location, construction period, scale and preservation status were confirmed and summarized. Based on the research of review, the historical plans of 14 gardens were organized (Figure 1-3).

Table 1- 1 Determination of Research Objects

No.	Name	Owner	Ways	Location	Period	Scale	Preservation Status
1	Chunwangfu	RN	RB	IN	TZ	25262.3	Basically intact.
2	Gongwangfu	RN	RB	IN	TZ	27800.1	Basically intact.
3	Langrun	RN	RB	OUT	XF	78414.4	Mountains, waters, and plants exist.
4	Qinghua	RN	RB	OUT	DG	89412.5	Most buildings and few mountains, waters and plants exist.
5	Chengze	RN	RB	OUT	DG	22301.2	Some buildings and water systems exist.
6	Taobeilefu	RN	RB	IN	GX	10570.9	Most of elements are well preserved.
7	Zhenbeizifu	RN	NB	IN	GX	14479.3	Few buildings, rockeries, plants exist.
8	Gunbeizifu	RN	RB	IN	GX	13879.5	Most buildings,mountains and waters are preserved.
9	Liwang	RN	RB	OUT	GX	18053.3	Few buildings, mountains and waters exist.
10	Banmu	OP	RB	IN	DG	3038.4	All dismantled.
11	Guichun	OP	NB	IN	GX	5011.2	All dismantled.
12	Zang	OP	RB	IN	GX	3242.3	All dismantled.
13	Ke	OP	NB	IN	XF	4115.0	Basically intact
14	Najia	OP	NB	IN	GX	5754.5	Few pavilions , rockeries and stones exist.

Owner: status / occupation of the garden owner. RN : royal or nobility, OP: officials or politicians

Location: The location of the gardens in Beijing. IN: inside of the city, OUT: outside of the city.

Period: construction period. DG (Daoguang):1821—1850, XF (Xianfeng):1851—1861, TZ (Tongzhi):1862—1874, GX (Guangxu):1875—1908, XT (Xuantong):1909—1912.

Ways: construction Ways. NB : newly built, RB : rebuilt.

Scale: square meters (m^2).

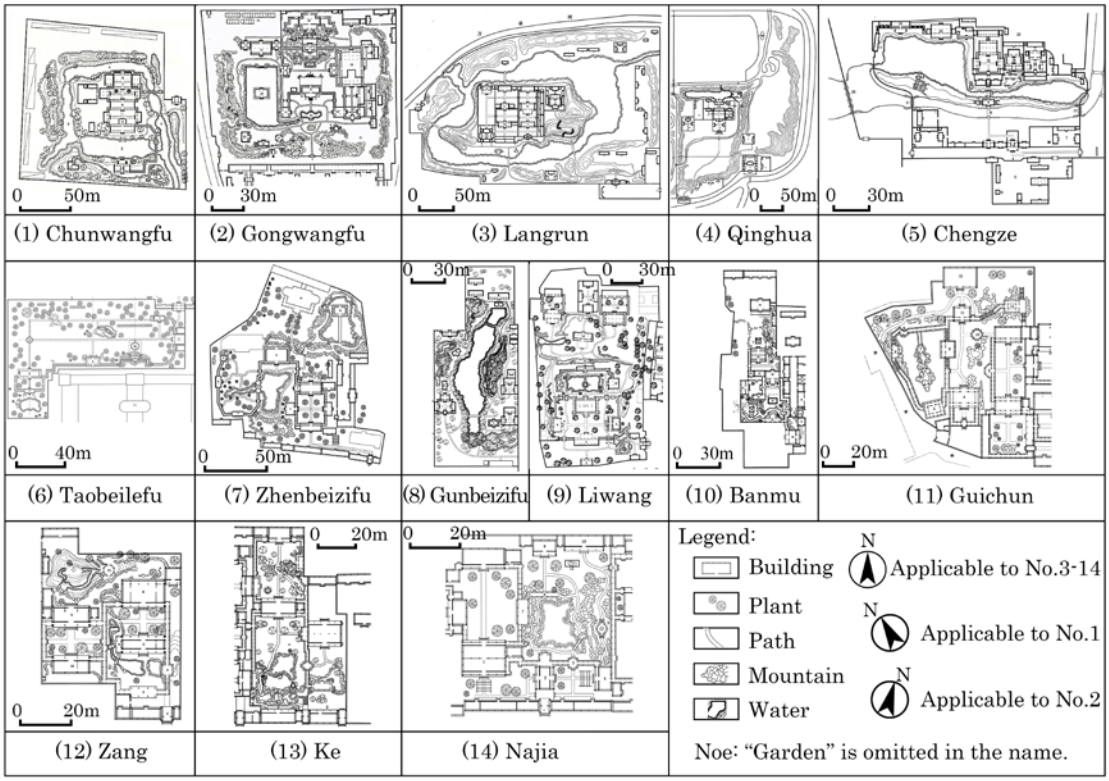

Figure 1- 5 Historical Plans of the Study Objects

By sorting out the elements information of the 14 gardens, it can be found that the data of layout, scale, and type of buildings, mountains ,waters and paths can all be obtained through analysis and measurement. However, the literature review fails to provide information on plant distribution in Langrun Garden, Qinghua Garden, and Chengze Garden. Even gardens with distribution information of plants, such as Chunwangfu Garden and Gongwangfu Garden, lack specific details on plant size, height and type. In addition, due to limitations in the capacity of this paper, it is challenging to discuss the characteristics of the buildings, mountains, waters, paths, plants, or other garden elements of each of the 14 gardens individually. Based on the above considerations, this study aims to conduct a

comprehensive examination of the buildings, mountains, waters, and paths of 14 gardens. In future research, the scope of research will expand to the characteristics of plants in Beijing private gardens, which will supplement the content of this papers.

5 Methodology

5.1 Literature Review

By visiting the Beijing Capital Library, the books, annals, and reports related to Beijing private gardens during the Qing Dynasty were collected. In the Web of science, China National Knowledge Infrastructure (CNKI), National Institute of Informatics (CiNii), Google Scholar and other web search engines, the keywords such as "Beijing", "private", "garden" and "traditional" were used in pairs to research papers and journals of Beijing private garden during the Qing Dynasty. Finally, 4 early annals, 17 related books of Beijing private garden, and 49 highly cited and influential journals and papers were collected (Table 1-2). Most of them introduce Beijing private gardens in Qing Dynasty through case sharing and life events.

Table 1- 2 Literature Statistics

Types	Names	Authors	Years	Language
Annals	The Yearbook of Beijing Garden	Dequan Xu	1990	Chinese
	The Yearbook of Beijing Garden	Dequan Xu	1991	Chinese
	The Yearbook of Beijing Garden	Dequan Xu	1992	Chinese
	The Yearbook of Beijing Garden	Dequan Xu	1993	Chinese
Books	Tian Zhi Ou Wen	Jun Zhen	1907	Chinese
	Gardens of China	Sirén, Osvald	1949	English
	Lv Yuan Cong Hua	Yong Qian	1979	Chinese
	Yuanlin Congtan	Congzhou Chen	1983	Chinese
	Analysis of The Traditional Chinese Garden	Yigang Peng	1986	Chinese
	The Gardens of Beijing	Hong Lin	1990	Chinese
	Yandu Congkao	Zongfan Chen	1991	Chinese
	Beiing Yuanlin Shihua	Xinghua Zhao	2000	Chinese
	Annals of Tsinghua University	Huijian Fang	2001	Chinese

	History of Ancient Chinese Gardens	Juyuan Wang	2006	Chinese
	History of Chinese Classical Gardens	Weiquan Zhou	2008	Chinese
	Yanyuan Historical Tales	Renzhi Hou	2008	Chinese
	Record of Private Garden in Beijing	Jun Jia	2009	Chinese
	The Private Gardens of North Chain	Jun Jia	2013	Chinese
	Beijing Gudian Yuanlinshi	Linhuai Li	2016	Chinese
	Beiing Yuanlin Shi	Yan Dong	2019	Chinese
	Research on Ancient Northern Private Gardens	Jun Jia	2019	Chinese
Journal	Prince Kung's Palace and its adjoining garden in Peking	H.-S. Ch'ên	1940	English
	Collection of Essays on Forestry and Garden History	Juyuan Wang	1980	Chinese
	A Preliminary Study of Beijing's Houses and Gardens in the Qing Dynasty	Juyuan Wang	1983	English
	Fine Buildings in Simple Styleand Elegant Rockeries in Wonderful Layout-A Studythe Garden of Ma Huitang sResidence in Beiing	Jun Jia	2003	Chinese
	The Layout Characteristics of Northern Gardens	Tingfeng Liu	2004	Chinese
	The Natural Characteristics of Northern Gardens	Tingfeng Liu	2004	Chinese
	Private Gardens in Northern of China	Tingfeng Liu	2004	Chinese
	The humanistic spirit of Northern Gardens	Tingfeng Liu	2004	Chinese
	Garden of A Book Collector-Study on Cangyuan in Beljing	Jun Jia	2005	Chinese
	Research on Private Gardens of Beijing	Dayu Zhang	2006	Chinese
	Private Gardens in Beijing in Yuan and Ming Dynasty	Jun Jia	2007	Chinese
	Rockeries in the Private Gardens in Beiing	Jun Jia	2007	Chinese
	Buildings in the Private Gardens in Beijing	Jun Jia	2007	Chinese
	The Water Feature Design Art in the Private Gardens in Beijing	Jun Jia	2007	Chinese
	Study of Jiyuan in West Suburb of Beijing	Jun Jia	2007	Chinese
	Langrunyuan in West Suburban of Beijing	Jun Jia	2007	Chinese
	Study on the garden of Prince Zhen in Shishahai，Beiiing	Jun Jia	2007	Chinese
	The Study on Private Gardens in Beijing during the Qing Dynasty	Jun Jia	2008	Chinese
	The Inscribed Boards and Couplets in the Private Gardens of Beijing	Jun Jia	2008	Chinese
	Site Selection of the Private Gardens in Beijing	Jun Jia	2008	Chinese

	Exploring the Social and Cultural Connotation of Private Gardens in Beijing	Jun Jia	2008	Chinese
	An Introduction for Tthe Research on Private Gardens in Beijing	Jun Jia	2008	Chinese
	Influences of Living Activities on Gardening in Private Gardens in Beijing	Jun Jia	2008	Chinese
	Study on fhe Garden of Guichun Resjdence，Beiiing	Jun Jia	2008	Chinese
	Study on Taobeile's Garden in Beijing	Jun Jia	2008	Chinese
	Study on the Chengzeyuan Garden	Jun Jia	2008	Chinese
	Survey and Analysis of the Conservation Situation of the PrivateGardens in Beijing	Jun Jia	2009	Chinese
	Plant Landscapes in the Private Gardens in Beijing	Jun Jia	2010	Chinese
	Study on the Garden of Hao's Residence in Beijing	Jun Jia	2010	Chinese
	Re-research on the History of the Three Gardens in Peking University	Wei Geng	2011	Chinese
	The Courtyard Greening and Private Gardens of Beijing Siheyuan	Weiwei Li	2011	Chinese
	Research on Path Scapes in Beijing Private Gardens	Changle Zhang	2012	Chinese
	Study on Heritage Gardens in Peking University	Yao Wang	2012	Chinese
	Study on Garden Art of Cuijin Garden	Can Huang	2012	Chinese
	A Study on Plant Landscape in Beijing Private Garden	Yue Wang	2013	Chinese
	A Study on the Architecture and Spatial Morphology of the Mansion Buildings of Princesand Dukes Inherited Within the Same Rank of Nobility in Qing Dynasty in Beijing	Xin Shen	2014	Chinese
	Classical Courtyard Houses of Beijing: Architecture as Cultural Artifact	Donia Zhang	2015	Chinese
	Research on Space Morphology of the Gardens of Prince’ s Mansion in Beijing in Qing Dynasty	Liwei Zhang	2016	Chinese
	The Enlightenment of Private Gardens and Water Art in the Western Suburbs of Beijing on the Construction of Sponge Cities	Xinyuan Liu	2016	Chinese
	Research on the Architecture Spatial Form of Prince's Mansion Building in Qing Dynasty in Beijing	Fan Qiu	2016	Chinese

	The Fengshui Theory of Prince Gong ' s Mansion and it' s Garden	Qian Dong	2016	Chinese
	The research on Situation Theory and Management of Gas Theory in the mansion of monarch in Qing Dynasty	Shaobo Hao	2018	Chinese
	Study on the Protection and Utilization of Private Gardens in Beijing Old City	Hongxiang Lei	2019	Chinese
	Study on the Spatial Organization Feature of Private Garden in Three Hills and Five Gardens Area by the Influence of Multi-cultural	Xinze Wu	2019	Chinese
	Exploration of Traditional Gardening Techniques of Suitability of Private Gardens in Beijing	Jun Jia	2020	Chinese
	Analysis of Living and Recreational Activities in Beijing Private Gardens	Jun Jia	2021	Chinese
	Relationship between the Water Pattern and Cultural Heritage in Three Hills and Five Gardens Region	Yanzhi Sun	2021	Chinese
	Research on Water Adaptability Landscape in the Three Mountains and Five Gardens Area from the Perspective of Regional Landscape	Lei Xu	2021	Chinese
	Wanliutang-A Famous Private Garden in Qing-dynasty Beijing	Jun Jia	2021	Chinese

5.2 Satellite Imagery

Calibrating historical survey maps using actual garden samples is crucial for correcting any scale distortions. However, due to severe destruction, only a few traditional private gardens in Beijing have been preserved. Additionally, the COVID-19 pandemic has made fieldwork challenging, with many areas closed off. To overcome these limitations, this study utilized historical satellite imagery to calibrate the survey maps. By identifying key features like buildings, landscapes, road networks, and boundaries that were left behind, the true scale of the historical survey maps was determined, and their specific dimensions were calibrated.

5.3 Analytical Methods

After calibrating the historical survey maps, this study used AutoCAD 2015 software to create digital versions. ArcGIS 10.8.2, Fragstats, and DeepMap software were employed to determine the scale and layout of various elements within the gardens. Building, mountains, waters and paths types were identified based on historical survey maps and documentation. Next, using the indicators mentioned above, factor analysis was conducted using SPSS 25.0 software to reduce the number of indicators. Systematic clustering analysis was then used to categorize the garden samples, with similar garden types grouped together until all garden samples were classified. Microsoft Excel software was used to perform statistical analysis of the garden indicators between groups, thereby clarifying the differences in garden features. For complex and quantitative parameters and indicators, linear regression and correlation analysis were employed to determine causality. For parameters and indicators that are easy to understand and qualitative, the distribution and aggregation of attributes such as garden owners' characteristics, construction period, construction Ways, and location in each group were analyzed to determine the causal mechanism of garden features between groups.

6 Research Framework

This study mainly elaborates on the spatial characteristics of BTPGs from the scale, form, and layout characteristics of buildings, mountains and waters, and paths. It also interprets the causes of differences in garden characteristics from four aspects: the status / occupation of the garden owner, construction period, construction method, and garden location in Beijing city. The specific research composition is shown in the following figure (Figure 1- 4).

In the first chapter, the research background, current status, objectives, and significance of studying private gardens in Beijing are presented. The objects and content of the study are clarified, and the research methods and structure are formulated.

The second chapter introduces the construction and distribution of private gardens in Beijing during the early, middle, and late Qing Dynasty. Combining the social culture, economic situation, and geographical environment of that time, the causes of the distribution pattern of private gardens are explained. Finally, the preservation status of private gardens in Beijing is summarized.

The third chapter explores the spatial characteristics of private gardens in Beijing from the perspective of architecture. By analyzing the scale, layout type, and orientation angle of the buildings, 14 private gardens in Beijing are grouped into three types of building layouts within the gardens using clustering analysis.

Chapter fourth explores the spatial characteristics of BTPGs based on the mountains and waters elements. According to the scale, form, and layout type of the mountains and waters, three mountains and waters construction modes and four spatial prototypes of BTPGs were identified using factor analysis and systematic clustering.

The fifth chapter provides a comprehensive analysis of three types of garden paths found in Beijing traditional gardens, focusing on their characteristics. The study employs correlation and factor analysis techniques to integrate 28 quantitative path indicators into five key aspects: average length, scale, network connectivity, width, and aggregation. These 28 indicators can be summarized using six primary metrics: average connection length, number of path sections, alpha index, average width, average tortuous angle, and concentration degree. Finally, based on the six representative indicators, three forms of garden path layout were confirmed

for traditional private gardens in Beijing.

Chapter sixth summarizes and sorts out the results of the three core chapters of buildings, mountains and waters and paths. This part also elaborates on the influence of the garden owner' occupation, the construction method, the garden location, and the construction period on the formation of the style characteristics of private gardens in Beijing.

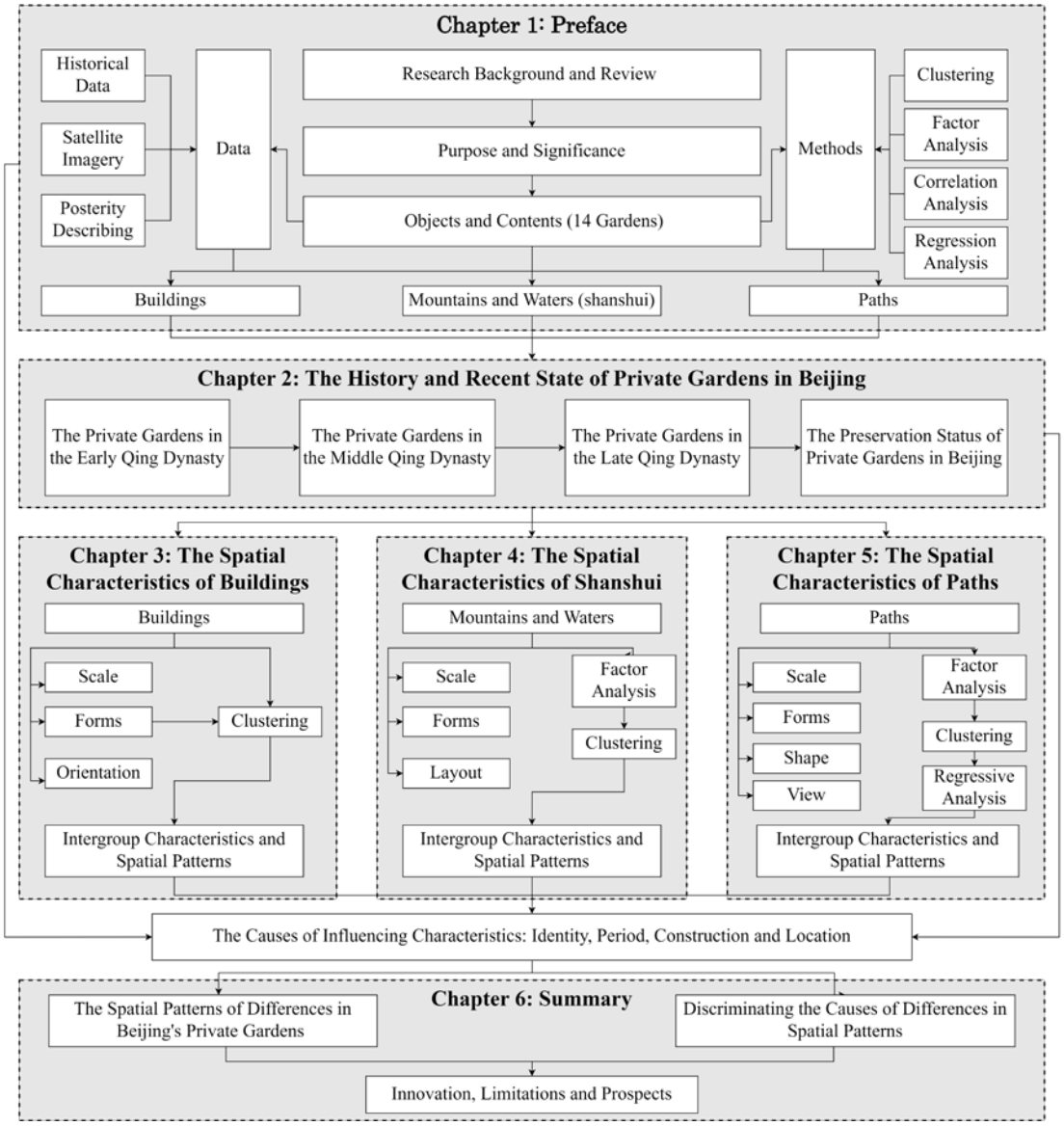

Figure 1- 6 Research Framework

Reference:

1)Peng, Y. (1986): Analysis of The Traditional Chinese Garden, China Architecture & Building Press.

2)Zhou, W. (1999): History of Chinese Classical Gardens, Tsinghua University Press, pp.1-18, 374.

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9)Hou, R., et al. (1988): Yanyuan Historical Tales, Peking University Press.

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11)Yue, W. (2013): A Study on Plant Landscape in Beijing Private Garden, Beijing Forestry University.

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13)Changle, Z. (2012): Research on Path Scapes in Beijing Private Gardens Nanjing Agricultural University.

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15)Liwei, Z. (2016): Research on Space Morphology of the Gardens of Prince's Mansion in Beijing in Qing Dynasty, Beijing University of Civil Engineering and Architecture.
16)Can, H. (2012): Study on Garden Art of Cuijin Garden, Beijing Forestry University.
17)Shaobo, H. (2018): The Research on Situation Theory and Management of Gas Theory in the mansion of monarch in Qing Dynasty, Tianjin University.
18)Yao, W. (2012): Study on Heritage Gardens in Peking University, Beijing Forestry University.

Chapter 2

The History and Recent State of Beijing's Private Gardens during the Qing Dynasty

The Qing Dynasty was the last peak period of the Chinese classical gardens and also the peak period of private gardening in Beijing. According to the division of the Qing Dynasty period by Zhou and Jia[1, 2], this study defines the reign period from Emperor Shunzhi to Emperor Kangxi as the early Qing Dynasty (1643-1722), the period from Emperor Yongzheng to Emperor Daoguang as the middle Qing Dynasty (1723-1850), and the period from Emperor Xianfeng to Emperor Xuantong as the late Qing Dynasty(1851-1912). In order to provide a more comprehensive introduction to the gardening cultural, achievements, and distribution characteristics of three periods in the Qing Dynasty, this section has sorted out all historical gardens recorded in literature review and plotted the distribution plans of gardens in Beijing.

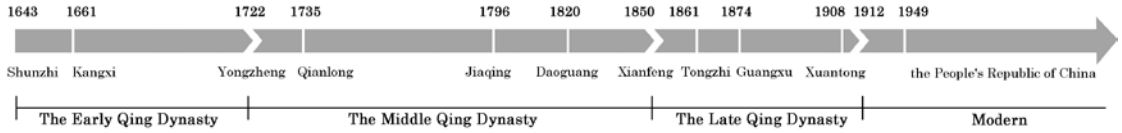

Figure 2- 1 Dividing the Periods of the Qing Dynasty

1 The Early Qing Dynasty (1643-1722)

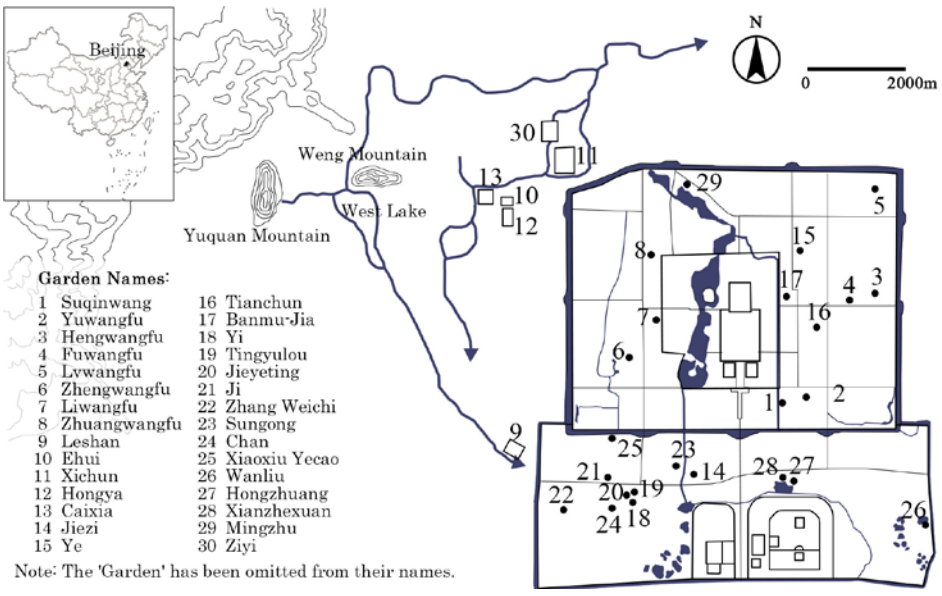

Figure 2- 2 The Location of BTPGs in the Early Qing Dynasty

In 1644, the Ming Dynasty was overthrown and the Qing army entered the border, still designated Beijing as the capital, and ended the turbulent era that lasted for more than 30 years. During the war, most of gardens in Beijing were destroyed or disappeared, making it very difficult to investigate and repair them. In the early Qing Dynasty, the entire city of Beijing was in a state of cultivation and restoration. The garden construction projects from Emperor Shunzhi to the early Emperor Kangxi period mostly focused on repairing Ming Dynasty palaces, altar temples, as well as imperial gardens such as Xiyuan Garden and Nanyuan Garden, with less vitality for new garden construction. Therefore, there were few new built private gardens recorded during this period[2, 3]. Until the middle of Emperor Kangxi's reign, the world gradually calmed down and the economy began to recover. Emperor Kangxi began to build Xiangshan Palace, Chengxin Garden, and Changchun Garden in the western suburbs of Beijing, triggering the first climax of the imperial gardens construction in the Qing Dynasty. At the same time, the construction of private gardens began to enter a prosperous period.

In the early Qing Dynasty, the law implemented the separation of Eight Banners and civilians for living in different regions of Beijing. The Eight Banners are stationed in the inner part (north) of Beijing in different directions, while Han officials and civilians can only reside in the outer part (south) of Beijing[4]. This also indirectly lead to the princes, nobility, nobles, and high-ranking officials of the Eight Banners occupying various major mansions in the inner city, and built numerous gorgeous gardens such as Liwangfu Garden, Zhengwangfu Garden, Yuwangfu Garden, etc. At the same time, a large number of private gardens for Han officials in the outer city also emerged, such as Wanliu Garden, Yi Garden, Chan Garden, Ji Garden, Jieyeting Garden, Banmuyuan Jia Garden, Feng Garden, and so on, all of which were well-known at that time.

With the further development of society, the contradiction between the differentiation of the Manchu Nationality and Han Nationality has become increasingly prominent, in order to win over Han intellectuals and ease the conflicts between the ethnic groups. In order to win over Han intellectuals and alleviate the conflicts between the two nationalities[5], Emperor Kangxi began to pay attention to learning Han culture and recruiting talents from all over the world. The Manchu nobilities and ministers also followed suit and showed great respect to Han literati. These literati mostly came from the southern regions and formed an important cultural influence in Beijing. They often had a high level of appreciation for garden design, and wrote couplets or designed mountains and waters for the Banmu Garden, Wanliu Garden and Yi Garden, which became an important cultural phenomenon of the time and also reflected the influence of the southern literati on the style of Beijing's private gardens in the early Qing dynasty.

The spatial design technique of Wanliu Garden was sparse and atmospheric. There are ten thousand willow trees planted in the garden, with few other miscellaneous plants. The spatial framework was built with soil mountains and artificially excavated pools, emphasized the natural form of mountains and rivers, making it full of wild appearance[6] (Figure 2-3 Left). Yi Garden and Wanliu Garden were adjacent, but their styles were completely different. Yi Garden was famous for its spacious and magnificent landscape, with cleverly constructed water systems that resemble nature. The rockeries were either towering or plain, full of changes[3, 7] (Figure 2- 3 Right). They represent two different tendencies of Beijing's private gardens: simplicity and elegance, as well as richness and grandeur. The garden-making had both reached a high level, but due to the lack of historical records, their features and style can only be felt from the scattered written records.

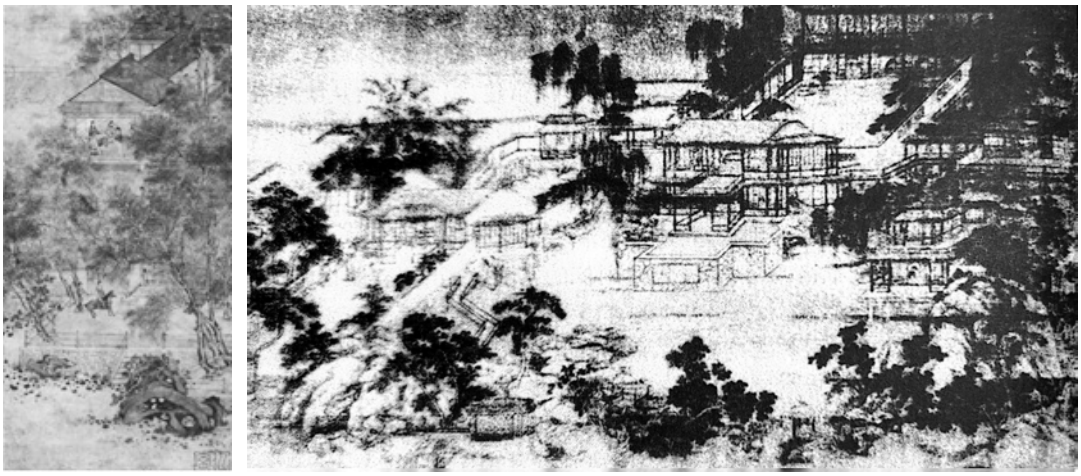

Figure 2- 3 Historical Images of Wanliu (Left) and Yi Garden (Right)

Among the research objects, only Banmu Garden and the eastern half of Qinghua Garden (Xichun Garden) were new built during this period. The Banmu Garden was built by Governor Jia of Shanxi in the early Qing Dynasty. After several changes in ownership, it was once designated as a warehouse, and the waters in the garden were also filled. Its early appearance was greatly damaged, and it was not rebuilt until the late Qing Dynasty when it was under the ownership of Linqing. The appearance of this period can only be known from the description of the garden owner Lin Qing. The garden was designed by Li Yu, a literati came from Jiangnan of China, with rockeries and marshes. The reception platform and hall are spacious and bright (Figure 2- 4)[8, 9].

Xichun Garden was built in the 46th year of Emperor Kangxi's reign (1707). And the Qinghua Garden as eastern half of Xichun Garden, was relatively minor compared to its western side. The number of buildings was not large, and the outdoor space was relatively spacious (Figure 2-5). Afterwards, Xichun Garden continued to change ownership and was once included in the imperial garden as a subsidiary of Old Summer Palace. In the second year of the Daoguang reign (1822), Xichun Garden was divided into two parts: Hande Garden and Chunze Garden, respectively. During the reign of Emperor Xianfeng, Hande Garden was renamed Qinghua Garden.

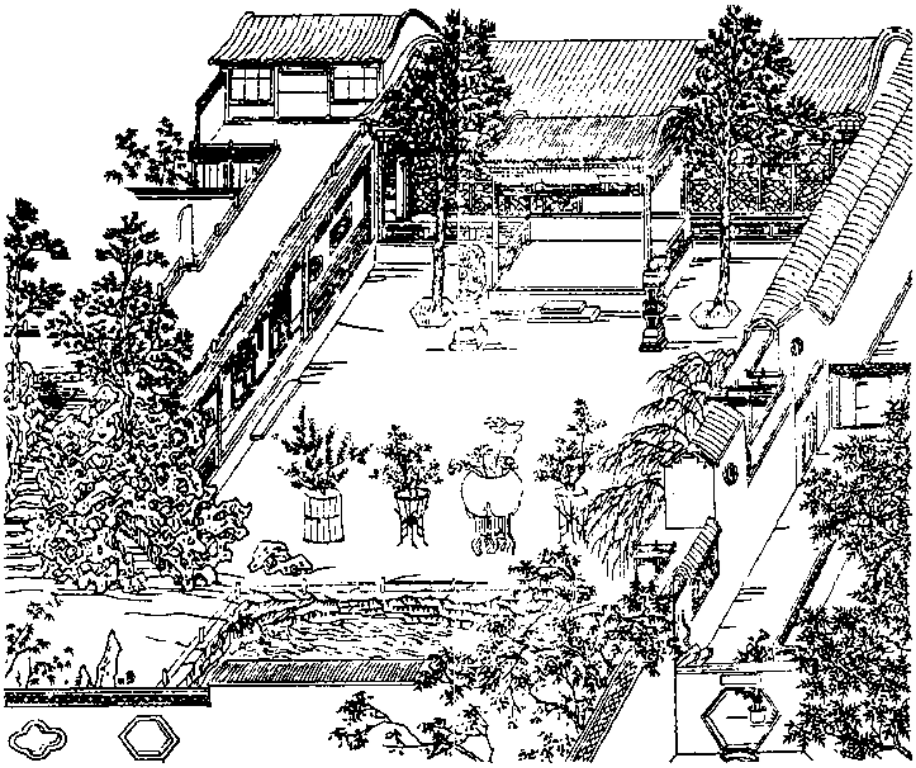

Figure 2- 4 Historical Image of Banmu Garden

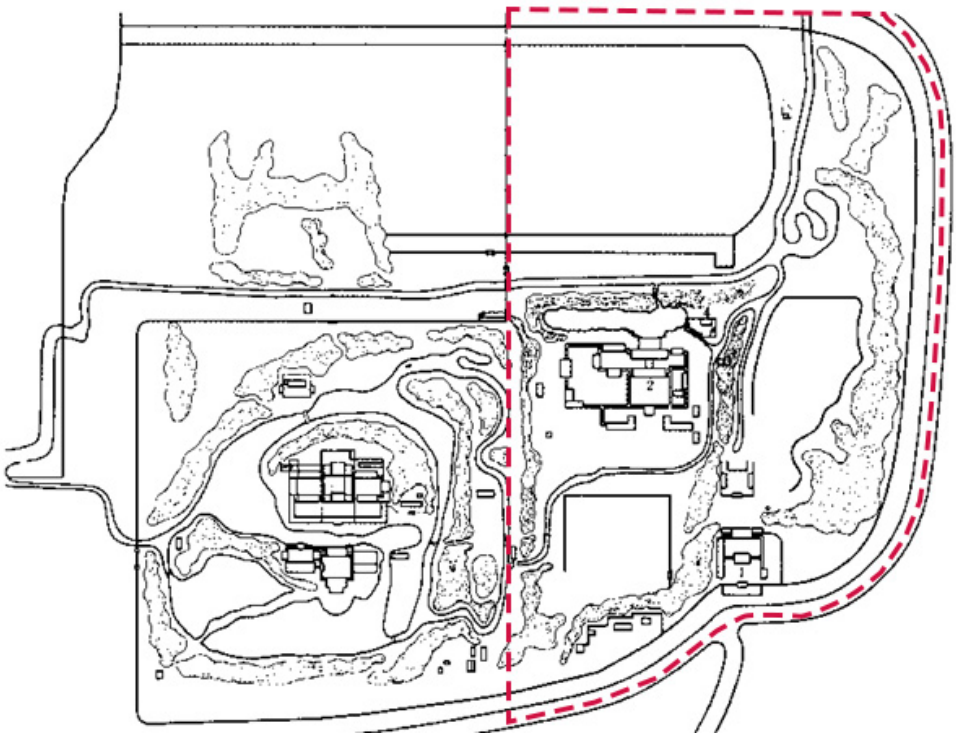

Figure 2- 5 The prelife of Qinghua Garden as the Eastern Part of Xichun Garden

Although both gardens first appeared in the early Qing Dynasty, they underwent reconstruction and renaming in the late Qing Dynasty, representing the ideological and artistic conception of the late Qing garden owners. Therefore, the study categorizes them as garden scope of the late Qing Dynasty.

2 The Middle Qing Dynasty (1723-1850)

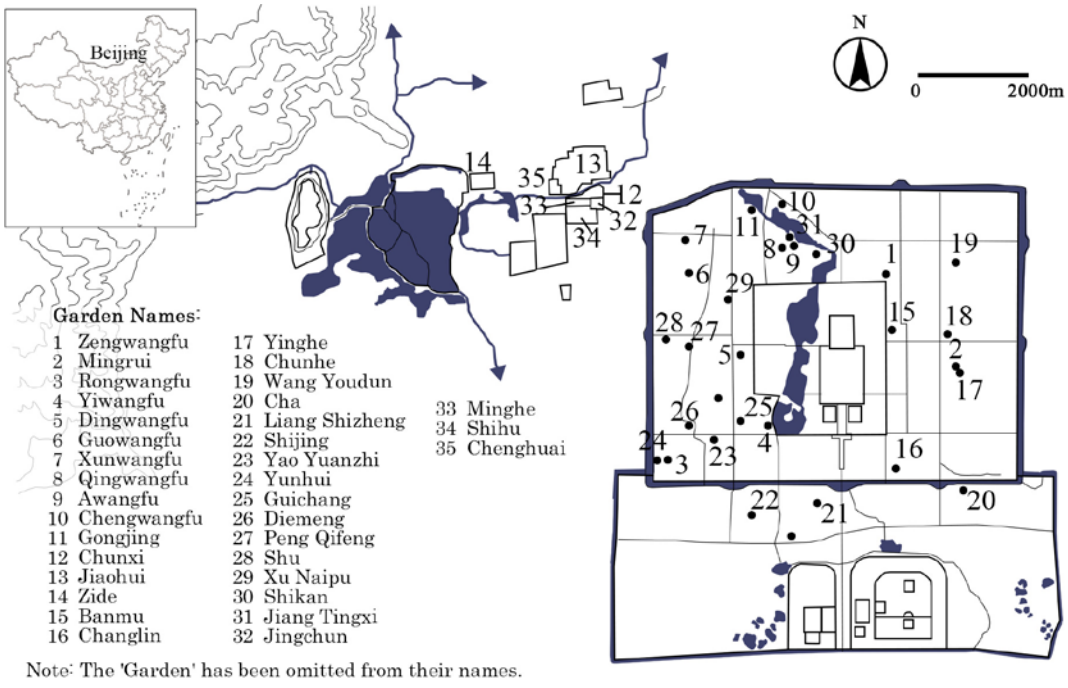

Figure 2- 6 The Location of BTPGs in the Middle Qing Dynasty

During the reign of Emperor Yongzheng and Emperor Qianlong, the Qing Dynasty had a long time of peace and known as flourishing age. During this period, the imperial gardens were vigorously built. Emperor Qianlong had a great love for southern gardens, and the construction of gardens continued with a significant increase in quantity compared to the early Qing Dynasty, and reached its peak. It was also during this period that Han officials gradually migrated to the city, and several Han ministers' gardens appeared in the centre of Beijing, such as Wang Youdun Garden and Jiang Tingxi Garden. But the scale of these gardens is generally small and cannot be compared to the gardens of the nobles and nobility.

During this period, the number of gardens in Beijing has reached dozens. Among them, the gardens of princes and nobles are mostly located in the west side of Beijing, which also responds to the statement that the eastern part of Beijing is mostly inhabited by wealthy merchants, and there are more princes and nobles in the western part of Beijing[10]. In addition to the above reasons, there are also other factors conducive to the construction of gardens in the western part of Beijing, such as the early enfeoffment of sufficient land to design gardens by the princes and nobles in western part, and the proximity to the Shichahai River system was beneficial for building gardens. The more famous gardens in the prince's residence include the Hui Garden of Zhengwangfu and the Guowangfu Garden. The layout of Zhengwangfu Garden is compact, with ponds, rockeries, waterfalls, lilacs, willow trees, and other scenery inside the garden. The winding corridors allow tourists to shuttle between rockeries, pools, flowers and trees, highlighting the elegance of literati (Figure 2-7)[11]. The scale of Guowangfu Garden is grand, twice the size of its mansion. Inside, there were tall earthen hills that extend from the northeast to the southwest of garden, and ultimately end with a pool. There are scenic pavilions on the hills and beside the pool, highlighting the natural and wild charm[12].

Figure 2- 7 The Plan and Buildings of Zhengwangfu Garden

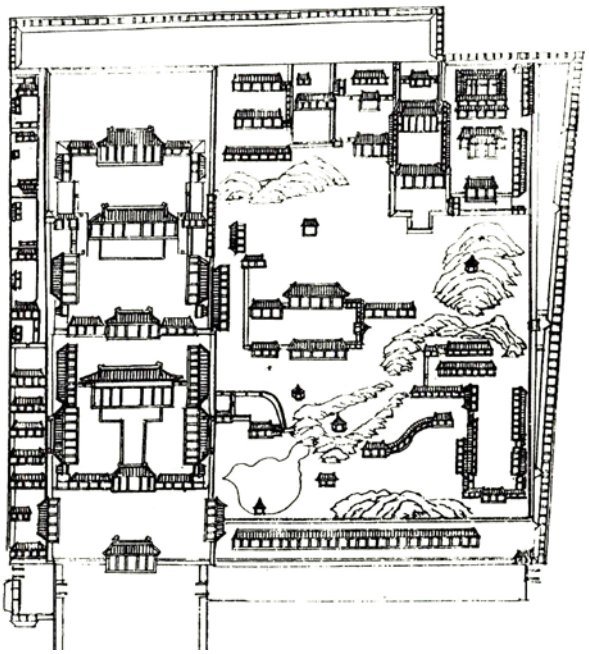

Figure 2- 8 The Plan of Guowangfu Garden

In the mid to late Qing Dynasty, the national power gradually declined, and the gardens of princes, nobles, ministers and officials also underwent changes of ownership. For example, Rongwangfu Garden and Qingwangfu Garden were both famous gardens of princes gardens at that time. In the late Qing Dynasty, after a major change of ownership, they were transformed and rebuilt into what is now known as Chunwangfu Garden and Gongwangfu Garden. Among them, it is worth introducing the Banmu Garden purchased by Lin Qing in the 21st year of the Daoguang reign (1841), which underwent major repairs and became the most famous private garden in Beijing during that period, with both legendary. The renovated garden acquired a completely new outlook, and the layout also integrates the characteristics of the north and south. It changes the strict layout of one main building in north and two bedrooms in east west side commonly seen in Beijing, but compared to the southern gardens, it highlights the solemn atmosphere of the north. The garden was equipped with small waters, rockeries, and curved corridors, with rich spatial changes and diverse spatial forms (Figure 2- 9).

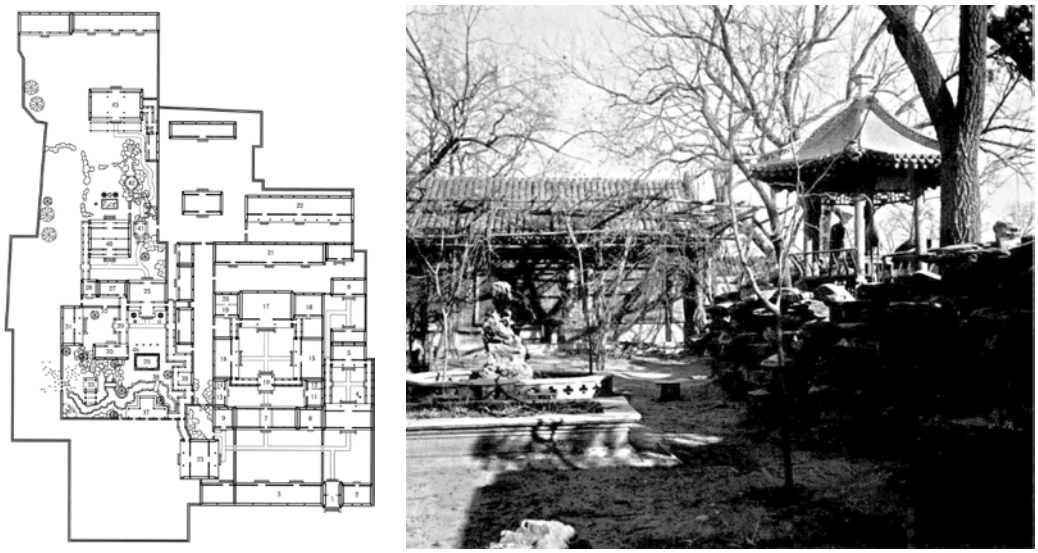

Figure 2- 9 Restoration Images of Banmu Garden during Linqing Period

Compared to inside the city, the construction of private gardens outside the city is relatively less, and the construction of private gardens is also carried out around the western suburbs with good water features and large areas of farmland. The peripheral areas of Old Summer Palace also gradually built private gardens and gift gardens for nobles and nobles as protective barriers, with a significant increase in number compared to the early Qing Dynasty. Among them, there were well-known scenic spots such as Chengze Garden, Chunhe Garden (Langrun Garden), Shuchun Garden, Zide Garden, Minghe Garden and Weixiu Garden, all of which fully utilized the unique water resources and environment of the Haidian area, created a famous scenic spot for that time.

The prelife of Chengze Garden was the private garden of Minister Yinghe during the Jiaqing and Daoguang periods. It was renamed in the eighth year of Daoguang (1828) and underwent major renovations in the 25th year of Daoguang (1845). According to the historical records, the former appearance of this garden presented a narrow shape with a length from east to west and a short distance from north to south. The east, north, and west sides were surrounded by walls. On the south side was the landscape area, with a mound of earth built in the middle, separating the river channel and

forming a barrier for the entire garden (Figure 2- 10)[13].

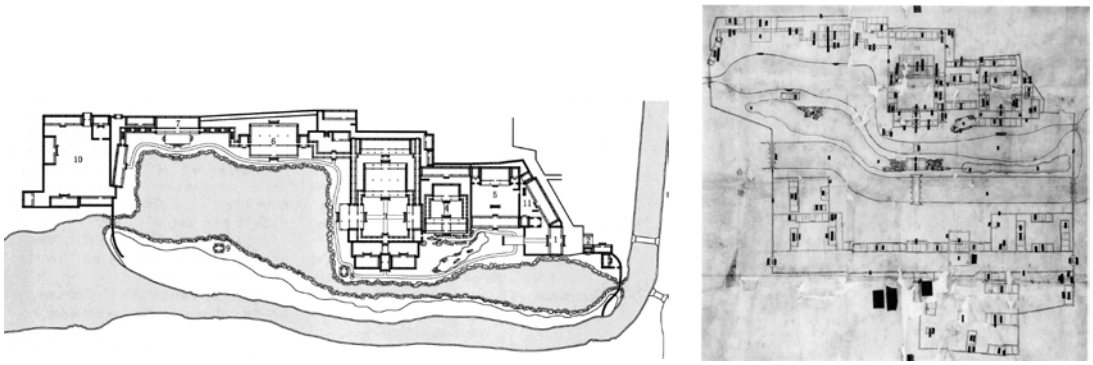

Figure 2- 10 The Plan of Chengze Garden Before (left) and After (right) the Daoguang Period

Chunhe Garden, as the predecessor of Langrun Garden, underwent a change of ownership and renovation in the early years of Xianfeng period. The mountains and waters pattern still presents a circular model in the before and after. On the basis of retaining the original buildings, a large number of new buildings have been added in the central area, presenting a well-regulated and prominent courtyard structure with strict rules and axes (Figure 2-11) [14]. In addition, Shuchun Garden, Zide Garden, Minghe Garden, and Weixiu Garden were also private gardens built by nobles and nobility in the suburbs of Beijing during this period. They all presented a grand scale and a ring layout of mountains and waters. The water system of these gardens also came from outside. The mountains were piled up with soil, and some were decorated with stones and rockeries. Their style and form were basically fixed and unified[15-18].

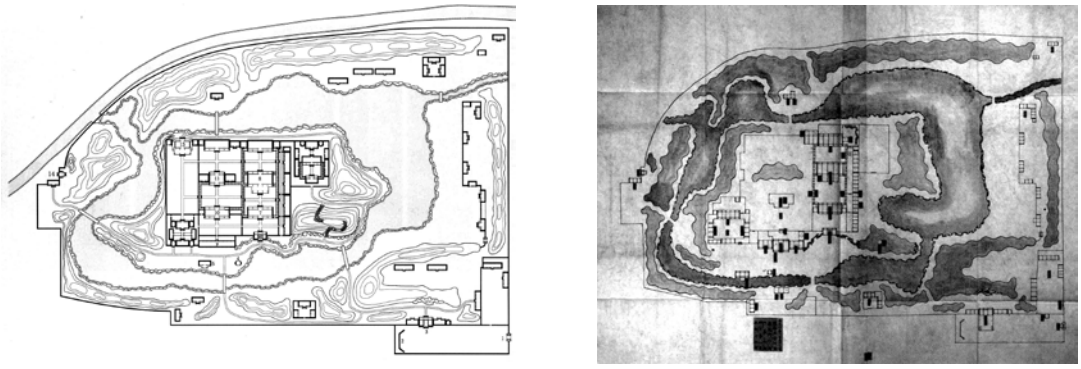

Figure 2- 11 The Plans of Langrun Garden Before and After Rebuild

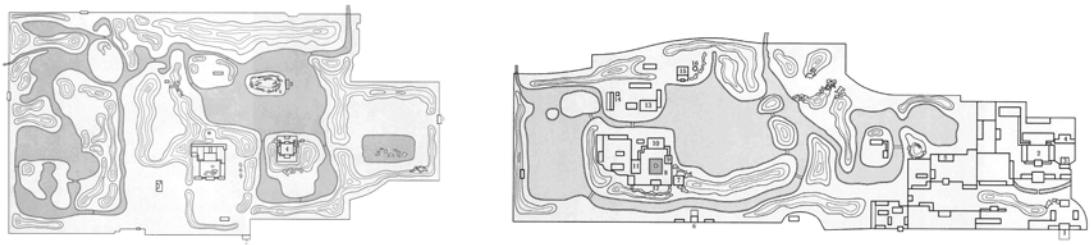

Figure 2- 12 The Plan of Shuchun Garden and Minghe Garden

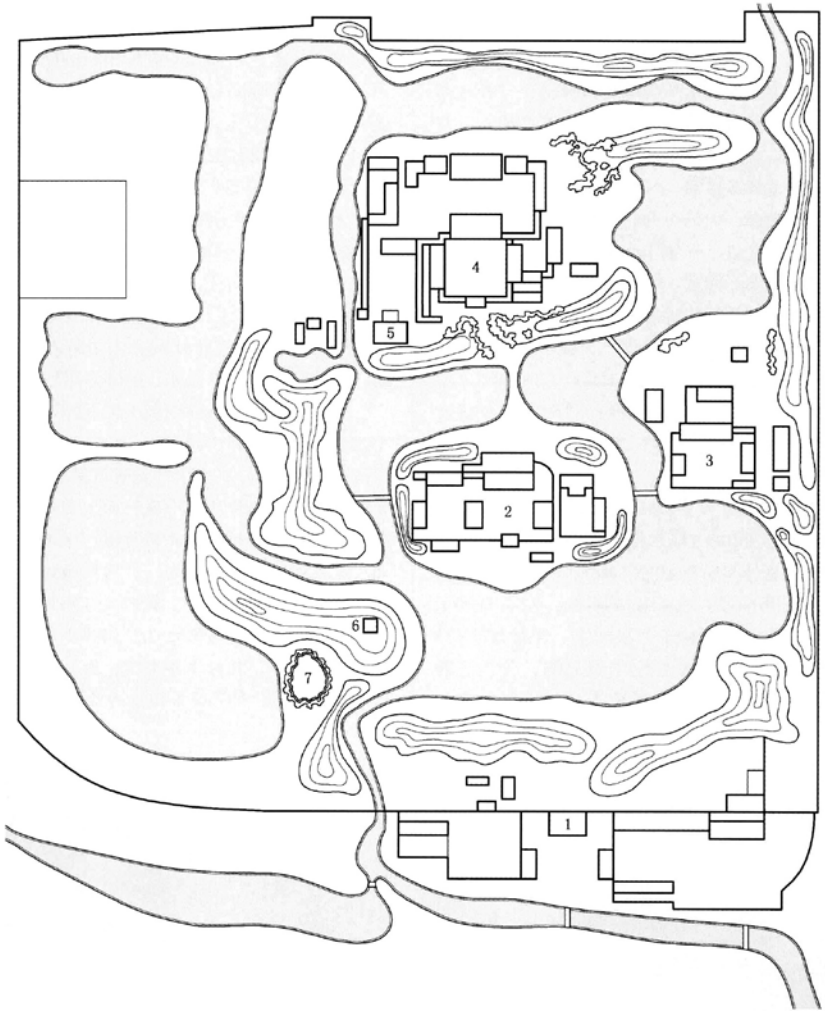

Figure 2- 13 The Plan of Weixiu Garden

Overall, this period was an important stage in the construction of private gardens in Beijing, with a significant increase in the number of gardens and the beginning of their transformation from prosperity to decline. The gardening principles during this period were also basically mature and unchangeable, and in terms of innovation, they were not as innovative as the garden forms of the early Qing Dynasty.

3 The Late Qing Dynasty(1851-1912)

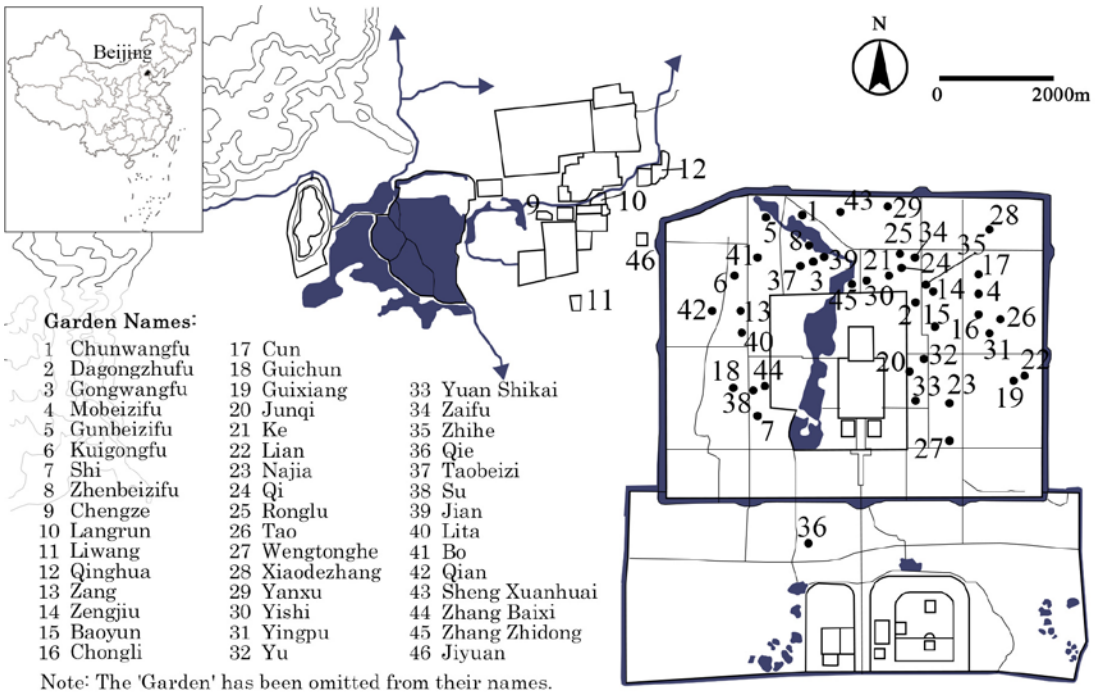

Figure 2- 14 The Location of BTPGs in the Late Qing Dynasty

After the 20th year of the Daoguang reign (1840), the Qing Dynasty faced domestic trouble and foreign invasion, its national power greatly declined. The construction of imperial gardens also became increasingly wearied, and many famous gardens such as the Old Summer Palace, Qingyi Garden, and Summer Palace were damaged. The construction of private gardens was also greatly inferior to the early and middle Qing Dynasty[3]. During the Tongzhi and Guangxu periods, the Qing Dynasty once placed great importance on Han officials and established the Start Westernization projects, leading to a relaxation of the national pressures. During the Tongzhi period, the restoration of the Old Summer Palace began. During the Guangxu period, the imperial government allocated funds to rebuild the Western Garden and the Summer Palace. Another small peak of garden construction emerged, which was also the last peak of private garden construction in Beijing (Figure 2-14). During the Guangxu period, Beijing's gardens suffered heavy blow due to the devastation of war again and

collapsed after one setback, with few new gardens appearing thereafter.

In the center of Beijing, the gardens of princes, nobles, and officials are still the main attractions, such as Chunwangfu Garden, Gongwangfu Garden, Taobeilefu Garden, Gubeizifu Garden, Zhenbeizifu Garden, Guichun Garden, Zang Garden, Ke Garden, Najia Garden, etc. These gardens were mostly renovated from the old site in the mid Qing Dynasty, with only Zhenbeizifu Garden, Guichun Garden, Ke Garden and Najia Garden were newly built during that period. These small private gardens such as Ke Garden, Zang Garden, Guichun Garden, etc. had the characteristics of typical Beijing residences and gardens. They built mountains, arranged water, and decorated pavilions and corridors in narrow spaces, with intricate and varied spaces, effectively imitating the charm of private gardens in the south. However, influenced by Western ideology and culture, buildings with Western style had also appeared in private gardens, such as the arch design of Gongwangfu Garden with a Western style (Figure 2- 15). The most representative garden influenced by Western gardening is the Taobeilefu Garden, which has an overall layout with axes and straight paths, showing a rare sense of rational geometry from the plane (Figure 2- 16).

Figure 2- 15 The Western Style Arch of Gongwangfu Garden (Left) and the Pavilion of Taobeilefu Garden (Right)

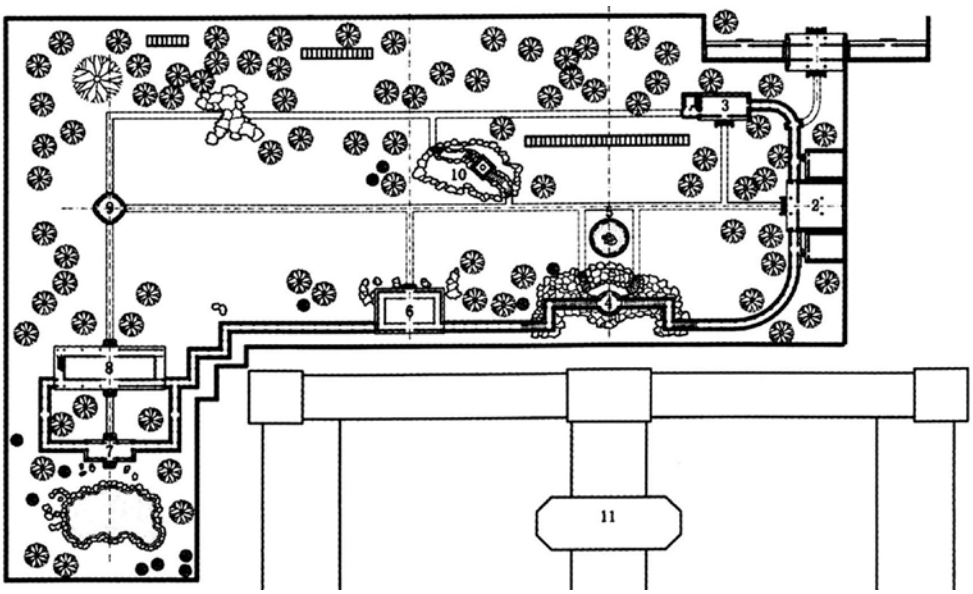

Figure 2- 16 The Plane of Taobeilefu Garden

Outside the Beijing, the renovation and construction of private gardens for nobles are also quite lively. Among them, well-known ones include Liwang Garden, Chengze Garden, Langrun Garden, Qinghua Garden, Weixiu Garden, Minghe Garden, Jingchun Garden, etc. The Liwang Garden was built in the middle of the Qing Dynasty and was destroyed in the tenth year of Xianfeng (1860). After four years of reconstruction, it was completed in the fourteenth year of Guangxu period (1888) and was known for its sturdy stacked stones and spacious halls (Figure 2- 17).

Figure 2- 17 The Rockeries and Pavilions of Liwang Garden

These gardens, such as Chengze Garden, Langrun Garden, and Qinghua Garden, underwent changes in ownership, major repairs, or division during this period. However, the layout of mountains and waters still followed the

style of the middle Qing Dynasty. The scenery of waters, mountains and forests were still beautiful and dense, making them become famous suburban gardens in this period.

On the whole, due to reasons such as war, economy, and politics during the late Qing Dynasty, private garden construction in Beijing experienced a temporary active stage during the Tongzhi and Guangxu periods, and most of the existing gardens were works of construction or renovation during that period. However, the overall trend still declined[10]. Most of the famous gardens during this period were rebuilt from the ruins of the mid Qing Dynasty, and the newly built gardens are still a few. Although these gardens are unique in terms of architecture, mountains, waters and paths, and are praised by historical records, compared to middle period gardens such as the Hui Garden of Zhengwangfu and the Yunli Garden of Guowangfu, they still cannot be considered the highest level in Beijing's private garden.

4 Preservation Status（1923-2021）

Based on the monographs on the Chinese traditional gardens by Wang(2006), Jia(2009) and Zhou(1999), this study combined with relevant journal literature from other scholars, summarized the preservation of over 100 Beijing's private gardens in during the Qing Dynasty (Table 2- 1). This table covers information such as the status / occupation of the garden owner, construction Ways, location,construction period and preservation status, and divided the preservation status into four categories: Well, Good, Bad and Disappear.

Well is a well preserved type of gardens, with their buildings, mountains,waters, paths, and other spatial structural skeletons basically preserved. The stones, flowers, trees and other elements in the garden have also been well saved in this day. Good refers to gardens where most of the elements are well preserved, such as their buildings, mountains,waters and

other spatial structural frameworks. However, the paths, stones, plants, and other elements are no longer existent. Bad refers to gardens where a small number of elements are preserved, with most of them containing only a small amount of mountains, buildings, and plants, while all other elements have not been preserved. Disappear refers to gardens that have not been existed at all. These gardens are now completely extinct and their characteristics can only be traced back through historical data or records.

Table 2- 1 Summary of the Preservation Status of Beijing's Private Gardens in during the Qing Dynasty

No.	Garden Names	Owner	Ways	Location	Period	Status	Records
The Early Qing Dynasty (1643-1722)							
1	Suqinwang	RN	NB	INN	SZ	Disappear	Little
2	Yuwangfu	RN	NB	INN	KX	Disappear	Little
3	Hengwangfu	RN	NB	INN	KX	Disappear	Little
4	Fuwangfu	RN	NB	INN	KX	Bad	Little
5	Lvwangfu	RN	NB	INN	KX	Disappear	Little
6	Zhengwangfu	RN	NB	INN	SZ	Disappear	Little
7	Liwangfu	RN	NB	INN	SZ	Bad	Much
8	Zhuangwangfu	RN	NB	INN	SZ	Disappear	Little
9	Leshan	RN	NB	OUT	SZ	Disappear	Little
10	Ehui	RN	NB	OUT	KX	Disappear	Little
11	Xichun	RN	NB	OUT	KX	Good	Much
12	Hongya	RN	RB	OUT	KX	Good	Little
13	Caixia	RN	NB	OUT	KX	Good	Little
14	Jiezi	CS	NB	INS	KX	Disappear	Little
15	Ye-Tong	OP	NB	INN	SZ	Disappear	Little
16	Tianchun	OP	RB	INN	KX	Disappear	Little
17	Banmu-Jia	OP	NB	INS	SZ	Disappear	Little
18	Yi	OP	NB	INS	KX	Disappear	Little
19	Tingyulou	OP	NB	INS	KX	Disappear	Little
20	Jieyeting	OP	NB	INS	KX	Disappear	Little
21	Ji	OP	NB	INS	KX	Disappear	Little
22	Zhang Weichi	OP	NB	INS	SZ	Disappear	Little
23	Sungong	OP	NB	INS	KX	Disappear	Little
24	Chan	OP	NB	INS	KX	Disappear	Little
25	Xiaoxiu Yecao	OP	NB	INS	KX	Disappear	Little
26	Wanliu	OP	NB	INN	KX	Disappear	Little
27	Hongzhuang	OP	NB	INN	SZ	Disappear	Little

28	Xianzhexuan	OP	NB	INN	KX	Disappear	Little
29	Mingzhu	OP	NB	INN	KX	Well	Little
30	Ziyi	OP	NB	OUT	KX	Disappear	Little
The Middle Qing Dynasty (1723-1850)							
1	Zengwangfu	RN	NB	INN	DG	Disappear	Little
2	Mingrui	RN	NB	INN	QL	Bad	Little
3	Rongwangfu	RN	NB	INN	QL	Disappear	Little
4	Yiwangfu	RN	NB	INN	QL	Disappear	Little
5	Dingwangfu	RN	NB	INN	QL	Disappear	Little
6	Guowangfu	RN	NB	INN	YZ	Disappear	Little
7	Xunwangfu	RN	NB	INN	YZ	Bad	Little
8	Qingwangfu	RN	NB	INN	QL	Well	Little
9	Awangfu	RN	NB	INN	YZ	Bad	Little
10	Chengwangfu	RN	RB	INN	JQ	Well	Little
11	Hongjing	RN	RB	INN	YZ	Good	Little
12	Chunxi	RN	NB	OUT	JQ	Disappear	Much
13	Jiaohui	RN	NB	OUT	YZ	Disappear	Little
14	Zide	RN	NB	OUT	YZ	Good	Little
15	Banmu	OP	RB	INN	DG	Disappear	Much
16	Changlin	OP	NB	INN	JQ	Disappear	Little
17	Yinghe	OP	NB	INN	DG	Disappear	Little
18	Chunhe	OP	NB	INN	QL	Disappear	Little
19	Wang Youdun	OP	NB	INN	QL	Disappear	Little
20	Cha	OP	NB	INS	-	Disappear	Little
21	Liang Shizheng	OP	NB	INS	QL	Disappear	Little
22	Shijing	OP	NB	INS	QL	Disappear	Little
23	Yao Yuanzhi	OP	NB	INN	DG	Disappear	Little
24	Yunhui	OP	NB	INN	JQ	Disappear	Little
25	Guichang	OP	NB	INN	-	Disappear	Little
26	Diemeng	OP	NB	INN	QL	Disappear	Little
27	Peng Qifeng	OP	NB	INN	QL	Disappear	Little
28	Shu	OP	NB	INN	JQ	Disappear	Little
29	Xu Naipu	OP	NB	INN	DG	Disappear	Little
30	Shikan	OP	NB	INN	QL	Disappear	Little
31	Jiang Tingxi	OP	NB	INN	YZ	Disappear	Little
32	Jingchun	OP	NB	OUT	QL	Bad	Much
33	Minghe	OP	NB	OUT	DG	Good	Much
34	Shihu	OP	NB	OUT	JQ	Good	Much
35	Chenghuai	OP	NB	OUT	YZ	Disappear	Little
The Late Qing Dynasty(1851-1912)							
1	Chunwangfu	RN	RB	INN	GX	Well	Much
2	Dagongzhufu	RN	RB	INN	XF	Disappear	Little

3	Gongwangfu	RN	RB	INN	XF	Well	Much
4	Mobeizifu	RN	NB	INN	无	Good	Little
5	Gunbeizifu	RN	RB	INN	GX	Good	Much
6	Kuigongfu	RN	NB	INN	GX	Bad	Little
7	Shi	RN	NB	INN	GX	Disappear	Little
8	Zhenbeizifu	RN	NB	INN	GX	Disappear	Much
9	Chengze	RN	RB	OUT	DG	Good	Much
10	Langrun	RN	RB	OUT	XF	Good	Much
11	Liwang	RN	RB	OUT	GX	Well	Much
12	Qinghua	RN	RB	OUT	DG	Good	Much
13	Zang	OP	RB	INN	GX	Disappear	Much
14	Zengjiu	OP	RB	INN	DG	Disappear	Little
15	Baoyun	OP	NB	INN	TZ	Disappear	Little
16	Chongli	OP	NB	INN	GX	Good	Little
17	Cun	OP	NB	INN	TZ	Disappear	Little
18	Guichun	OP	NB	INN	GX	Disappear	Much
19	Guixiang	OP	NB	INN	TZ	Disappear	Little
20	Junqi	OP	NB	INN	GX	Bad	Little
21	Ke	OP	NB	INN	XF	Well	Much
22	Lian	OP	NB	INN	-	Good	Little
23	Najia	OP	NB	INN	GX	Bad	Much
24	Qi	OP	NB	INN	XF	Disappear	Little
25	Ronglu	OP	NB	INN	GX	Disappear	Little
26	Tao	OP	NB	INN	XT	Disappear	Little
27	Wengtonghe	OP	NB	INN	TZ	Disappear	Little
28	Xiaodezhang	OP	NB	INN	XT	Bad	Little
29	Yanxu	OP	NB	INN	GX	Disappear	Little
30	Yishi	OP	NB	INN	GX	Disappear	Little
31	Yingpu	OP	NB	INN	XF	Disappear	Little
32	Yu	OP	NB	INN	XF	Bad	Little
33	Yuan Shikai	OP	NB	INN	GX	Bad	Little
34	Zaifu	OP	NB	INN	GX	Good	Little
35	Zhihe	OP	NB	INN	XF	Bad	Little
36	Qie	OP	NB	INS	-	Disappear	Little
37	Taobeizi	OP	RB	INN	GX	Good	Much
38	Su	OP	NB	INN	XF	Disappear	Little
39	Jian	OP	NB	INN	GX	Disappear	Little
40	Lita	OP	NB	INN	GX	Disappear	Little
41	Bo	OP	NB	INN	GX	Disappear	Little
42	Qian	OP	NB	INN	GX	Disappear	Little
43	Sheng Xuanhuai	OP	NB	INN	TZ	Disappear	Little

44	Zhang Baixi	OP	NB	INN	GX	Disappear	Little
45	Zhang Zhidong	OP	NB	INN	GX	Bad	Little
46	Jiyuan	OP	RB	OUT	GX	Bad	Little

Note: The 'Garden' has been omitted from their names. ① Owner: status / occupation of the garden owner. RN : royal or nobility, OP: officials or politicians, CS:civilians or scholars. ② Ways: construction Ways. NB : newly built, RB : rebuilt. ③ Location: The location of the gardens in Beijing. INN: inside of the north city, INS: inside of the south city, OUT: outside of the city.
④ Period: construction period. DG (Daoguang):1821—1850, XF (Xianfeng):1851—1861, TZ (Tongzhi):1862—1874, GX (Guangxu):1875—1908, XT (Xuantong):1909—1912. ⑤ Status: the preservation status of gardens. Well: well preserved, Good :partially well preserved, Bad: A fat lot portion is preserved, Disappear: already lost today.⑥ Records: Historical records.

From the Table 2-1, it can be found that only the Xinchun Garden (alternate name: Mingzhu Garden and Chengwangfu Garden), Gongwang Garden (alternate name: Qingwangfu Garden), Ke Garden, and Liwang Garden have been well preserved. Some of the well preserved gardens include Hongya Garden (alternate name: Jixian Garden), Caixia Garden (alternate name: Hanfang Garden and Weixiu Garden), Xichun Garden (alternate name: Qinghua Garden), Zide Garden, Mobeizifu Garden, Hongjing Beizifu Garden (Gubeizi Mansion), Chengze Garden, Langrun Garden, Chongli Garden, Lian Garden, Zaifu Garden and Taobeizifu Garden. Their spatial skeleton structure such as buildings, mountains, and waters has been well preserved. For example, Xichun Garden is currently located on the campus of Tsinghua University, but its circular skeleton of mountains and waters can still be clearly distinguished()[19]. Unfortunately, the vast majority of gardens in Table 2-1 have disappeared today, also making it difficult to distinguish their ruins.

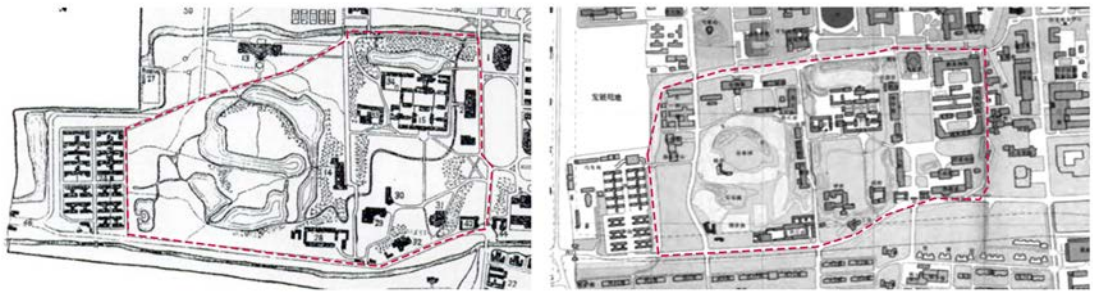

Figure 2- 18 The Plans of Xichun Garden in 1948 (left) and 1998 (right)

After 1949, Beijing, as the capital and political center of China, ushered in large-scale urban constructions with the increase of population and changed in land property rights. The traditional gardens became an obstacle to urban development, and these precious legacies were not yet valued at that time. As a result, a large number of garden waters were filled, rockeries were pushed down, pavilions and corridors were demolished. Flowers and trees have been cut down to build more housing areas. It can be said that private gardens in Beijing during the Qing Dynasty had suffered serious damage overall[20]. At present, only the Chunwangfu Garden, Gongwangfu Garden, Ke Garden and Chongli Garden had been listed as objects of important cultural relics under national protection. The Chunwangfu Garden, Gongwangfu Garden and Ke were all outstanding representatives of private garden art in Beijing, while the landscape of Chongli Garden warelatively simple and only some elements remain[3]. In addition, the Liwang Garden and the Gunbeizifu Garden had been listed as cultural relics protection objects in Beijing, and the level of protection was still relatively low. At present, relatively well preserved sites such as Weixiu Garden and Lian Garden have not yet entered the scope of important protected objects. It can be seen that the protection of private gardens in Beijing needs to be more perfect.

Nowadays, Gongwangfu Garden and Chunwangfu Garden are open to the public in the form of heritage gardens. Some gardens have become part of universities, such as Shuchun Garden (also called Shihu Garden), Minghe Garden, Langrun Garden, Chengze Garden, and Weixiu Garden, which belong to Peking University, Qinghua Garden belongs to Tsinghua University, and Taobeilefu Garden belongs to Beijing Normal University. There are also some gardens that have become the office space of the company, such as Li Garden occupied by China National Record Corporation, the former site of Yu Garden occupied by the Chinese

Archaeological Research Institute, and Gubeizifu Garden has been turned into an internal leisure garden by Jishuitan Hospital. Some gardens have also become dining and leisure venues, such as the Najia Garden becoming the current Najia Restaurant, and the Yuewei Garden becoming the Jinyang Restaurant. Some gardens have also become government confidential units (Military Commission or central ministries) such as Ke Garden, Jian Garden, Zhenbeizifu Garden, etc. It can be seen that the use of existing traditional private gardens in Beijing has become very complex due to lack of unified management.

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Chapter 3

The Spatial Characteristics of Beijing's Private Gardens in the Qing Dynasty Based on the Buildings

1 Background and Purpose

The buildings in traditional Chinese gardens not only provide multiple functions such as residence and sightseeing, but also an important component of the spatial framework and layout of the garden, and also provide and present the characteristics of the garden style. They often control the structure of garden spaces and provide and present garden style features, playing a unique and important role in traditional Chinese gardens[1].

Chinese traditional gardens attained maturity during the Qing Dynasty, when many famous private gardens developed in both North and South China[2]. However, due to the cold and arid climate, the solemn political image and the unique cultural background of the north, the garden buildings here show great stylistic differences from those of the south. The northern garden buildings are generally located in a dignified and rigorous layout, reflecting the environmental characteristics of the region. Therefore, a study of the architecture of the northern private gardens of the Qing Dynasty is not limited to the architectural characteristics and garden styles of the period, but also contributes to a better understanding of the relationship between architecture and the regional environment.

Past research into Chinese traditional gardens is mainly focused on the private gardens of the south and the royal gardens in the north, with little attention given to the private gardens of the north[3]. Research examining the related buildings is limited, and mainly considers two aspects, the architectural form and the spatial layout. In terms of architectural form, Liu[4] and Zhou[2] introduced the architectural types, carving decorations, roof styles and colour matchings of the Beijing and the Shandong gardens respectively. Zhang analysed the garden architecture layout of the Royal Palace in Beijing, and proposed the courtyard layout mode[5]. Liu identified

the characteristic prominent axis in the private garden buildings in the north while Jia highlighted the official style[6, 7]. Gao applied Feng Shui to explain the characteristics of the south-facing buildings in northern gardens[8].

Most current studies examine the architecture independently from the garden and omit the interpretation of characteristics relating the architecture to the garden space. Therefore, starting from the garden and building plans, this study extracts the layout type and orientation of the buildings, obtains the layout mode of the buildings and the garden space, and interprets the orientation layout and space type of private garden buildings in northern China.

2 Objects and Methods

In Jia's Study on *Private Gardens in North Ancient China*[9], gardens built by royal relatives, bureaucrats and civilians are classified as private gardens. During the Qing Dynasty, Beijing was the most prosperous site for area of private gardens in the north, followed by Shandong and Shanxi. As the political centre of the period, more gardens were built in Beijing than in Suzhou and Yangzhou in the Qing Dynasty[9]. Many scholars gathered in Shandong, and the prosperity of water transport here promoted the construction of gardens. The Shanxi gardens in the Qing Dynasty adopted a unique form and style[3]. On this basis, the study object gardens were selected as follows: ① New or large-scale reconstructions of northern private gardens in the Qing Dynasty; ② Meeting Jia's definition representing the characteristics of the north; ③ Having architectural distribution and space forms. 14 gardens in Beijing and Shandong were selected as meeting these criteria (Table 1-1).

Garden statistics are drawn from Jia's *Record of Private Garden in Beijing* [9] and *The Private Garden of North China* [3], Zhou's *The History of*

Chinese Classical Gardens [2] and Liu's series of northern garden periodicals [4, 6]. This information includes the construction period, geographical location, identity of the owner and orientation of the garden entrance. Four of the 14 gardens were newly constructed in the Qing Dynasty while the other ten experienced substantial transformation or reconstruction during this period. The historical drawings of the gardens selected in this study are the plans of the gardens as constructed or transformed in the Qing Dynasty (Figure 3- 1).

The garden plans are drawn using Autocad.2014 software. Use the query function of the software to obtain information on the area, quantity, and proportion of the building to the garden. Afterwards, this enables the deviation distance and the angle between the building axis and the garden centre to be calculated using the software area function (Figure 3-1). The spatial type model is constructed from the architectural disposition form, axis relationship spatial enclosure degree and scale, and the 14 gardens are analysed using SPSS25.0 software (Ward Method and Squared Euclidean Distance) [10]. The garden clustering results based on the architectural spatial layout characteristics are obtained. Finally, combined with the basic garden information and the characteristics of the architectural, the inter group mode is analysed for correlation between the characteristics of the architectural scale, form and orientation, and the garden space.

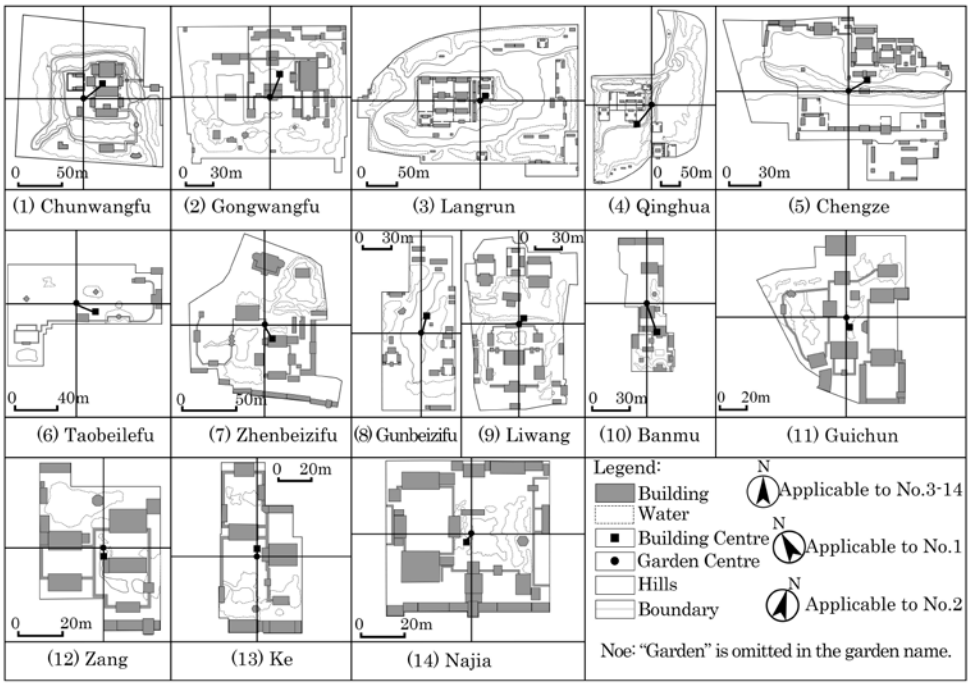


Figure 3- 1 The Layout of Buildingd

3 Building Features

3.1 Scale

In this study, the scale indicators of Beijing's private garden buildings are divided into three indicators, namely building area(BA), building numbers (BN), and the ratio of building area to courtyard area(BR: building plot ratio)[7]. They are the most fundamental indicators for measuring the scale of a building. If the area ratio between the building and the garden is large, it indicates that the architectural elements in the garden occupy more space, and the spatial structure of the garden is highly likely to be affected by the buildings.

3.2 Form

On the basis of the characteristics of the buildings in these private gardens and the architectural disposition form (D) [11], there are three sub-categories, the yard type (DY), line type (DL) and scattered point type (DS).

The axis layout is also a feature of these gardens. Depending on whether the building axis is consistent with the garden axis [12], the axis (A) can also be divided into three sub-categories, the axis identity type (AI), the axis difference type (AD) and the axis non type (AN). In terms of the degree of building enclosure [13], on the basis of the area of enclosed garden space (S), this can be classified as open type (SO), half open type (SH) and closed type (SC) (Figure 3-2).

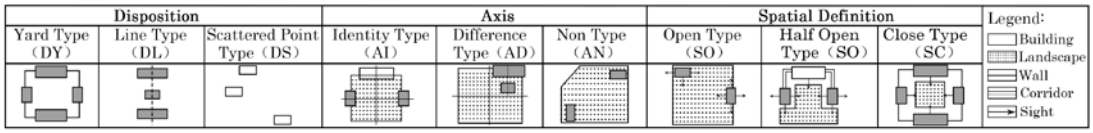


Figure 3- 2 Basic Forms of Building

3.3 Orientation

According to Gugerty's description of the environmental reference system or environmental reference frame, orientation takes the midpoint of the research scope as the reference [14]. Here, the plan centre of the garden and the buildings is taken as the origin of the orientation, the distance (D) between them is the degree of building deviation, and the angle (A) between the line formed by the two midpoints and the east-west direction indicates the direction of building deviation (Figure 3-3). When the distance is larger, it indicates that the building is more offset from the center of the garden.

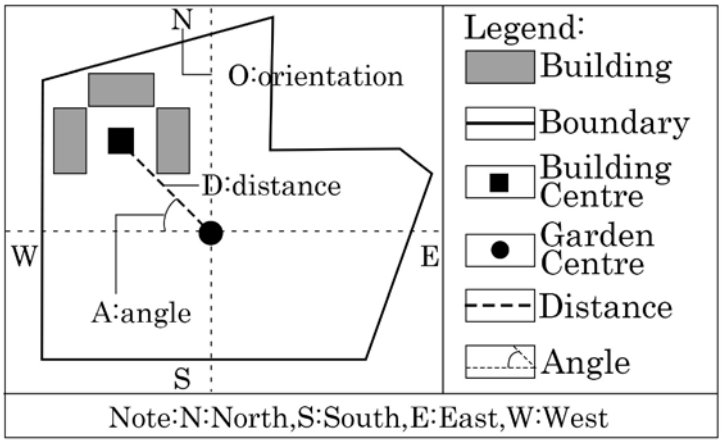


Figure 3- 3 Orientation Acquisition

4 Results

4.1 Statistical

In terms of scale, the average size of buildings in 14 gardens is 2373.1 m^2, with the smallest being Banmu Garden of 866.3 m^2, and the largest being Langrun Garden of 4827.9 m^2. The average number of buildings is 36.9, with the lowest being 11 in Taobeile Garden and the highest being 81 in Chengze Garden. The average plot ratio of buildings is 19.4%, with Qinghua Garden being the smallest, only 3.3%, and Zang Garden being the largest, which is 36.3%.

About the form, all 14 gardens have courtyard type, line type, difference type, and half open type, 13 gardens have three scattered point forms, 11 gardens have non axis buildings, 10 gardens have buildings of closed type, and 8 gardens have open type buildings. Only 4 gardens have identity type of axis.

In terms of orientation, the largest building offset distance is Qinghua Garden (64.7m) and the smallest is Zang Garden (3.5m), with nearly half the gardens (6) distributed between 0 and 10m, and half the gardens (7) distributed between 10 and 30m. In terms of building deviation, this is to the northeast for six gardens, the northwest for zero, with five to the southeast and three to the southwest (Table 3- 2).

Table 3- 1 The Information of Research Objects

No.	Disposition	Axis	Space	Scale	Number	Ratio	Orientation	Distance	Angle
1	DY+DL+DS	AD+AN	SO+SH+SC	2281.6	24.0	9.0	EN	28.8	33.3
2	DY+DL+DS	AI+AD+AN	SO+SH+SC	4268.8	47.0	15.4	EN	27.6	72.5
3	DY+DL+DS	AI+AD+AN	SO+SH+SC	4827.9	75.0	6.2	WS	4.4	16.8
4	DY+DL+DS	AD+AN	SO+SH+SC	2983.2	65.0	3.3	WS	64.7	51.5
5	DY+DL+DS	AI+AD+AN	SO+SH+SC	3407.6	81.0	15.3	EN	20.7	30.9
6	DY+DL+DS	AD	SO+SH+SC	964.8	11.0	9.1	ES	21.0	25.5
7	DY+DL+DS	AD+AN	SO+SH+SC	2950.4	33.0	20.4	ES	14.7	62.1
8	DY+DL+DS	AD	SO+SH+SC	1436.8	31.0	10.4	EN	18.8	72.8
9	DY+DL+DS	AI+AD+AN	SH+SC	3054.1	34.0	16.9	EN	3.6	56.3

10	DY+DL+DS	AD+AN	SH+SC	866.3	18.0	28.5	ES	22.2	69.7
11	DY+DL+DS	AD+AN	SH	1564.1	24.0	31.2	ES	5.5	68.6
12	DY+DL+DS	AD+AN	SH	1176.9	20.0	36.3	ES	3.5	82.2
13	DY+DL+DS	AD	SH	1486.8	22.0	36.1	EN	3.0	89.4
14	DY+DL+DS	AI+AD+AN	SH	1954.9	32.0	34.0	WS	3.7	56.2

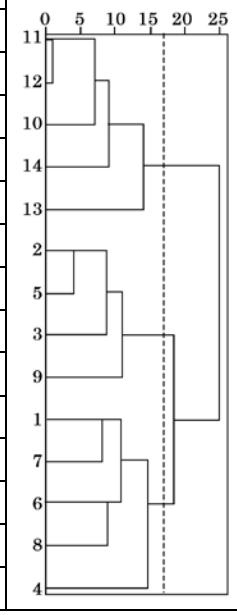
Note: The number of gardens derived from Figure 3- 1. ① The unit of scale is m^2. ② The unit of the ratio is %. ③ The unit of distance is m. ④ The unit of angle is °.

4.2 Clustering

In cluster analysis, the data was standardized, and the distance between groups is btained by the Squared Euclidean Distance method, and the number of groups is divided according to the principle of maximizing the distance between groups and appropriate number of groups [15]. The 14 gardens are divided into Groups A, B and C (Table 3- 2). Afterwards, the data between each group was statistically analyzed using Excel software.

Table 3- 2 The Results of Clustering

Group	No.	Names	Owner	Ways	Location	Period
A	11	Guichun	OP	NB	IN	Late
A	12	Zang	OP	RB	IN	Late
A	10	Banmu	OP	RB	IN	Middle
A	14	Najia	OP	NB	IN	Late
A	13	Ke	OP	NB	IN	Late
B	2	Gongwangfu	RN	RB	IN	Late
B	5	Chengze	RN	RB	OUT	Middle
B	3	Langrun	RN	RB	OUT	Late
B	9	Liwang	RN	RB	OUT	Late
C	1	Chunwangfu	RN	RB	IN	Late
C	7	Zhenbeizfu	RN	NB	IN	Late
C	6	Taobeilefu	RN	RB	IN	Late
C	8	Gunbeizifu	RN	RB	IN	Late
C	4	Qingua	RN	RB	OUT	Middle



① Owner: status / occupation of the garden owner. RN : royal or nobility, OP: officials or politicians ② Location: The location of the gardens in Beijing. IN: inside of the city, OUT: outside of the city.③ Period: construction period. The Early Qing Dynasty(Early):1643—1722, The Middle Qing Dynasty(Middle):1723—1850, The Late Qing Dynasty(Late):1850—1912. ④ Ways: construction Ways. NB : newly built, RB : rebuilt.

Group A has five gardens without open type (SO). They all have yard style

(DY), linear style (DL), scattered point style(DS), difference axis style (AD), and half open style (SH) architectural models. Most gardens have non axis style (AN) buildings. Only one garden exhibits identity type (AI) and closed spatial (SC) characteristics. In addition, the group of garde has the smallest building area, number, and degree of deviation, but has the highest building plot ratio and angle of deviation, indicating that this group of gardens is a type with a typical enclosed courtyard as the main framework, and the building has a clear axis, but it is not consistent with the landscape axis.

There are four gardens in Group B, namely Gongwangfu Garden, Langrun Garden, Liwang Garden and Chengze Garden. The configuration forms of the nine courtyards type are basically all present, with very few gardens lacking in identity axis type (AI) and spatial openness (SO). In terms of building scale, the restructured courtyard has the highest building area and number, but has a lower building plot ratio. The building offset angle and distance are between Group A and C. The reorganization of a garden is a form with a variety of architectural types and a grand scale, and the building axes aligned and consistent with the garden axes.

There are 5 gardens in Group C, including Chunwangfr Garden, Qinghua Garden, Taobeilefu Garden, Zhenbeizifu Garden, and Cunbeizifu Garden. All of them have courtyards (DY), linear (DL), scattered points (DS), difference axis style (AD), closed (SC) and half open (SH) types, and do not have identity axis (AI) type. In terms of scale, the building area and number are still relatively large, with an increase in proportion compared to Group B, However, the offset distance of the buildings is larger than Group B, and the offset angle is relatively small. This reflects the grand scale of the buildings in this group of gardens, with rich spatial types. However, the scale of the gardens is still smaller than Group B. The separation of the architectural axis and the landscape axis in the form of gardens is completely different from Group B.

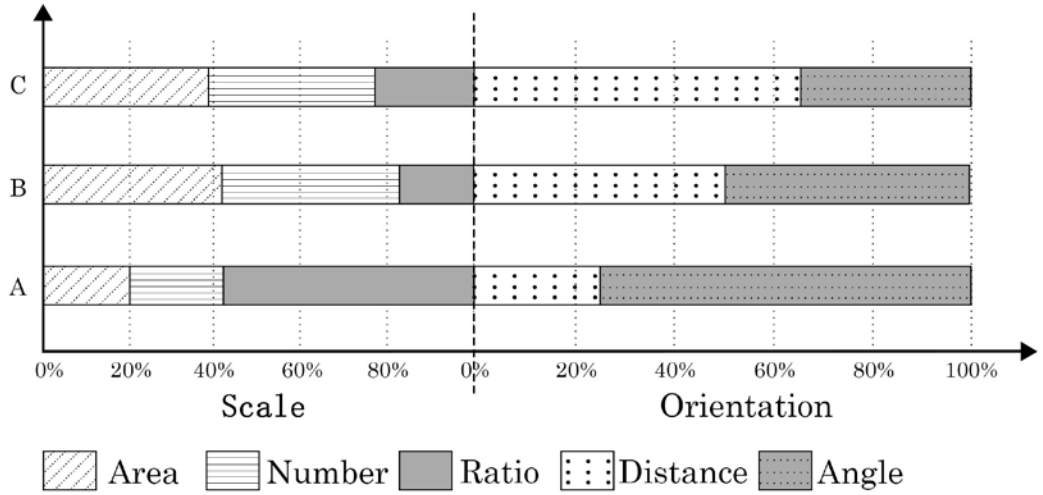


Figure 3- 4 Differences in Scale, Distance and Angle Between Groups

5 Comprehensive investigation

In order to distinguish the differences between the building layout forms and orientation in the various groups conveniently, the clustering results are matched with the building layout forms and orientation information to obtain the layout features of the buildings in the garden (Figure 3-5).

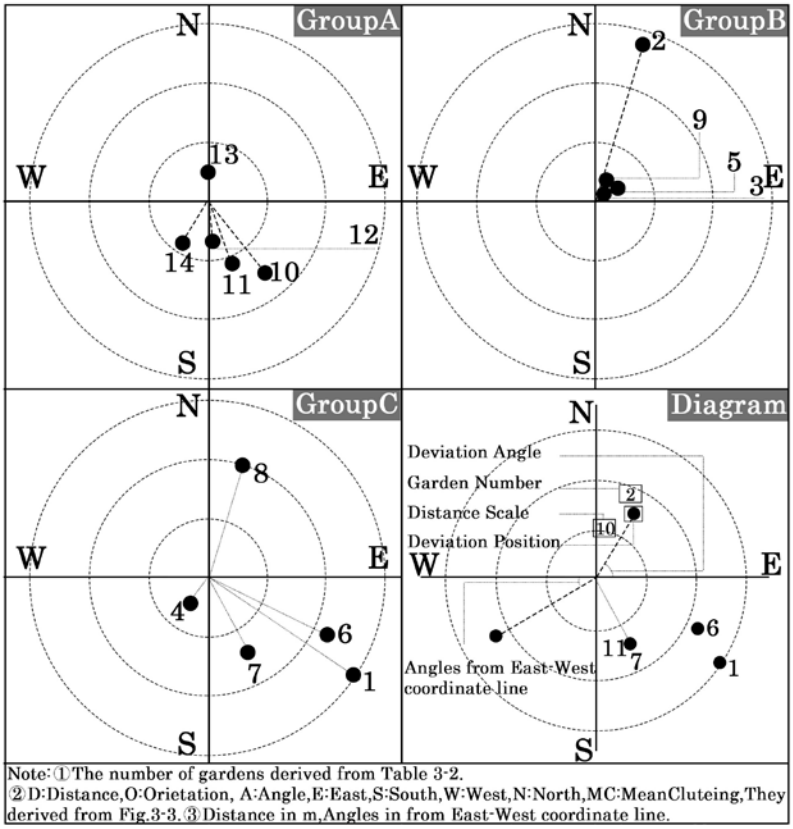


Figure 3- 5 Characteristics of Architectural Orientation

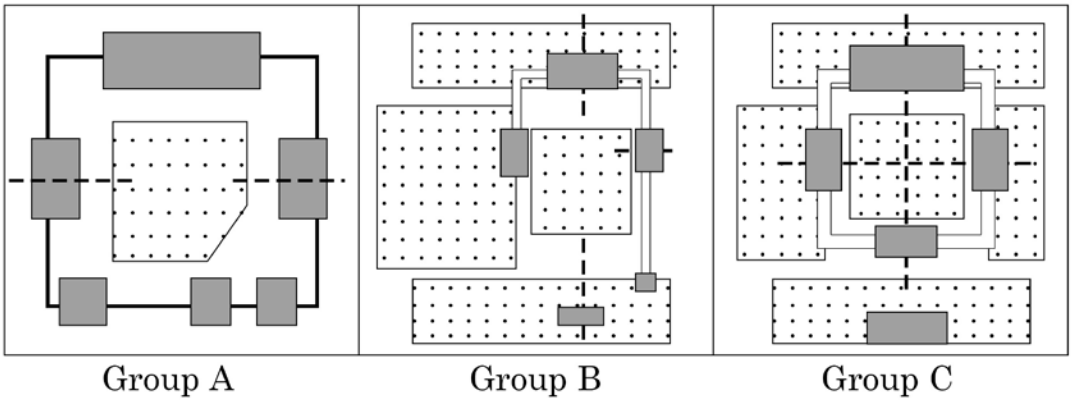


Figure 3- 6 The Layout Mode Diagram of Three Groups

5.1 Group A

In group A (5 gardens), the layout of the non (100%) and difference axis type (80.0%) has the highest frequency. It shows that this group of garden buildings has relatively few restrictions on landscape elements, and the landscape layout is more flexible and changeable. In addition, the architectural scale of this group of gardens is not large (average 1409.79 m^2), but the proportion of buildings is as high as 33.22%, indicating that this group often have a smaller garden scale, and the main gardening elements are buildings. From the perspective of orientation, the courtyard buildings tend to lean towards the southeast direction of these gardens, but the degree of deviation is very small (average 7.57 m), and the center of the building is basically consistent with the center of the garden.

The data and plans of the gardens show that the proportion of restructured garden buildings is large, but the scale of the garden is small, and the layout inside the garden is very similar to the classic form of Beijing's quadrangle courtyard. The buildings surround the landscape elements and form an observation area within the courtyard. However, unlike the traditional quadrangles, the layout of this group of courtyard is more flexible and varied, without a rigorous and solemn axis controlling the layout of the landscape (Figure 3- 6).

In Zang Garden (No.12) and Ke Garden (No.13), the architecture surrounds the landscape and forms the boundary of the garden. The garden space is divided into east and west courtyards by buildings, with similar offsets (3.5m and 3.0m), and the whole axis of the garden is led by the main hall buildings on the north of the two courtyards. Here, the whole building in Zang Garden is slightly offset to the south (82.2°), allowing space for mountains and landscaping to the north (Figure 3-1). The landscape in Ke Garden is central, with the large buildings in the north indicating a bias in to the north (89.4°) (Figure 3-1). In Najia Garden (No.14), building is evenly arranged in all directions to enclose the landscape elements, and forming a central scenic area with a slight deviation (3.7m) overall. The garden gate, auxiliary rooms, pavilions, corridors, halls and other important buildings are located in the south, which makes the overall building centre deviate to the south (56.2°), leaving space for water and mountain management in the north. The whole building contains a small square nested courtyard, with a prominent building central axis that is different from the landscape axis (Figure 3-1). Guichun Garden (No.11) is also a small garden with a large number of architectural. The southeast area is a concentration of buildings, while the landscape in the northwest area is enclosed by buildings forming a courtyard. The entire architectural axis and garden axis are not unified. Although there is a design of a typical Beijing's quadrangle courtyard, there is also incorporates the long and winding spatial forms of southern private gardens.

These group A gardens were all located within the city of Beijing and built by literati and politicians in the middle or late Qing Dynasty. Compared with other groups, the gardens and buildings in this group are least, and the overall axes of these garden are not prominent, but the part axis layout is still obvious. The central part of the garden is used to construct landscape elements to form a scenic area. There are many large-buildings on the north

side of the gardens, and the smaller buildings on the east and west sides are evenly distributed. This guides the layout of the internal landscape elements, with a regular northern courtyard style of the wing-rooms on either side of a one-storey house. In addition, the designer integrated the gardening methods of the south and north.They not only use the courtyard layout pattern of north, but it also utilized the landscape construction techniques from the south, which is a set of garden types that reflect the integration of art from the north and south.

5.2 Group B

In group B (4 gardens), the layout of the axis identity type (75.0%) has the highest frequency and the central axis characteristic is the most obvious. The disposition of courtyard type, linear type and scattered type is the only configuration mode in the group(100.0%). The large proportion of open spaces (75.0%) indicates that the vast majority of such garden buildings do not enclose the garden spaces, and the mixture of half open (100.0%) and enclosed (100.0%) type also indicates the diversity of such garden spaces. In terms of scale and orientation characteristics, this group of courtyards has the largest building scale (3889.60 m^2) and number (59.25), but has a much smaller proportion of buildings (13.4%) than Group A, indicating the grandeur of its garden scale. In addition, the degree of offset of garden buildings in this group is not generally high (14.08 m), and half of them (50.0%) have an offset above 5m. Most buildings in this group are offset to the east (75.0%). Three gardens have an offset orientation consistent with the garden gate, while offsets to the south and west (25.0%) are still less.

The plans for these gardens show most buildings are enclosed by the natural landscape space in the form of courtyards, presenting a close space feeling. The courtyards show a central axisymmetric layout, and control the internal landscape space has a uniformly axis relationship. In addition, the

buildings are evenly distributed within the gardens, presenting the characteristic of unified and coordinated layout (Figure 3- 6).

There are a large number of buildings within the Gongwangfu Garden (No.2),they are close to the north, and slightly offset to the east, making the west side of the courtyard ideal for building mountains and water features. In addition, the building has a compound courtyard layout, forming three axes in the east, middle and west. The middle axis is the longest and becomes the center of the garden (Figure3-1). Langrun Garden also has a grand architectural scale, but its proportion is relatively small. The buildings are mainly concentrated in the middle of the garden, surrounded by rivers and mountains, forming an isolated island. In addition, the buildings largely control the layout of the landscape elements within the courtyard, forming an axis that runs through the entire garden around the center of the building (Figure3-1). The buildings inside the Liwang Garden are equally grand in scale, with four clusters of buildings, one large and three small, evenly distributed in the north and south areas of the garden. The landscape elements in the garden surround the southern courtyards, which blend with each other. The northern courtyards are independent and clustered, so the overall architectural layout does not deviate significantly in any particular direction (Figure3-1). Chengze Garden also has a grand architectural community, which is a spatial structure composed of two groups of buildings in the north and south. The northern building community has a clear central axis, leading to a strip-shaped axis layout of rivers and mountains in the south, making the overall layout of the garden more unified and solemn (Figure3-1).

These gardens were built on a large scale by the emperor's family, and most of them were bestowed gardens distributed outside the Beijing. The garden scale was grand, with a prominent central axis, and the architectural layout was relatively concentrated and evenly distributed

within the garden. Garden architecture has a complex layout, with its center of gravity intentionally shifting northward, creating a space for the construction of mountain and water landscapes in the south.At that time, in order to reflect the identity and status of the garden owner, the grand building scale and dignified axis layout was the preferred choice. By deliberately locading the north, the gardens have an open space in the south and arranged landscape elements that emphasize the balanced spatial distribution. The proximity of the buildings to the garden door also reflects the need of the garden owner for convenience.

5.3 Group C

In Group C, the open courtyard type (100.0%) is its unique feature. The buildings scale of this group is still relatively large (average 2123.3 m^2), but the proportion is the lowest (10.4%). In addition, the distribution of buildings mostly leans towards the east side, mostly located in the northeast (40.0%) and southeast (40.0%), with the greatest deviation of buildings from the garden center (29.6m).

Compared to Group B, the gardens scale of this group is relatively small, but still larger than that of Group A, which is a transitional type between them. Although there is a clear architectural axis, it cannot fully control the layout of the landscape, reflecting the integration of architecture and landscape, rather than a subsidiary relationship (Figure 3- 6).

For example, there are relatively abundant buildings in Chunwangfu Garden (No.1),and the main building is offset to the east (28.9m) in the form of two courtyards and closed to the south (33.3°), extending a "U" shaped corridor to form a half open courtyard around the landscape on the south of the garden. The building axis runs through the whole garden, while less than 50m to the East, there is a garden gate for the convenience of the garden owners. Hence, the open space for landscaping to the west enriches

the garden space (Figure 3-1).There are also curved corridors in Zhenbeizi Garden (No.4), the buildings show obvious traces of eastward migration (14.7m). At the same time, the building centre deliberately closes the garden gate on the south (62.1°), creating an open space in the north. In addition, the secluded corridor in the west divides the landscape, so the overall layout is a three-entry courtyard in the east and west directions, showing a semi open and enclosed spatial configuration. Each courtyard has an independent axis, which echoes the landscape layout inside the courtyard (Figure 3-1). There are also long corridors in Taobeilefu Garden, but the extension direction is opposite to Zhenbeizifu Garden. The courtyard is located on the southwest side of the garden, deviating from the central scenic area. The long corridor extends northeast to the northern gate, with a square pavilion in the middle of the corridor forming a local axis. The north side is a vast landscape area, and walking inside the corridor can have a panoramic view. The courtyards of Qinghua Garden and Gubeizifu Garden are also not concentrated together, and the architecture and landscape have not formed a unified axis. For example, they have courtyard layouts in the northwest, northeast, southwest, and southeast, with each courtyard having its own axis. The courtyards and mountains and rivers are intertwined, showing a trend of mutual integration and inseparable.

This group of gardens is all built by nobles and nobilities, mainly distributed within the Beijing. Although they are still grand in scale, they are not as rigorous as the courtyards of nobles and nobilities in Group B, but are more magnificent and grandeur than those in Group A. The reason for this is not only that the identity and status of the garden owner are not as prominent as those of Group B gardens, but also that this group of gardens was more influenced by the style of southern gardens during the construction period, and the garden owner was influenced by literati thinking, showing a more open and inclusive volition.

6 Conclusions

Starting from the scale, layout and orientation of the buildings, combined with basic information such as the construction period, geographical location, identity of the owner and orientation of the garden door, this paper discusses the characteristics of these gardens and buildings to obtain three space patterns. The courtyard buildings in Group A surround the landscape space and are evenly and symmetrically distributed to the east and west, showing characteristic regularity and symmetry apart for the north courtyard. The overall style follows the classic Beijing quadrangle dwellings style, but also incorporates the flexible and diverse forms of southern gardens. Group B shows characteristic solemnity with a prominent axis. The gardens and buildings have a grand scale, reflecting the noble social status and strong economic strength of the garden owners. The garden buildings scale in Group C have moderate size, with the larger buildings located to the north and forming a part axis running through the landscape. These gardens present an open space form. The three types show differences in architectural scale, layout and orientation and reflect the important impact in the identity and geographical location of the garden owners as well as the complex form of the social environment of the time. This analysis develops our understanding of the directions and layout of North Chinese private gardens for a continued exploration of the garden spaces of this period.

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Chapter 4

The Spatial Characteristics of Beijing's Private Gardens in the Qing Dynasty Based on the Mountains and Waters (Shanshui)

1 Background and Purpose

An important element of traditional Chinese garden design, “mountain and water” (shanshui) features not only represent the skeleton of a garden’s spatial structure but also play important roles in its aesthetic and contextual expression; they complement each other and are inextricably linked [1]. In short, in a traditional Chinese garden, where there is a mountain feature, there is also water [2]. Traditional Chinese gardens are an integrated form of nature [3] and are characterised by the miniaturisation and simulation of natural landscapes. They display a variety of realistic natural shanshui features, such as waterfalls, lakes, rivers, cliffs, gorges, peaks and caves of various types[4]. Over time, the construction of traditional garden landscapes changed from a simple simulation of the forms of natural landscapes (during the Northern and Southern dynasties) to an expression of the poetic and pictorial mood of landscapes (during the Tang and Song dynasties). The increasing abstraction and condensation of gardening techniques embodied the Taoist philosophy of the beauty of the “mirror of the heart” (during the Ming and Qing dynasties)[5], focusing on people’s spiritual needs[6]. This formed a garden landscape culture with unique Chinese characteristics.

The Qing dynasty (1636–1912), the last period of glory for traditional Chinese gardens, saw the development of mature traditional gardens in the north and south [7]. As the country’s political centre at the time, Beijing was the site of a large number of private gardens built by bureaucratic literati. During this period, the number of gardens created in Beijing exceeded that in both Suzhou and Yangzhou and showed a high level of artistic achievement [8]. However, the mountains and water (shanshui) style of private gardens in Beijing at the time was influenced by the style of gardens in the south, with deep and winding waterfront lines and the use of not only

thin and translucent lakeside stones but also thick and robust local blue stones, presenting the dual characteristics of northern robustness and gravitas and southern softness and delicacy [9]. They fully reflected the natural environment, political culture and social needs of Beijing at the time [10]. The study of shanshui in private gardens in Beijing is not only a means of elucidating the spatial characteristics of these features but also a way of gaining insight into the natural environment of Beijing and the political culture of the region.

Currently, most researchers use personal accounts and other historical sources to outline and elucidate the characteristics of particular Beijing private gardens. Shanshui features are analysed in terms of three dimensions: layout, material construction and ideology. In terms of layout, Wang points out that during the Ming and Qing dynasties the water outside Beijing was so clear that the imperial family and ministers built gardens there[11], which became well known for their remarkable water features. The city itself lacked water sources, with few rivers from which to draw water (and it was illegal to draw water from these rivers for private use). As a result, many gardens in the city featured small pools, with mountain features much less prominent, merely like the memory of a mountain[11]. Liu compares the shanshui layout of the Chunwangfu Garden and the Gongwangfu Garden, pointing out that in the former, shanshui are arranged symmetrically around an axis [12-14]. In later studies, Jia and Zhang identify different patterns of shanshui layout, such as scattered, central, linear and encircling [9, 15, 16]. In terms of material construction, Zhu summarises the echniques of using earth and stone together for large rockeries and piling stones without exposing earth for small rockeries[17]. Jia points out that rockeries in northern private gardens are most commonly found in earthen mountains or stony mountains [8]. In terms of ideology and mood, Liu detects the influence of Taoist and Confucian philosophy on the

layout of shanshui features in the garden of the Gongwangfu Garden[18]. Zhang focuses on the garden owner of Ke Garden, whose use of natural landscape features reflected his quest for indifference to fame and fortune [19].

Most of the above studies present the characteristics of shanshui in Beijing private gardens in terms of the scale of the layout, the materials utilised and the emotions expressed in a qualitative manner. Although they usefully streamline the shanshui features of Beijing private gardens, the accuracy of their conclusions is often limited by the authors' own perceptions and personal feelings. A quantitative approach fills in these gaps and presents the findings more visually and accurately, making it possible to guide the shanshui design of today's gardens more precisely. Therefore, this paper sets out to analyse the patterns of shanshui features by setting relevant shanshui types and layout parameters for statistical and analytical, starting from the garden plane. So as to achieve the purposes of interpreting the shanshui characteristics of private gardens in Beijing during the Qing dynasty.

2 Objects and Methods

2.1 Objects

According to Jia in *The Private Gardens of the North China* and *Record of Private Gardens in Beijing*[8, 10], the category of "private gardens" generally refers to the gardens of mansions or villas used and occupied by individuals or their families on a long-term basis. In the Qing dynasty, however, many of the gardens of the imperial family were given away to others. Although the property rights to these gardens were still owned by the emperor, their construction, renovation and use depended on the personal preferences of the garden owners. Therefore, they are also included

in the study of private gardens. This study selects gardens from the above-mentioned books based on the following three criteria. ①The gardens were built or renovated during the Qing dynasty (1636 – 1912) and show the Qing style of gardening and artisanship.② The gardens contains mountain and water elements. ③ The gardens are well-preserved or well-documented examples of gardens of the period. Eighteen such gardens are selected for the final study (Figure 4-1).

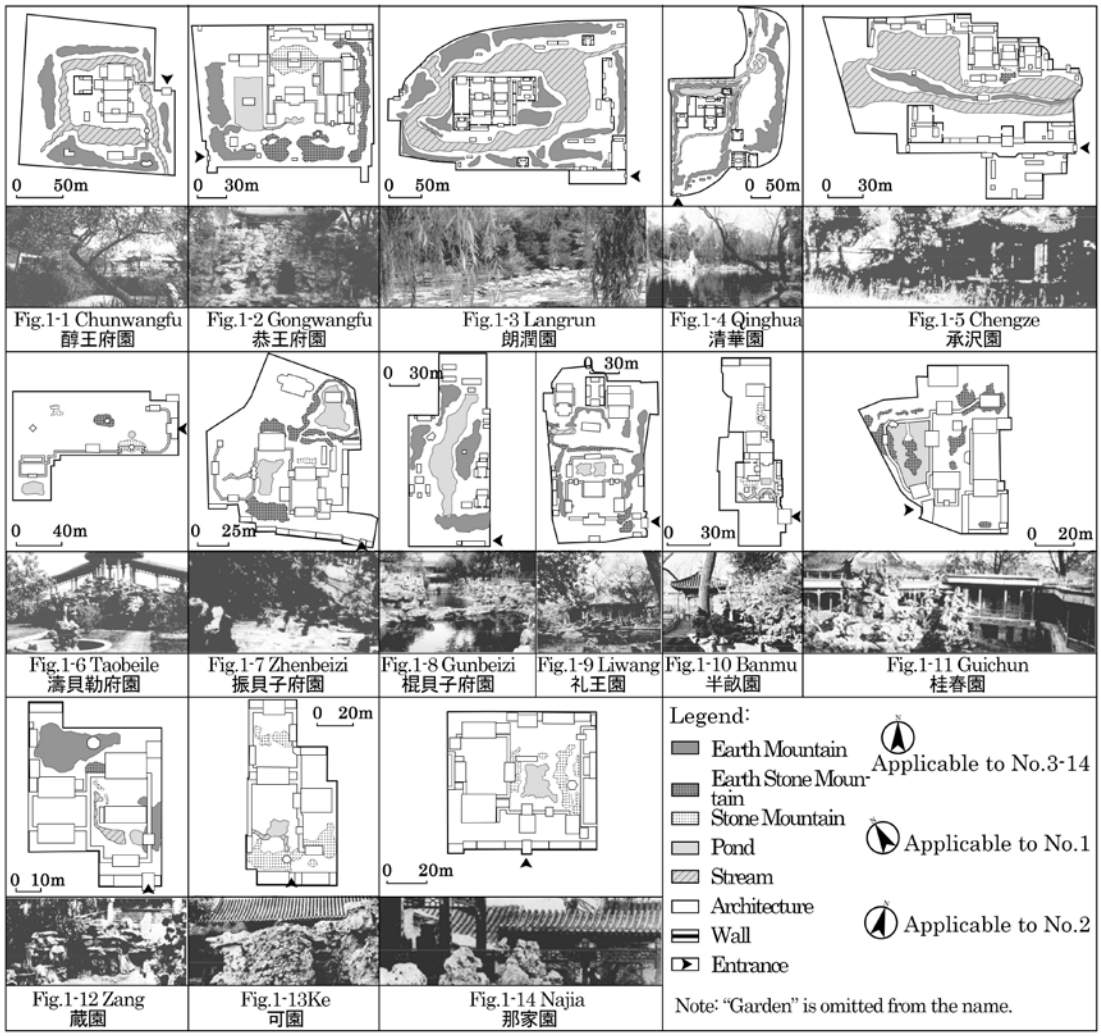


Figure 4- 1 Garden Plans

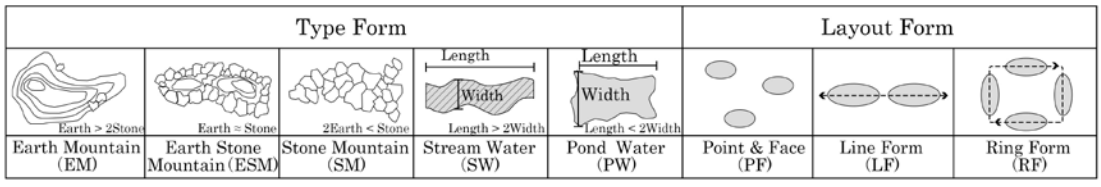


Figure 4- 2 Forms of Mountain and Water Features

Nine of these gardens were owned by palace nobility, usually gifted by the emperor to reward their service. The scale tends to be magnificent (Figure 4- 1), as the garden owners engaged in large-scale construction. These gardens comprise the Chunwangfu Garden (No.1), Gongwangfu Garden (No.2), Langrun Garden (No.3), Qinghua Garden (No.4), Chengze Garden (No.5), Taobeilei Garden (No.6), Zhenbeizi Garden(No.7), Gunbeizi Garden (No.8) and Liwang Garden (No.9). The Zhenbeizi Garden was a garden newly built by the corrupt and extravagant father and son Yi Kuang and Zai Zhen, and became a testimony to their corrupt practices, such as bribery [8]. Another five of the sampled gardens were owned by officials, such as generals, imperial officials and shangshu. They were smaller in scale than the gardens owned by nobility and most had been newly built by the owners or inherited from their families, including the Banmu Garden (No.10),the Guichun Garden (No.11), the Zang Garden (No.12), the Ke Garden (No.13) and the Najia Garden (No.14). The Banmu Garden (No.10) and Zang Garden (No.12) were purchased and converted by officials from other officials.The Guichun Garden (No.11), the Ke Garden (No.13) and the Najia Garden (No.14) were a newly built garden during that period.

2.2 Methods

First, a historical plan of the 14 sampled northern private gardens in Beijing during the Qing dynasty is established based on research in The Private Gardens of the North China and related Record of Private Gardens in Beijing. Information on the layout of the shanshui elements in each garden during the Qing dynasty is verified and refined from relevant written records (Yang, 2010). It combines the characteristics of Beijing private garden shanshui features with the study of shanshui features more generally[8, 16, 20] to develop a classification model that distinguishes their shanshui spatial forms. Secondly, an electronic version of the above sample

planes is drawn using AutoCAD.2022 software and the area of each type of shanshui is calculated using the software's area calculation function. The area values for the same type of shanshui are then counted and summarized using Excel software (Table 4-1). Next, SPSS.25 software is used to carry out a factor analysis of the area values for each of these types of shanshui, in order to reduce the number of indicators for each type of shanshui and to find the smallest number of indicators that most fully represent the shanshui characteristics of private gardens in Beijing and derive the total variance explained (Table 4-2) and a component matrix (Table 4-3).

Although the number of indicators for shanshui is compressed, the newly generated factors provide a highly condensed representation of the shanshui features of Beijing's private gardens, which may be ambiguous and obscure the interpretation of individual gardens. Such a condensed representation may also make it difficult to map the patterns of courtyard space. Therefore, the study also uses information on the area of the shanshui in each indicator to systematically cluster the 14 gardens into groups (using Ward's method and squared Euclidean distances) via SPSS 25.0 software[21)] and to map the pattern of shanshui features in each group. Ultimately, based on the scores of the 14 gardens for the new factors, a map of the distribution of the shanshui pattern groups for the new factor features is constructed, thus providing as multidimensional an overview as possible of the forms of shanshui features in the 14 gardens.

3 Shanshui Forms

Based on Jia's description of the composition of shanshui features in private courtyards in Beijing[8)], the study constructed indicators of the type of shanshui composition in terms of mountain construction and water management and the organisational relationship between the two. For this reason, this paper examines the characteristics of shanshui composition in

Beijing's private gardens, in terms of both the types of shanshui composition and the forms of organisation.

3.1 Types of Shanshui

Scholars mostly classify mountain elements into earth mountains, earth stone mountains and stone mountains, according to their earth and stone proportions[1, 7]. Earth mountains are defined as mountains that contain more earth than stone[22], including mountains made entirely of earth. Stones are often placed on the slopes or at the foot of these mountains to anchor the earth or are made into paths to facilitate climbing to the top of the mountains. These mountains often cover a large area and can be used to create a spatial framework for the garden or to grow plants to improve the garden environment. A stone and earth mountain has an equal distribution of stones and earth, which is constructed by first building a rockery and then piling stones on top of it to cover the earth[22], so that its appearance is similar to that of a natural rockery. Compared with earthen mountains, earth stone mountains have a smaller footprint and can be designed with a steeper slope, with more emphasis on the shape and veining of the mountain[23]. A stone mountain is composed almost entirely of rock, with gaps between stones filled with mud and ash[22]. The small footprint of stone mountains is often a condensed and moody depiction of the natural mountain landscape, allowing for the construction of majestic and unique mountain landforms such as peaks, cliffs and gullies[24](Fig. 4-2). The study categorises these types of mountain features according to their proportions of earth and stone. If the proportion of earth is more than twice that of stone, the mountain is an earth mountain (EM). If the proportion of stone is more than twice that of the earth, it is stone mountain (SM), and the middle is earth stone mountain (ESM).

Firstly, water elements are classified into 2 main categories, Stream

Water (SW) and Pool Water (PW), according to their shape and the presence or absence of flow[20]. Shape is determined using the ratio of the maximum length to the maximum width of the water body. When the value is close to 1 it means that the water body is approximately square or circular in shape, behaving as a surface; conversely, when the value is higher than 1, the water body behaves more narrowly and takes an overall banded shape. The ratio of 2 as the point of decomposition for circular and banded shapes (maximum length is twice the maximum width)[25]. A "stream" should firstly have a form factor greater than 2, and secondly the water should have the capacity to flow. By analogy, a "pool" is a body of water with a shape factor between 1 and 2 and in which the water has no capacity to flow (Fig. 4-2). In the case of a complex shaped water body (with both facets and strips), the division between "streams" and "pools" is based on the faceted area, cut from the junction of the two and then studied and calculated separately (Fig. 4-1).

3.2 Layout of Shanshui

From previous studies[20], it can be seen that the classification of scattered, central, linear and encircling follows the principle of grouping points, surfaces, lines and rings. When the number of mountain or water features in a garden is large, the characteristics of the dispersed type are well demonstrated, but when the number is reduced to a single shanshui, which is not at the centre of the garden and is not linear or encircling, the explanatory power of the dispersed type is limited. It is clear that this classification does not cover all shanshui situations. Therefore, this study combines the dispersed and central types. When there is only one shanshui, it has the property of a point from a macroscopic perspective, and can also be seen as faceted from a microscopic perspective. In this study, such cases are first grouped into point/facet forms and the remaining linear and

encircling types are added, giving a total of three indicators of the forms of shanshui layout in private gardens in Beijing. In this context, “point or face form” (PF) refers to the disorderly dispersion of mountains or water in the garden in the form of points or surfaces. “Line form” (LF) refers to a layout pattern in which the mountain or water features are organised in a single linear pattern with distinctive banding features. “Ring form” (RF) represents a pattern of local organisation of the garden interior with mountains or water enclosing the garden space in a circular fashion (Fig. 4-2).

Table 4- 1 The Information of Research Objects

NO.	Name	SO	CS	Age	Scale	P	Type Form					Layout Form					
							Mountain			Water		Mountain			Water		
							EM	ESM	SM	SW	PW	PF	LF	RF	PF	LF	RF
1	Chunwangfu	RN	RB	TZ	25262.3	27.8%	3876.2	0.0	0.0	3148.2	0.0	0.0	0.0	3876.2	0.0	324.4	2823.8
2	Gongwangfu	RN	RB	TZ	10570.9	28.0%	1915.6	2816.9	1297.4	42.3	1717.2	1297.4	0.0	4732.5	1717.2	42.3	0.0
3	Langrun	RN	RB	XF	27800.1	43.0%	17046.0	0.0	0.0	16704.9	0.0	2579.0	1188.9	13278.1	0.0	749.1	15955.8
4	Qinghua	RN	RB	DG	14479.3	28.0%	18968.4	0.0	0.0	4539.9	1494.0	2047.0	0.0	16921.4	0.0	1494.0	4539.9
5	Chengze	RN	RB	DG	78414.4	28.6%	795.3	80.7	10.9	5481.7	0.0	80.7	806.2	0.0	0.0	0.0	5481.7
6	Taobeile	RN	RB	GX	89412.5	6.3%	0.0	170.2	333.7	0.0	161.9	503.8	0.0	0.0	161.9	0.0	0.0
7	Zhenbeizi	RN	NB	GX	13879.5	18.5%	0.0	1775.9	61.5	60.5	786.8	644.5	61.5	1131.3	786.8	60.5	0.0
8	Gunbeizi	RN	RB	GX	18053.3	32.9%	2624.9	0.0	0.0	0.0	1944.1	0.0	0.0	2624.9	0.0	1944.1	0.0
9	Liwang	RN	RB	GX	3038.4	13.8%	1449.8	655.0	0.0	79.9	299.0	126.6	0.0	1978.2	299.0	79.9	0.0
10	Banmu	OP	RB	DG	5011.2	8.3%	0.0	0.0	169.9	57.2	25.8	0.0	169.9	0.0	25.8	57.2	0.0
11	Guichun	OP	NB	GX	3242.3	18.0%	0.0	0.0	513.1	0.0	391.2	268.4	244.6	0.0	391.2	0.0	0.0
12	Zang	OP	RB	GX	22301.2	17.5%	447.3	36.9	7.8	52.7	21.5	424.2	67.7	0.0	21.5	52.7	0.0
13	Ke	OP	NB	XF	4115.0	15.3%	0.0	0.0	536.7	26.9	66.9	112.4	424.3	0.0	66.9	26.9	0.0
14	Najia	OP	NB	GX	5754.5	8.1%	0.0	0.0	281.8	0.0	181.5	12.1	269.7	0.0	181.5	0.0	0.0

Note. ①.“Garden” is omitted from the name.②.SO:status/occupation of the garden owner, RN:royal or nobility, OP:officials or politicians, CI:civilian. ③.CS:construction situation, NB:new-built, RB:rebuilt. ④.Daoguang(DG):1821—1850, Xianfeng(XF):1851—1861, Tongzhi(TZ):1862—1874, Guangxu(GX):1875—1908, Xuantong(XT):1909—1912.⑤.Scale:The area of gardens. ⑥.Unit:square meter (m^2). ⑦.Percentage(P):The ratio of shanshui area to garden’ s. ⑧.The type and layout form derived from Fig. 2.

4 Results

4.1 Extraction of Principal Components

Using SPSS.25 software, the above indicators of the composition of the mountain and water are dimensionalised. A correlation matrix is constructed to standardise the data with principal component analysis. The number of component factors is established based on the intrinsic value and cumulative extent of the components (Table 4-1), and the variance factors of the variable indicators are eventually extracted using the maximum variance method to maximise the impact of the indicators on the

components without changing the indicators themselves (Table 4-2), to facilitate the naming of the components[26]. Of these, the intrinsic value to the 3rd principal component is 1.912 (greater than 1) and the resulting cumulative value is 90.881%, indicating that these 3 components well represent the characteristic information of the shanshui composition of the gardens.

Table 4- 2 Component Matrix

Type and Layout		I	II	III
W-RF		0.965	-0.203	-0.019
SW		0.964	-0.200	-0.023
M-LF		0.846	0.252	0.368
M-PF		0.796	-0.160	0.538
EM		0.774	-0.190	-0.443
M-RF		0.742	-0.010	0.617
W-PF		-0.093	0.984	0.044
ESM		-0.061	0.932	0.088
SM		-0.125	0.853	-0.108
W-LF		0.197	-0.319	0.873
PW		-0.124	0.422	0.847
Contri-bution	Single	40.365%	27.754%	22.762%
	Total	40.365%	68.119%	90.881%

Note:①. M:Mountain, W:Water. ②.Single: The contribution ratio of each factor. Total: The cumulative contribution ratio of factors. ③. The type and layout form derived from Fig. 2.

Within Component I, the mountains are dominated by earth mountains (0.796), which take the form of lines (0.774), facets (0.846) and rings (0.965), while the water bodies take the form of streams (0.964) with rings (0.965). The gentle slope of the mountain and the large area it covers tend to convey a dignified and stable impression, while the streams are distributed in a circular shape in the garden, making the layout of the shanshui look more balanced in all directions[8], hence the name of this factor: “dignity”.

In Component II, the highest loadings are for water facets (0.984), earth stone mountains (0.932) and stone mountains (0.853). The surface-shaped water bodies in the gardens are mostly miniature versions of the natural

shapes of large lakes. The stone and earth mountains and stone mountains take advantage of the small footprint and distinctive shape of the stones, not only compressing the space of the mountains and saving land but also providing a condensed depiction of the natural peculiarities of peaks, cliffs and ravines[27]. This is a form of reduction of the natural landscape, so the factor is named “compressibility”.

Within Component III, there are only two indicators for the type of pond (0.847) in the form of a ribbon (0.873), reflecting an imitation of a natural ribbon lake. This form of water body extends in one direction and often has the appearance of a long river in the forest when viewed from one end to the other[8], for which reason the factor is named “extensibility”.

Table 4- 3 Total Variance Explained

Comp-onent	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	Variance	Cumulative	Total	Variance	Cumulative
1	5.039	45.809%	45.809%	4.440	40.365%	40.365%
2	3.046	27.691%	73.500%	3.053	27.754%	68.119%
3	1.912	17.381%	90.881%	2.504	22.762%	90.881%
Extraction Method : Principal Component Analysis						

4.2 Classification Results

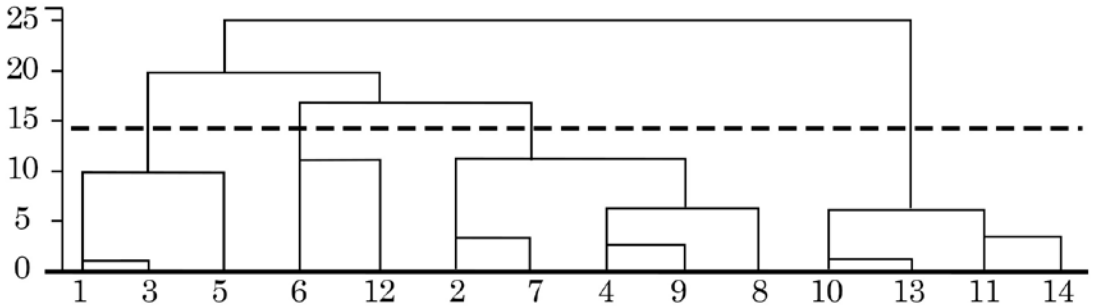
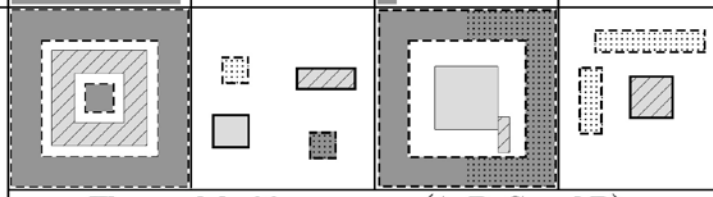


Figure 4- 3 The Results of Cluster Analysis

The study uses the systematic clustering function of SPSS.25 software to group the 14 gardens based on numerical information of the shanshui in 11 indicators. Based on the principles of maximum inter-cluster distance, maximum differentiation and moderate cluster size[28], the 14 garden samples are finally divided into four groups and named Group A, Group B,

Group C and Group D respectively (Fig. 4-3). Subsequently, based on the grouping results, the percentage of different shanshui types within each group is counted in each group using EXCEL software (Table 4-4). The groups are also displayed within a three-dimensional Cartesian coordinate system constructed from Components I, II and III, based on the principal component scores, as a means of clarifying the differences between groups (Fig. 4-4).

Table 4- 4 Proportions and Patterns of Shanshui

Type and Layout \ Group		A	B	C	D
Mountain	EM	96.6%	45.5%	60.1%	0.0%
	ESM	3.0%	20.6%	34.9%	0.0%
	SM	0.4%	33.9%	5.0%	100.0%
	PF	8.1%	93.1%	14.7%	19.4%
	LF	32.6%	6.9%	0.7%	80.6%
	RF	59.3%	0.0%	84.7%	0.0%
Water	SW	100.0%	35.5%	21.2%	24.4%
	PW	0.0%	64.5%	78.8%	75.6%
	PF	0.0%	64.5%	53.9%	75.6%
	LF	4.9%	35.5%	31.1%	24.4%
	RF	95.1%	0.0%	15.0%	0.0%
Legend: EM, ESM, SM, SW, PW					
		The model of four groups (A, B, C and D)			

Group A comprises gardens with three courtyards (Nos. 1, 3 and 5), which are characterised by EM (96.6%), RF of mountain (59.3%) and SW (100%) RF of water (95.1%) as the main components (Table 4-4). Compared to the other groups, this group of gardens has a higher degree of dignity in Component II, as the boundary range is concentrated on the positive side. In Component II, as all are on the lower side of the negative axis, the

shanshui in this group of gardens show a lower level of compressibility in their simulation of natural landscapes compared with the other three groups. For Component III, the concentration of gardens in this group on one side of the negative axis suggests that the shanshui in this group sometimes have a lower extensibility (Fig. 4-4).

Group B, with only two gardens (Nos. 6, 12), has the smallest number of gardens. Its gardens show a shanshui type with PF of mountains (93.1%) (EM: 45.5%, ESM: 20.6%, SM: 33.9%) and faceted ponds (PW and PF of water) (64.5%) (Table 4-4). In Components I, II and III, the two gardens are in a relatively central area compared to those in Groups C and D, indicating that their shanshui have medium levels of dignity, compressibility and extensibility. However, compared with Group A, this group is much smaller in Component I than its lowest level, indicating that the shanshui in their gardens differ significantly from those in Group A in terms of dignity (Fig. 4-4).

Group C consists of five gardens (Nos. 2, 4, 7, 8 and 9), with mountain types consisting mainly of EM (60.1%) and ESM (34.9%), showing a circular (RF: 84.7%) layout. Water bodies are dominated by ponds (78.8%), accompanied by streams (21.2%), with PF (53.9%), LF (31.1%) and RF (15.0%) distributions (Table 4-4). This group is evenly distributed on both the positive and negative sides of Component I and Component II, reflecting the high and low levels of dignity and compressibility of shanshui elements in these gardens. In component III, the courtyards in this group are all at positive values and much higher than the other three groups, reflecting their higher extensibility (Fig. 4-4).

Group D consists of eight gardens (Nos. 10, 11, 13, 14) and is the most numerous group of garden forms. In terms of the proportion of elements, this group is dominated by SM (100.0%) and PW (75.6%), with the mountains mostly distributed in LF (80.6%) and the water bodies in both

PF (75.6%) and LF (24.4%) (Table 4-4). From Components I and III, the range of the gardens in this group is concentrated in the lower left compared with the other three groups, showing that the layout and space of the shanshui have lower degrees of dignity and extensibility. However, from Component II, the range of the gardens is smaller than that of Group C but overall greater than that of Group A. This indicates that the shanshui in the gardens in Group D is more comparable to the natural landscape than some of the gardens in Group C, with a clear advantage over Group A (Fig. 4-4).

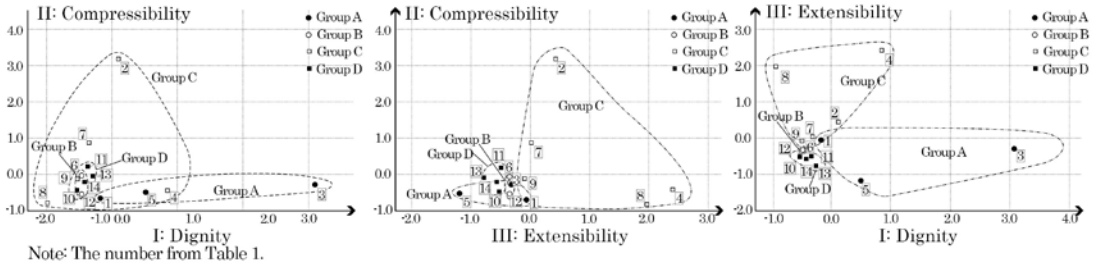


Figure 4- 4 Allocation of Gardens in Each Group

5 Discussion

5.1 Group A

In sum, this group of gardens shows a layout in which earthen mountains and streams surround the garden space and the shanshui is evenly distributed in terms of layout, appearing balanced and stable (Table 4-4). In this group, No. 3 and No. 5 are more dignified than No. 1, which may be related to the scale of the gardens and the proportions of their shanshui elements. For example, in both Nos. 1 and 3, the gardens are surrounded by a ring of mountains and streams, but the proportion of shanshui in the garden in No. 3 is 43.0%, much higher than in No. 1, and the scale of the garden in No. 3 is much larger than in No. 1 (Table 4-2), which shows the importance attached to shanshui in No. 3. In this group, the dignity of both No. 3 and No. 5 is higher than that of No. 1. This is in addition to the fact

that in No. 3, not only are there rings of mountains and streams surrounding the garden at the periphery, but there is also a distribution of earth mountain within the ring, forming a multiple enclosed layout of mountains-water-mountains (Fig. 4-1), which is more complex than No. 1. In No. 5, the garden is very similar in scale and proportion to the shanshui in No. 1, but it lacks the encircling layout of the earth mountain and the stream is so much larger than the mountains that the latter appear to form an island at the centre of the lake, like a small continent (Fig. 4-1). The relative lack of dignity of No. 1 is due not only to the scale mentioned above, but also to the layout of the water bodies. In the south-east and south-west corners of the garden, there are two ribbon streams that act as channels to the outside water supply, breaking up the solemnity of the circular water to some extent and giving it a more flexible and gentle appearance (Fig. 4-1). In addition, Nos. 1, 3 and 5 all have a low level of compressibility and extensibility, echoing the group's focus on the simulation of the natural landscape layout and the fact that the circular layout pattern makes it difficult to produce extension in one direction.

This group of gardens, all rebuilt by the palace nobility in the middle or late Qing Dynasty (Table 4-1).They are heavily dominated by mountains and water, and the layout of mountains surrounded by water is its most distinctive feature; this layout allows the gardens to be isolated from the outside world, avoiding the hustle and bustle of the city, and echoing the Taoist emphasis on escape from society and seclusion in the Peach Garden. In addition, Jia's description of the three gardens in terms of seclusion, dignity and naturalness[8)] is verified, but there are still differences in degree in these characteristics. No. 3, the most dignified of them all, is undoubtedly the richest in its layout pattern, surrounded by mountains and water, providing a valuable example of a classical garden[8)].

5.2 Group B

On the whole, the shanshui in this group of gardens exist in a faceted form, but the types of mountains are more multi-faceted and the water bodies are mainly ponds, with a scattered and disorganised distribution (Table 4-4). This is a good illustration of why these two gardens, No. 6 and No. 12, are disadvantaged in terms of dignity and extensibility (Fig. 4-4). In the south-east of No. 6, for example, there is a rockery underneath the gallery and pavilion, the northern part of which is piled up with lake stones, while the southern part of the rockery is inlaid with blue stone, abstractly portraying two different mountain forms[8]. In addition, in the central part of the garden, there is an earth stone mountain on which a pavilion is placed, and the terrain is flat, reflecting the natural topography of the undulating mountains (Fig. 4-1). In No. 12, the northern mountain is made of earth mixed with a small number of stones, on which plants are planted and pavilions are provided in which for people to rest and enjoy the view, which is very similar to the shanshui space in traditional Chinese paintings. However, in the middle of the garden, there are stone mountains piled up, which create a staggered height and also give rise to different forms of water bodies, such as waterfalls, streams and ponds[8], which is a highly scaled-down representation of the natural landscape (Fig. 4-1).

In contrast with that of Group A, the shanshui form of this group of gardens is to some extent abstract, but in some ways it also offers a realistic expression of the natural landscape. Group B is a group of garden forms with a variety of features, and the identity of garden owners is also variable. This conclusion follows Jia's assessment of the two gardens and sheds light on the causes, strengths and weaknesses of the variations.

5.3 Group C

The mountain layout of this group of gardens is very similar to that of Group A, which is in the form of rings, but its material construction tends to be excessive, like that of Group B, showing a combination of earth mountains and earth stone mountains. The shape and distribution of its water body differ from the circular layout of Group A, showing faceted and banded characteristics (Table 4-4). This also explains why the solemnity of this group of gardens is neither strong nor weak. In this group of gardens, the compressibility and ductility of mountains and water features are variously high and low. No. 2 and No. 7 have high compressibility but low ductility, which is the opposite of No. 8 and No. 4 (Fig. 4-4). For example, in No. 2, there is a group of large rockeries constructed of lake stones in the north of the garden. There are steps, corridors and pavilions on the mountain. There are caves inside the mountain, which are tortuous and deep, with the artistic conception of natural karst caves. However, ductility is low. There is a lake on the west side of the garden, which is long from north to south and narrow from east to west. There is a boat building in the middle, which cuts the water surface space and interrupts the ductility. A banded stream extends from the southeast corner of the water body, connecting to a bat-shaped pool in the centre, which simulates a variety of water features in a limited range, showing high compressibility. Similarly, in the middle of No. 7, there is a rockery built of blue stones. There are stone caves inside the rockery and steps to the top of the mountain, similar to the design method of the rockery in No. 2's mansion. The water body in the west of the garden is designed with an open water surface, which passes under the corridor and turns into a curved stream, echoing the design of the southeast direction of No. 2's mansion water area. The water body in the north of the palace garden is long from north to south and east to west.

There is a boat building in the center to separate the water surface (Fig. 4-1), which is also very similar to the design of the water body in the north of No.2. In No. 4, the earth mountains and streams form a layout mode of double rings side by side in the garden, and in No. 8, there is also a circular layout of earth mountains, which is very similar to the mountain characteristics of Group A. However, in the design of water space, No. 8 uses a ribbon of water to cross the north and south of the garden, like a jade belt. When people stand at one end of the water and look towards the other side, it is like standing in a valley and looking into a long river[8] (Fig. 4-1). Similarly, there are banded lakes in the north of No. 4. Although the proportion of lakes relative to garden area is relatively small compared with that of No. 8, the areas of the two are not much different (Table 4-1) and they have similar design Ways. In addition, on the west side of No. 9, there are banded pools. Although there is a certain degree of extensibility, due to the small scale and proportions of No. 9 (Table 4-1), its embodiment of extensibility is not as obvious as that of No. 4 and No. 8 (Fig. 4-1).

In Record of Private Gardens in Beijing, Jia repeatedly mentions the influence of Confucianism and Taoism on the shanshui construction of this group of gardens, manifested in the construction of shanshui elements on an axis[8]. But now we can find clues to this influence only in the types and layout of mountains and waters. This group was mainly rebuilt by members of the court in late Qing Dynasty, similar to Group A, and the layout around the mountain shows the same Taoist reclusive thought as Group A[8]. On the other hand, the shanshui forms of this group are as rich and diverse as those of Group B, which is an embodiment of the Confucian principle of the "middle way".

5.4 Group D

According to the layout analysis results for the gardens, banded stone

mountains and ponds combined with surface and banded are the prominent features of this group of gardens (Table 4-4). Compared with Group A, the gardens in this group are less solemn but more compressed, and they are less ductile than the gardens in Group C (Fig. 4-4). No. 11 in Group D is the most conspicuously compressed. In the northeast of the garden, there is a rockery piled with blue stones, which has a unique shape. On the rockery, there is a square pavilion, which is connected to a courtyard on the west side through a corridor. The interior of the courtyard is occupied by a pool, and there are towering lake stones at the center of the pool, creating an exquisite effect. In addition, the height of the northern corridor varies complexly, and there are rockeries of different sizes alongside the corridor. This creates an impression of walking between mountains and forest[8]. No. 13 offers an even better example, with a rockery built from blue stones in its lower part and lake stones in its upper part. There are square pavilions and climbing trails on the rockery. A small stream stretches from the middle of the northern part of the rockery and converges into a surface lake, reminding viewers of the liveliness of natural mountains, forests and springs. In addition, in the north of the garden, there are not only stones symbolising a mountain peak but also scattered lake stones symbolising the shape of the mountain, which are full simulation of landscape poetry and painting[8]. In No. 14 and No. 10, the construction of stone mountains and surface water bodies is still the focus. Using the uneven shapes of blue stones and lake stones, the majestic momentum of real mountains is simulated. The combination of surface and line water features simulates the curved rivers and wide lakes of the natural world.

Evaluating the above gardens, Jia uses words such as “exquisite”, “tortuous” and “changeable” and points out that their spatial construction method can be described as “seeing big things through small ones”, which is similar to construction method of the private gardens in the south[8].

Judging from the identities of the garden owners, this group of gardens was built by officials and politicians at that time within the city of Beijing. Compared with the gardens in Groups A and C, the construction of Group D's gardens was more restricted. Building rich shanshui space in a narrow space is a major challenge for designers. In addition, the application of lake stone materials resembles southern private gardens, which demonstrates the subjective identification of the impact of southern private gardens on Beijing private gardens[9].

6 Conclusions

Focusing on planar composition, this study analyses the types and layout of shanshui features in 14 private family gardens in the north of Beijing. Using factor analysis, the main components and types of shanshui in the gardens are extracted and the characteristic differences in shanshui between the groups are clearly identified by clustering. It is found that objective conditions such as the identity of the garden owner and the scale of the garden restrict the construction of shanshui, as reflected in the types of materials used and layout and forms of shanshui. The construction period and the location of the garden have a weak impact on the layout of the shanshui. Due to limitations on the length of this paper, this finding will be further elaborated in subsequent research. In general, the quantitative research results agree with the qualitative research results of predecessors, but to a large extent, they provide a more accurate depiction of the relative prominence of certain characteristics of each garden's shanshui layout and the reasons for their formation, providing a more precise understanding of private gardens in Beijing. Due to war and major environmental and economic changes after the Qing dynasty in China, the vast majority of private gardens in Beijing have been destroyed or otherwise disappeared, leaving only Chunwangfu Garden and Gongwangfu Garden preserved to

date[8]. Therefore, the number of samples selected is limited, which adds great difficulty to the research. In future research, the researcher will continue to look for lost examples of private gardens in Beijing to increase the number of research objects and provide a better reference for relevant research.

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Chapter 5

The Spatial Characteristics of Beijing's Private Gardens in the Qing Dynasty Based on the Paths

1 Background and Purpose

1.1. Research Background and Status

As the pioneer and prototype for urban parks[1, 2], traditional gardens reflect the purest regional culture and display gardening techniques[3, 4]. Several traditional gardens are listed as cultural heritage sites by their regions and some are recognised globally for their outstanding universal value[5]. As a public component of urban green spaces, traditional gardens provide value and function that cannot be replaced by ordinary parks or open green spaces[6]. Some modern urban parks and greenbelts attempt to imitate traditional garden forms[7], producing mixed gardens combining traditional and contemporary styles, but the outcome is widely criticized by users and scholars[8]. Can modern urban parks integrate the design wisdom of traditional gardens while meeting the needs of contemporary society[9, 10]? To answer this question, the intentions underlying traditional garden design require research and depth of understanding[11].

Since the 1990s, garden designers have examined the tradition of garden style[12-14].For example, contemporary landscape designers in Britain, France, Italy, China, Japan,and Islamic regions are striving to follow the direction set out in traditional gardens, and this has produced many excellent examples[15-18]. However, initial research on the inheritance and development of CTGs has generally taken a qualitative approach[19], considering to a greater or lesser extent the feelings of researchers or designers. This allows room to improve the accuracy of the research results. Today, scholars can accurately describe the style characteristics of a garden by using a series of index parameters in the form of field measurement and questionnaires[20, 21], and use these parameters to establish a quantitative evaluation model for garden characteristics[22, 23], thus greatly improving the accuracy of the results. However, data acquisition is still constrained by the

prerequisites for measurement (instrumentation, weather, permission of the park or garden manager, etc.) and the survey population (sample size, structure, etc.). As a branch of mathematics, graph theory considers graphs as its research object to describe specific relationships between various objects[24]. This method is not affected by objective conditions such as the environment, instrumentation, and weather, and hence overcomes the limitation of data acquisition previously mentioned. By using graph theory, reasonably specifying parameters and indicators, and applying analysis and modelling software (such as ArcGIS, Grasshopper. Available from http://www.esri.com/software/arcgis and http://www.grasshopper3d.com (accessed on 1 October 2022)), the designer can take a more scientific, accurate and efficient approach.

Chinese Traditional Gardens (CTGs), with their millennia-long history[25], have had a profound impact on the design Ways of traditional gardens in Europe[26], South Korea, and Japan[27-29], and are still referred to in contemporary garden design[19, 30]. In late 20th century China, rapid urbanization resulted in the speedy construction of urban parks and greenbelts that largely ignored traditional garden design[31]. Specifically, CTGs attempt to create a natural microcosm, presenting visitors with a different view at every step[32, 33], leading along secluded, winding paths, and displaying grand visions through small scenes [34]. The garden path is the key element in this effect[35]. Its design is the outcome of the consideration and experience of the garden owner and the designer and was constantly adjusted through personal experiments, considering various factors ranging from body size to the psychological and spiritual needs of the garden owners[36]. Therefore, the quantification of garden paths is an important factor to accurately describe the garden owner's needs and to guide the garden designer.

CTGs reached maturity during the Qing Dynasty, when the gardening art

of the southern and northern gardens attained its historical peak[37]. Due to the differences between natural conditions and social outlooks, as well as the varying political and cultural conditions between the south and the north of China, the garden path styles in the two regions exhibit considerable differences[38]. For example, the southern garden path demonstrates a slender and tortuous temperament, while the northern garden path adopts a spacious, straightforward, symmetrical, and clear official style[39]. As the political centre of the Qing Dynasty, private gardening activities in Beijing were very numerous in this period. There are several more gardens in Beijing than in Suzhou and Yangzhou, the main cities of the south where traditional gardens can be found[40]. The function and historical statues of Beijing's traditional private gardens (BTPGs) is equivalent to the private gardens of the south, yet researchers have tended to focus on the southern traditional gardens[38]. Further studies of private gardens on the north will help fill these gaps.

1.2. Review of Path Indicators

At present, it has been proved that calculations using road quantitative indicators can effectively guide planning and design[41]. Through the design of road alignment and the control of indicators, the designer can reduce the occurrence of traffic accidents, reduce road construction costs, and improve the user's experience[42-44]. On the basis of path/road studies, the relevant parameters can be categorised as scale indicators, shape indicators, and network indicators.

First, the scale indicators are calculated based on European geometry to describe the size and dimensions of the road. These include the length, width, quantity, and curvature, as well as other indicators developed from the these, such as the average length, maximum length, curvature change degree, etc.[45]. In Japan, a study compared the path widths of four

traditional gardens and two modern gardens in Tokyo. The data show that the average width of traditional garden roads (1.6–2.2 m) is much less than that in contemporary gardens (3.4–6.0 m)[46]. In addition, some scholars measured the curvature of the garden path in thirty traditional Japanese gardens. The results show that with an increase of the garden area, the degree of road tortuosity decreases until it approaches a fixed value[47]. In China, scholars used basic indicators such as length, area, width, and quantity to analyse and summarize the road characteristics of southern and northern gardens, obtaining some scattered data characteristics, such as the road width of northern gardens varying around two m and not being affected by the garden area[36,48-50]. In addition to the indicator characteristics of the garden road itself, the change of the visitors' sight line with one step is another important indicator to determine the opening and closing changes of the garden space. By means of fixed-point measurement or space syntax software (Depthmap) calculations, the periodic change in the range of vision can be detected[50-52]. However, due to the different nature of the various indicators and research objects, it is difficult to link and compare the research results. Nonetheless, it can be concluded that all studies have identified a certain connection between the garden path characteristics and the garden scale[53].

Second, the shape indicators are also calculated based on European geometry[54]. This aspect is concerned with the shape or morphological characteristics of path/road areas instead of scale, shape, and more complex formulations and theories, such as perimeter area ratio, shape index, fractal dimension, etc. Such indicators are mostly used to determine the geometric characteristics of green space, and there are few applications of these indicators in the study of the shape of garden roads. In the study of geometry, many indicator parameters can be used to calculate the boundary characteristics of green space[55], but these are prone to confusion and

misuse due to the huge and chaotic nature of morphological indicators systems[56, 57]. To overcome this problem, Riitters used the methods of correlation and principal component analysis to compress 55 morphological indicators into six representative indicators (average perimeter-area ratio, contagion, standardized patch shape, patch perimeter, area scaling, number of attribute classes, and large-patch density-area scaling[58]). The condition and the number of attribute classes are applicable to many types of patch elements. The path is a single element and is difficult to use. The other indicators are derived from the perimeter and area of the patch. Moreover, fractal geometry can effectively describe the complexity of road and path morphology[59, 60].

Finally, network indicators are based on topological geometry. They mainly focus on connectivity and compactness between points and lines of road alignment, such as connectivity, aggregation, dispersion, etc. [61]. In terms of connectivity, traffic topological networks are commonly studied using spatial syntax and complex network theory[62, 63]. The latter theory involves converting a large number of objects into points and lines to quantify the path's network connectivity through the average degree and average path length path[64]. Alpha (α), beta (β), and gamma (γ) indicators describe path network complexity conveniently and quickly[65, 66], and provide a wide reference for the analysis and evaluation of urban paths[67] and ecological corridors[68]. Similarly, spatial syntax is not only applied to the spatial opening and closing of the line of sight, but is also involved in the computation of network connectivity and depth value [69, 70]. However, the two indicators used in spatial syntax have the same theory as connectivity indicators such as α , β and γ , so it is sufficient to choose one set. In terms of aggregation or dispersion, although the centrality indicator is used to explain the degree of aggregation or dispersion of green or building blocks[71, 72], the principle is still applicable to path patches.

To sum up, in the study of medium-scale (block) and large-scale (city) path networks[73-76], several indicators are used to describe the geometric shape of paths[77, 78] and their topological network characteristics[79]. In contrast, the indicators for small-scale areas (such as gardens or parks) are rare. A quantitative indicator system specifically designed for garden paths is required. In addition, indicators may have different practical degrees when dealing with different sizes and types of roads and paths. The practical indicators for small-scale garden roads can be formulated by combining the calculation principles of indicators and using repair calculation methods.

1.3 Research Objective

The Section 1.2 expands the number and dimension of quantitative indicators of traditional garden paths by integrating existing quantitative studies of path characteristics at different scales (large: city; middle: block; and small: garden/park). Therefore, this research considers the traditional private gardens of Beijing in the Qing Dynasty as the research objects, combines the plane image information of the garden path and the larger existing quantitative indicator set, and applies factor analysis (FA) and correlation analysis (CA) to pursue the following three purposes:

1. Identification of representative indicators of the small-scale garden path network system.

2. Quantification and clarification of the path characteristics of private gardens in the Qing Dynasty in Beijing, and of the similarities and differences between them.

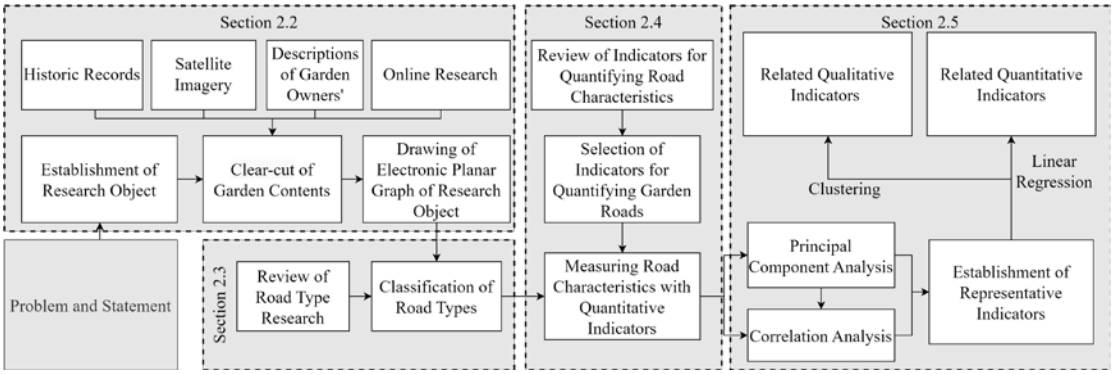
3. Development of suggestions for the design of garden paths of contemporary antique gardens/parks in Beijing.

2 Methodology

2.1 Study Method

The research method (Figure 5-1) included the following steps. (1) In Beijing, the research object is defined: historical records containing path data, satellite images, the descriptions of the garden owner, and on-site investigation are collated, and an electronic representation of the garden path is then made (Section 2.2). (2) Path types are subdivided according to the research objects (Section 3.1). (3) The quantitative research indicators (the largest indicator set) are selected, on as wide a basis as possible (Section 3.2). (4) The maximum indicator set of garden paths is compressed, and determine the impact mechanism on the characteristics of garden roads from both qualitative and quantitative perspectives (Section 3.3).

Figure 5- 1 Research Framework.



2.2. Study Case

Here, “private garden” refers to the residence or villa gardens used by individuals or their families over a long period[40]. In the Qing Dynasty (1616–1912), the gardens of the royal family and nobles were usually gifted by the emperor to reward their service. However However, the construction, transformation and use of the garden depended on the opinions of the royal family. Therefore, such gardens are also included in the study of private

gardens. Historical events (military, environmental, and economic) since the end of the Qing Dynasty led to most of the gardens being destroyed. Only Chunwangfu Garden and Gongwangfu Garden have been preserved [40]. Three criteria exist for the designation of private gardens as described above:

1. The construction period of the garden was during the Qing Dynasty, and its style and craftsmanship are also from this dynasty.

2. Basic information (garden size, owner's identity, and garden utilization) is detailed and reliable.

3. There are clear path elements in the garden that provide opening and closing changes of viewpoint as visitors walk along paths.

Only 14 existing private gardens in Beijing meet these three criteria.

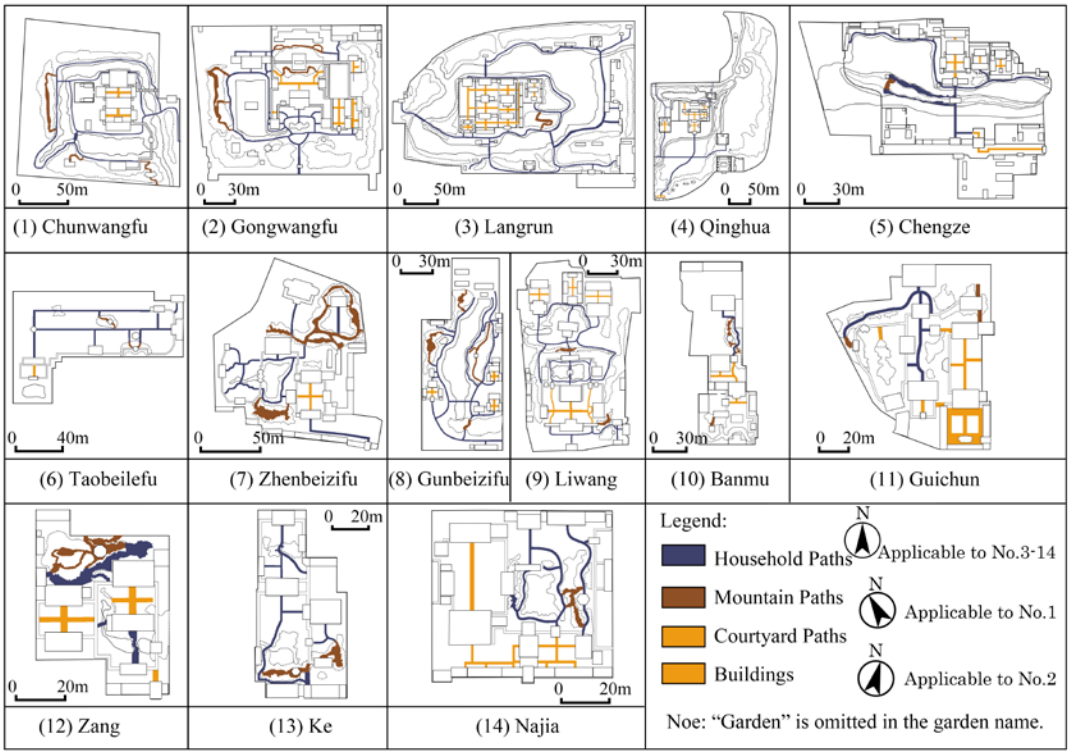


Figure 5- 2 The Plans of Research Objects

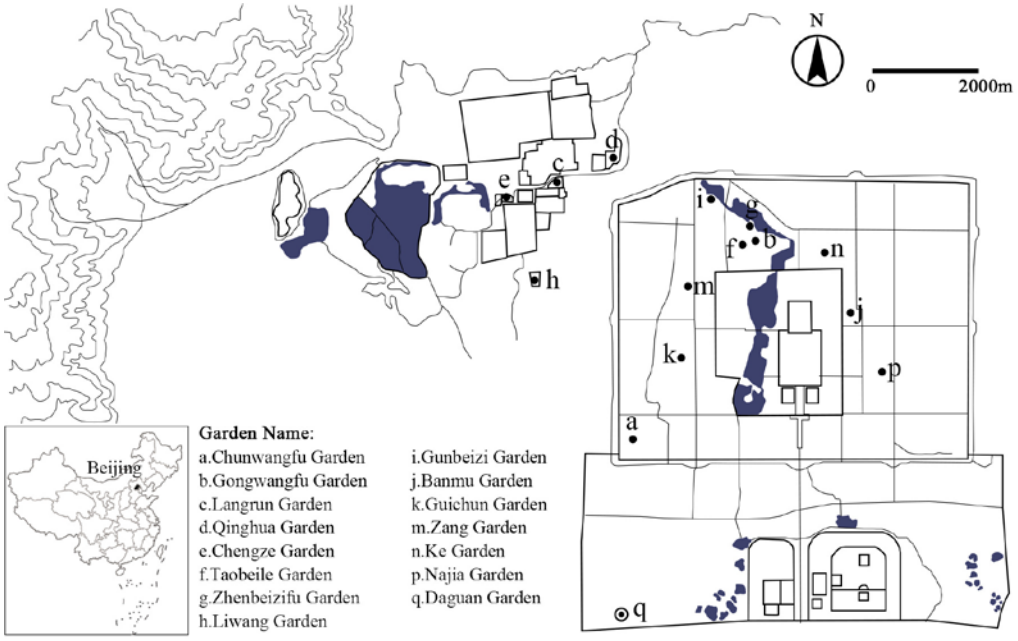


Figure 5- 3 Distribution of Research Objects in Beijing.

3 Indicators

3.1 Dividing the Type of Path

Different types of paths have different morphological characteristics, which are best extracted by classifying and analysing them one by one. This study considers three types of paths: HP (Household Paths), MP (Mountain Paths) and CP (Courtyard Paths: structures connected by covered paths). The buildings, pavilions, corridors, and garden paths share the same connecting function, because they are all covered by roofs, and walking on or through them has a different spatial feeling from external garden paths. Therefore, such covered structures are excluded from this study.

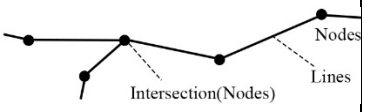
The service scope (SS) of MP is the mountainous area in the garden, whereas the SS of CP is the courtyard area, and that of HP is the garden's horizontal land. These differences may affect quantitative indicators such as the number, length, and area of paths, so they also need to be distinguished. In the garden outside the courtyard, the path mainly serves the needs of visitors viewing the garden landscape. It is often lengthy and

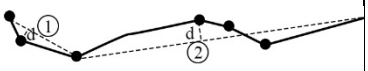
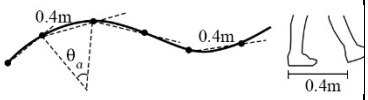
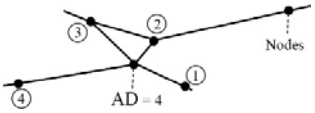
curved to extend the viewing time. Path elevation, in such cases, is higher than that of paths of the horizontal land surface (HP), which provide a shorter sight distance.

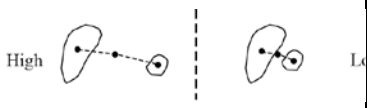
3.2 Establishment of Quantitative Indicators

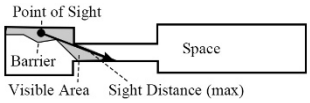
Based on the study of existing path indicators (Section 1.2) and in combination with the characteristics of BTPGs' paths, 28 indicators were selected to quantify the characteristics of paths (Table 5-1). Three categories, based on data types, were employed: path centreline (PC), path boundary (PB), and visible space on a path (PV).

Table 5- 1 Description of path quantitative indicators

Type	Indicator	Measurement	Interpretation	Reference
RC	Nodes (N)	Number of all Path nodes 	A node/vertex is the intersection of a minimum of two paths. Visitors can adapt or modify their itinerary here.	Patarasuk, 2013 [80]
	Lines (L)	Number of all path links	Line as the path section between two nodes.	Patarasuk,2013 [80]
	Total Length （TL）	Length of the th links	TL is the sum of the path centerline length in the garden.	Zhang, 2012 [36]
	Average Length (AL)		AL reflects the average length of all paths within the garden.	Zhang, 2012 [36]
	Density （D）	Garden Area (m^2)	D represents the density level of paths within the garden. A greater D value signifies a denser path	Forman and Hersperger, 1996 [81]
	Average Longer Paths (ALP)	= Links with a length greater than the AL. The number of .	ALP is the average of all path lengths greater than the AL. The greater the ALP, the longer the path appears.	Tong,2016 [73]
	Average Shorter Paths (ASP)	Links with a length less than the AL. The number of .	ASR is the average of all path lengths less than the AL. The the smaller the value of ASP, the shorter the path appears.	Tong,2016 [73]
	Variation of Path		The VPL is calculated as the square root of variance of each path	Tong,2016 [73]

	Length（VPL）		length. A greater value signifies a more obvious change in the path length.	
	Simple Paths（SP）	Number of simple straight lines cut into the path centerline. 	Through the Douglas-puke algorithm, the curve path centerline is decomposed into simple straight lines, and the SP is the total number of straight lines counted.	Tong,2016 [73]
	Circuitous Angle of One Step（CAS）	Change angle between step and . The number of steps. 	Taking the average step length of 0.4m as the unit, the centerline of the path is segmented. The average circuitous angle is the angle changed by each step. A larger CAS value signifies a larger angle that visitors need to change with each step.	Shinji et al., 1983 [47]
	Circuitous Angle of One Path (CAP)		CAP records the tourists' direction angle changes after walking from one path. A greater value of CAP indicates a more tortuous overall path garden path.	Shinji et al., 1983 [47]
	Intersection Deflection Angle (IDA)	Minimum angle at the th intersection. The number of intersections 	Measure all angles of each intersection and find the average value of the minimum angles of all intersections (IDA). A larger value equates to the increased strength of the turn that is required at the intersection.	Tong,2016 [73]
	Average Number of Connections (ANC)	The number of lines connected by the node. 	Degree represents the number of edges directly connected to a node in the network. ANC is the arithmetic average of the degrees of all nodes. A larger value, infers a more complex network relationship of the path.	Zeng, 2019 [64]
	Average Connection Length (ACL)	The total length of links connected by the th nodes.	ACL indicates the average length of the path linked by the nodes of a garden. The larger the ACL, the longer the path that is connected by this node.	Zeng, 2019 [64]
	Alpha ()		This measures the circuitry of a network, or the degree to which it provides alternative paths for traveling from one node to another.	Kansky K J,1963 [65]

			A greater value increases the connectivity of a network.	
	Beta ()		This reflects the complexity and completeness of a network by expressing the ratio of links to nodes. β<1 indicates a disconnected network; β= 1 a single circuit; β> 1 implies a greater complexity of network connectivity.	Kansky K J,1963 [65]
	Gamma （）		This is a measure of the extent to which the nodes are connected; called connectivity. Gamma index values range between 0 and 1. A value of 1 denotes a completely connected network.	Kansky K J,1963 [65]
	Centrality (CE)	The distance of node to the centroid of the garden. The summarization area of garden. 	The centrality indicator measures the average distance of the nodes to the garden center. To minimize the bias of the garden scale, the average distance was divided by the radius of a circle with the total garden area.	Huang et al., 2007 [71]
RB	Area (A)	Spatial extent of whole the entire path (m^2).	The absolute extent of the path area indicates the size of the path within its boundaries.	Zhang, 2012 [36]
	Perimeter(P)	Measurement of the whole path edge (m).	The perimeter of a shape is the total measurement of all the edges of the shape.	Zhang, 2012 [36]
	Average Width (AW)		Total path area divided by the sum of each path centerline length. A larger AW signifies a wider path.	Shinji et al., 1983 [47]
	Perimeter-Area Rate （PAR）		Area-perimeter ratio is defined by dividing area by perimeter of a convex space, to identify the 'fattest' convex when a convex map is drawn.	Riitters et al., 1995 [58]
	Shape Index (SHA)	= Perimeter of patch . = Area of patch .	Shape index corrects for the size problem of the perimeter-area ratio indicator by adjusting for a square standard and, as a result, is the simplest and potentially most straightforward measure of shape complexity.	Schwarz, 2010 [72]

	Fractal (FRE)		Fractal reflects shape complexity across a range of spatial scales (patch sizes).	Schwarz, 2010 [72]
RV	Field of Vision Area (FVA)	Spatial extent of whole vision (m^2). 	The area that can be seen on the path is the FVA. The larger the FVA, the more open the space.	Zhang,2016 [51]
	Average Visual Distance （AVD）	The length of sight line at node .	AVD is the average value of sight length when looking at both sides of the path at nodes. The larger the AVD, the greater the distance that can be seen on the path.	Zhang,2016 [51]
	Maximum Visual Distance （MVD）	The maximum sight distance length in the path.	MVD is the maximum sight distance on a given section of path. A greater value, equates to a greater visible range on the path.	Zhang,2016 [51]
	Variation of Visual Distance (VVD)		The VVD represents the magnitude of the fluctuation of the sight distance on the path. The larger the VVD value, the more obvious the spatial opening and closing changes present on the path.	Zhang,2016 [51]

The PC line category includes 18 indicators to describe the scale and network characteristics of the path. These characteristics are based on the centreline of the path, and statistically calculated using Grasshopper in Rhino 7 (for example, No. 2: Lines). The PB class includes six indicators that mainly describes the path shape. They are calculated using ArcGIS.10.2 and Fragstats software; the boundary line of the path serves as the data source (for example, No. 19: Area). The PV includes four indicators and fully describes the line-of-sight features on the path. It is constructed and calculated using the viewing area as data (for example, No. 25: Field of Vision Area).

3.3 Data Acquisition and Processing

According to the 14 gardens established in Section 2.2, Autodesk CAD. 2015 software's polyline function redraws their plans. For the data type

used by the indicator, the path boundary is determined by the boundary of the walkable area on the path. The centreline of the path is assisted and determined by its boundary path (Figure 5-4); the visible area (Figure 5-5) is defined by the water body, flat land, square, path, and other areas lower than the height of human sight[51].

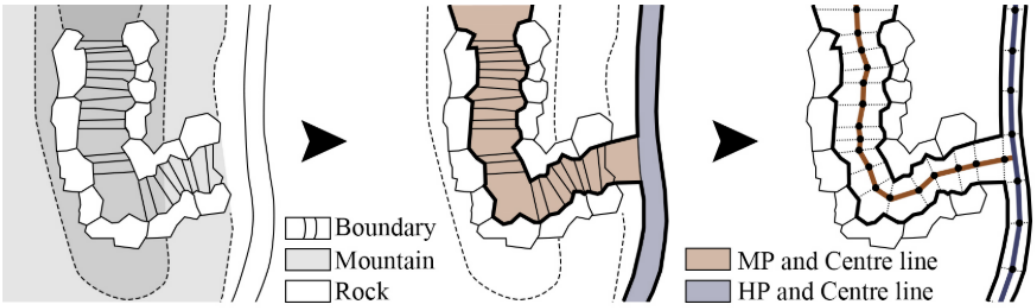


Figure 5-4 Determination of the Path Sideline and Centreline, Taking the Chunwangfu Garden as An Example

Note: left: historical original data; middle: determination of the path sideline; right: determination of the path centreline.

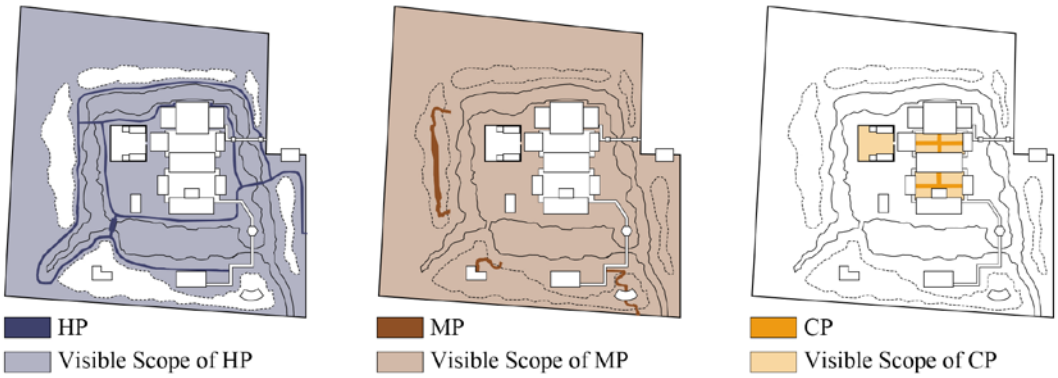


Figure 5- 5 Schematic Diagram of the Scope of View

Note: again, the example is the Chunwangfu Garden:Left: view of HP; Middle: view of MP; Right: view of CP

Results were statistically analysed using Excel software, according to the parameters set in Section 3.2. To compress the number of indicators, SPSS 25.0 statistical software was used in factor analysis and correlation analysis. Then, based on the compressed indicators, clustering analysis was used to group the paths of 14 gardens. Finally, the clustering results are combined with qualitative indicators such as the identity of the garden owner, garden

period, construction Ways to determine the degree of their impact on the characteristics of the garden paths, and to identify the causes of differences in garden path characteristics.

4 Results

4.1 Determination of Principal Indicators

In this study, 28 indicators of the 14 traditional gardens were extracted using the FA in SPSS 25.0 software. Before finalising results, Kaiser–Meyer–Olkin (KMO) and Bartley Spherical Test (BST) are used to check whether the data are suitable for the FA method. The results show that the KMO is 0.659, which satisfies the condition (KMO > 0.5) to establish the factor analysis model. The p-value determined using BST is 0.00 (less than 0.05), indicating that there is correlation between the variables and that the FA results are effective. As the results show that, after the fifth factor (Table 5-2), the eigenvalue declines to less than 1 (0.937), the overall extraction rate reaches more than 85% (85.017%). This better preserves the integrity of the 28 indicators. Therefore, the first five factors are selected as the final component.

In order to promote the interpretation and naming of the extracted factors without changing the mutual relationship between the factors, the varimax rotation method was used to change the factor load, readjusting the relationship between the factors and the original variables[72)]. The commonalities of all indicators are shown in the last column of Table 5-3, which reflects the extraction degree of indicator data on all factors. The closer the value is to 1, the better the extraction is. According to the results, except for the intersection deflection angle and centrality, the extraction rate of all indicators is higher than 70%, providing a good interpretation for all five factors.

Table 5-2 Total variance explained

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.454	40.906	40.906	9.056	32.341	32.341
2	5.885	21.017	61.924	5.825	20.805	53.146
3	2.881	10.289	72.213	4.484	16.015	69.160
4	2.214	7.906	80.119	2.276	8.129	77.289
5	1.371	4.898	85.017	2.164	7.727	85.017
6	0.937	3.345	88.362			
Extraction Method: Principal Component Analysis						

Table 5-3 The result of extracted factors.

Indicators	Component					Extraction
	1	2	3	4	5	
ACL	0.981	0.046	0.026	-0.010	-0.031	0.966
AL	0.980	0.103	0.008	0.004	-0.028	0.972
ASP	0.940	0.009	-0.093	-0.083	-0.069	0.904
ALP	0.928	0.134	-0.036	0.126	-0.073	0.902
VPL	0.918	0.263	0.096	0.116	-0.031	0.935
FVA	0.850	0.343	-0.078	-0.014	0.004	0.846
VVD	0.796	0.379	-0.266	-0.013	0.222	0.898
MVD	0.775	0.462	-0.165	0.005	0.116	0.855
AVD	0.727	0.253	-0.289	-0.192	0.285	0.794
CAP	0.628	-0.309	-0.058	0.055	0.507	0.753
L	0.021	0.912	0.205	0.087	-0.160	0.908
N	0.017	0.903	0.091	0.091	-0.217	0.880
TL	0.559	0.771	0.190	0.091	-0.069	0.956
P	0.569	0.766	0.193	0.064	-0.050	0.955
SP	0.484	0.761	0.280	0.138	0.061	0.914
A	0.556	0.752	0.179	-0.136	-0.034	0.926
SHA	0.447	0.669	0.328	0.140	0.189	0.811
α	-0.059	0.198	0.963	0.019	-0.025	0.970
ß	-0.033	0.392	0.900	0.002	-0.042	0.966
ANC	-0.042	0.420	0.881	0.014	-0.008	0.954
ɣ	-0.109	-0.140	0.871	-0.014	0.108	0.801
IDA	-0.074	0.299	0.558	-0.049	-0.400	0.568
AW	-0.026	-0.152	-0.028	-0.932	0.092	0.902
PAR	-0.058	0.055	-0.074	0.929	0.086	0.883
FRE	0.436	0.196	0.432	0.492	0.450	0.859
CAS	0.006	-0.349	-0.053	0.340	0.771	0.835

D	-0.248	-0.044	0.349	-0.035	0.704	0.681
CE	0.089	0.052	-0.180	-0.141	0.383	0.209
Rotation Method: Variance maximizing orthogonal rotation. See Table 5–1 for abbreviations of indicators.						

Since each factor contains more than two indicators, the naming of the new factor should not only signify all the indicators in the group as much as possible, but it should also differ and be independent from the other factors. If the new name cannot include all the indicator information making up the factor, the factor is renamed by referring to the indicators with the larger absolute load value in the factor. If the indicators in the same factor have a high correlation, this indicates that they can replace each other. Hence, the indicator with the highest load can be selected to refer to other indicators, so as to reduce the number of indicators[58]. Combining the results of FA (Table 5-3) and CA (Table 5-4), the naming of five factors and the selection of representative indicators are as follows:

Factor 1, Average, comprises ten indicator parameters (Table 5-3): Average Connection Length (ACL), Average Length (AL), Average Shorter Paths (ASP), Average Longer Paths (ALP), Variation of Path Length (VPL), Field of Vision Area (FVA), Variation of Visual Distance (VVD), Maximum Visual Distance (MVD), Average Visual Distance (AVD), and Circuitous Angle of One Path (CAP). These parameters are closely related to each other (Table 4), and collectively reflect the characteristics of average values of paths in all aspects. Therefore, the Average Connection Length (0.981) with the highest load is selected as the representative indicator of factor 1.

Factor 2, Scale, comprises seven indicators: Lines (L), Nodes (N), Total Length (TL), Perimeter (P), Simple Paths (SP), Area (A), and Shape Index (SHA) (Table 3). This factor is the most basic and common indicator when defining the path scale. Here, the Lines section with the highest value (0.912) is selected as the representative indicator.

Factor 3, Network, reflects the topology of the path network, and has five

indicators, Alpha (α), Beta (ß), Average Number of Connections (ANC), Gamma (γ), and Intersection Deflection Angle (IDA) (Table 5-3). There is a high correlation between these indicators (Table 5-4). Therefore, the Alpha (0.963) with the highest value is selected as the representative.

Factor 4,Wide, comprises three interrelated indicators: AverageWidth (AW), Perimeter Area Rate (PAR), and Fractal (FRA) (Table 5-4). As the paths are mostly narrow and long strips, the length should be focused on (and width can be ignored), so the ratio of area and perimeter is essentially equivalent to half of the path width, and the values of both are very similar and far greater than the value of Fractal (Table 5-4). As the Average Width (−0.949) is easy to understand and implement, it is selected as the representative indicator.

Factor 5, Aggregation, comprises three indicators: Circuitous Angle of One Step (CAS), Density (D), and Centrality (CE). Circuitous Average Angle is related to Density, but Centrality exists independently (Table 5-4). When only the average bending degree increases, the direction of each step will change greatly, making the overall layout of the path curl up. In addition, when the degree of Centrality becomes smaller, the path will focus on the centre of the courtyard. When the Density increases, the path will fill the whole garden. The independently existing Centrality (0.383) and CAS (0.771) with the highest load are selected as the representatives of this factor.

Table 5- 4 Correlations Among Path Indicators and Service Scope

Factors					**1**									**2**							**3**				**4**			**5**			**Factors**
	ACL	AL	ASP	ALP	VPL	FVA	VVD	MVD	AVD	CAP	L	N	TL	P	SP	A	SHA	α	β	ANC	γ	IDA	AW	PAR	FRA	CAS	D	CE		
	0.57**	0.60**	0.34*	0.65**	0.68**	0.81**	0.57**	0.58**	0.27	0.09	0.47**	0.50**	0.75**	0.74**	0.58**	0.74**	0.54**	0.06	0.16	0.16	-0.13	0.18	-0.16	0.01	0.34*	-0.24	-0.34*	-0.01	SS	
	1.00	1.00**	0.86**	0.86**	0.61**	0.86**	0.60**	0.64**	0.51**	0.77**	-0.02	-0.03	0.41**	0.41**	0.36*	0.42**	0.34*	0.04	-0.12	-0.14	-0.13	-0.16	0.14	-0.19	0.30	0.02	-0.27	-0.16	ACL	
		1.00	0.87**	0.86**	0.62**	0.89**	0.62**	0.66**	0.52**	0.75**	0.01	0.01	0.44**	0.45**	0.38*	0.45**	0.37*	0.03	-0.12	-0.13	-0.15	-0.17	0.12	-0.18	0.31	0.01	-0.27	-0.17	AL	
			1.00	0.60**	0.18	0.71**	0.34*	0.42**	0.48**	0.78**	-0.15	-0.16	0.12	0.12	0.07	0.15	0.11	0.07	-0.30	-0.32*	-0.19	-0.34*	0.30	-0.29	0.02	0.01	-0.29	-0.23	ASP	
				1.00	0.86**	0.81**	0.74**	0.74**	0.42**	0.56**	0.14	0.14	0.58**	0.59**	0.50**	0.57**	0.46**	-0.05	0.00	-0.02	-0.20	0.00	-0.09	0.08	0.37*	-0.03	-0.22	-0.03	ALP	
					1.00	0.65**	0.74**	0.68**	0.26	0.25	0.35*	0.35*	0.77**	0.78**	0.71**	0.74**	0.62**	0.01	0.28	0.28	-0.10	0.23	-0.27	0.17	0.55**	-0.06	-0.08	0.07	VPL	**1**
3	α	1				1.00	0.75**	0.79**	0.61**	0.55**	0.18	0.18	0.60**	0.60**	0.48**	0.62**	0.48**	0.01	-0.09	-0.09	-0.16	-0.16	0.12	-0.15	0.32*	-0.02	-0.29	-0.14	FVA	
	β	0.70**	1				1.00	0.94**	0.68**	0.37*	0.25	0.25	0.63**	0.64**	0.55**	0.65**	0.54**	-0.21	-0.06	-0.03	-0.33*	-0.08	-0.04	0.03	0.40*	0.05	-0.12	0.08	VVD	
	ANC	0.67**	0.99**	1.00				1.00	0.78**	0.39*	0.29	0.29	0.64**	0.65**	0.58**	0.66**	0.54**	-0.05	-0.05	-0.03	-0.25	-0.07	0.08	-0.01	0.31	-0.03	-0.19	-0.05	MVD	
	γ	0.85**	0.71**	0.70**	1.00				1.00	0.41**	-0.09	-0.10	0.21	0.22	0.16	0.26	0.19	-0.05	-0.36*	-0.34*	-0.31	-0.39*	0.50**	-0.29	0.04	0.06	-0.18	-0.07	AVD	
	IDA	0.33*	0.72**	0.72**	0.20	1				1.00	-0.27	-0.28	-0.01	0.00	0.08	0.02	0.07	-0.04	-0.27	-0.28	-0.06	-0.40*	0.20	-0.14	0.25	0.48**	0.00	-0.18	CAP	
4	AW	0.07	-0.35*	-0.37*	0.01	-0.36*	1.00				1.00	0.99**	0.76**	0.75**	0.79**	0.71**	0.61**	0.29	0.62**	0.63**	0.03	0.49**	-0.36*	0.16	0.33*	-0.34*	-0.02	-0.07	L	
	PAR	-0.11	0.12	0.15	-0.08	0.14	-0.78**	1.00				1.00	0.73**	0.72**	0.74**	0.68**	0.54**	0.18	0.54**	0.55**	-0.09	0.50**	-0.37*	0.17	0.27	-0.36*	-0.08	-0.06	N	
	FRA	0.26	0.52**	0.54**	0.30	0.28	-0.54**	0.43**	1.00				1.00	1.00**	0.93**	0.95**	0.87**	0.23	0.47**	0.48**	0.02	0.33*	-0.28	0.12	0.51**	-0.25	-0.11	-0.01	TL	
5	CAS	-0.13	-0.19	-0.18	0.11	-0.35*	-0.11	0.30	0.41**	1.00				1.00	0.94**	0.96**	0.87**	0.23	0.47**	0.48**	0.02	0.33*	-0.25	0.12	0.50**	-0.24	-0.08	-0.02	P	**2**
	D	0.18	0.36*	0.39*	0.25	0.27	-0.07	0.18	0.38*	0.44**	1				1.00	0.87**	0.88**	0.29	0.56**	0.57**	0.08	0.36*	-0.31	0.18	0.60**	-0.16	0.04	-0.04	SP	
	CE	-0.09	-0.07	-0.09	-0.13	-0.16	-0.04	0.00	-0.05	0.01	0.06	1				1.00	0.81**	0.22	0.44**	0.45**	0.02	0.33*	-0.09	-0.06	0.41**	-0.26	-0.08	-0.03	A	
Factors		α	β	ANC	γ	IDA	AW	PAR	FRA	CAS	D	CE					1.00	0.34*	0.51**	0.52**	0.21	0.26	-0.26	0.16	0.65**	-0.08	0.09	0.03	SHA	
				3				**4**			**5**																			

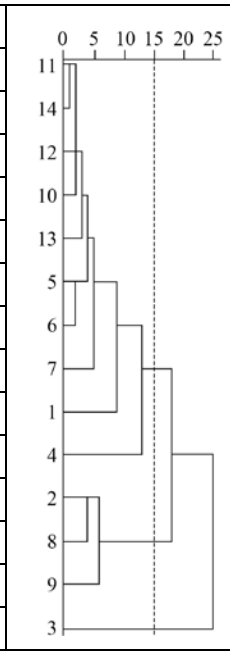
* $p < 0.5$. ** $p < 0.01$; See Tables 1 and 3 for abbreviations of indicators and factors.

Finally, the 28 indicator parameters were compressed into six indicators that are highly representative but only weakly correlated with each other (Table 5-4): Average Connection Length, Lines, Alpha, Average Width, Circuitous Angle of One Step, and Centrality. They constitute the most basic parameters with which to describe the characteristics of BTPG paths.

4.2 Cluster Results

The 14 private gardens were analyzed and clustered using SPSS 25.0 software, utilizing six representative indicators. Through the application of the principles of maximum distance between groups and moderate quantity, three distinct groups were identified and labeled as Group A, Group B, and Group C.

Table 5- 5 The Statistics of Cluster result

Group	No.	Name	Owner	Location	Ways	Period	
A	11	Guichun	OP	IN	NB	GX	
A	14	Najia	OP	IN	NB	GX	
A	12	Zang	OP	IN	RB	GX	
A	10	Banmu	OP	IN	RB	DG	
A	13	Ke	OP	IN	NB	XF	
A	5	Chengzeyuan	RN	OUT	RB	DG	
A	6	Taobeilefu	RN	IN	RB	GX	
A	7	Zhenbeizifu	RN	IN	NB	GX	
A	1	Chunwangfu	RN	IN	RB	TZ	
A	4	Qinghuayuan	RN	OUT	RB	DG	
B	2	Gongwangfu	RN	IN	RB	TZ	
B	8	Gunbeizifu	RN	IN	RB	GX	
B	9	Liwang	RN	OUT	RB	GX	
C	3	Langrun	RN	OUT	RB	XF	

① Owner: status / occupation of the garden owner. RN：royal or nobility, OP: officials or politicians ② Location: The location of the gardens in Beijing. IN: inside of the city, OUT: outside of the city. ③ Period: construction period. DG (Daoguang):1821—1850, XF (Xianfeng):1851—1861, TZ (Tongzhi):1862—1874, GX (Guangxu):1875—1908, XT (Xuantong):1909—1912.④ Ways: construction Ways. NB：newly built, RB：rebuilt.

According to the current clustering results, Group A has the highest number of gardens (10), which includes all types of gardens built by officials,

newly constructed gardens, and gardens built in the middle of the Qing Dynasty. Additionally, there are some gardens built by princes, converted gardens, and gardens constructed in late-stage of Qing Dynasty. These gardens are located both inside and outside of Beijing and have an irregular distribution. Among the three groups, Group A household paths are most prominent with the least number of segments L, the smallest alpha, and the maximum degree of CAS. Its mountain paths have the shortest ACL, the maximum degree of twists and turns CAS, and the degree of CE. In terms of courtyard paths, Group A has significantly fewer Land the maximum degree of CAS compared to the other two groups.

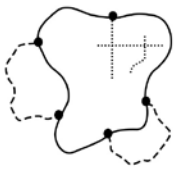
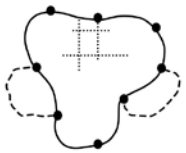
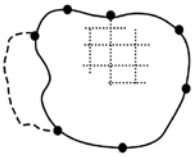
Indicators	Type	Group A	Group B	Group C	
ACL (m)	HP	19.80	12.94	32.00	
	MP	10.85	23.50	64.82	
	CP	8.73	7.15	9.44	
L (pcs)	HP	13.80	44.33	44.00	Group A
	MP	6.89	6.33	1.00	
	CP	11.56	20.67	43.00	
α	HP	-0.08	-0.01	-0.01	
	MP	-0.11	-0.14	0.00	
	CP	-0.08	-0.07	-0.08	Group B
AW (m)	HP	1.34	1.02	1.42	
	MP	2.01	1.94	2.87	
	CP	1.64	1.33	1.81	
CAS (deg)	HP	2.26	1.23	0.50	
	MP	3.31	2.77	2.60	Group C
	CP	0.39	0.27	0.10	Legend:
CE	HP	0.59	0.55	0.65	Household Paths
	MP	0.67	0.52	0.24	Mountain Paths
	CP	0.61	0.64	0.35	Courtyard Paths
					Breakpoint

Figure 5- 6 Differences of Paths in Characteristics Between Groups

Group B has three gardens, all of which were converted by princes in the late Qing Dynasty. Most of these gardens are located outside the Beijing, while a few are inside. The most significant feature of Group B household

paths is the smallest ACL, the most number of L, and the minimum degree of AW and CE. In terms of mountain paths, Group B has the smallest alpha, while in courtyard paths, it has the minimum ACL, alpha, AW and the maximum degree of CE.

Group C has only one garden, which was converted by a prince in the late Qing Dynasty and is located outside the Beijing. Its household paths have the maximum ACL, AW, and CE. And with the smallest CAS. Its mountain paths have the maximum ACL, alpha, AW, and the smallest number of L, and degree of CE. In terms of courtyard paths, it has the maximum ACL, number of L, and AW. And with the smallest degree of CAS and degree of CE.

4.3 Correlation Results

In order to eliminate the influence of different site areas on the results, the linear relationship between the service area of various types of paths in 14 traditional gardens and the representative indicators was tested. Table 6 shows that the Average Connection Length (ACL) of HP and MP, and the Links (L) of CP, are linearly related to the garden area served $p < 0.05$) and meet the conditions of linear correlation. The correlations between other ndicators and the garden area are not significant ($p > 0.05$), with the standard deviation etween indicators being low and the fluctuation small. Therefore, the average value of raditional garden paths can be directly used to guide the design of contemporary garden paths and there is no need for correlation analysis (Figure 5-7).

Table 5-6 Reference range of BTPGs

Indicators	Type	BTPGs				Correlations	Sig. (p-Value)
		MAX	MIN	AVE	SD		
ACL (m)	HP	46.93	7.66	19.20	11.99	0.827 **	0.0006
	MP	64.82	5.20	17.92	16.72	0.947 **	0.0000
	CP	11.30	4.46	8.42	2.01	0.38	0.2864
L (pcs)	HP	51.00	4.00	22.50	14.56	0.28	0.3353

	MP	18.00	1.00	6.31	4.75	−0.18	0.3934
	CP	43.00	1.00	16.08	11.47	0.719 **	0.0076
α	HP	0.01	−0.13	−0.06	0.05	−0.07	0.7969
	MP	0.11	−0.36	−0.11	0.14	0.16	0.5129
	CP	0.00	−0.17	−0.07	0.05	−0.40	0.2392
AW (m)	HP	2.67	0.91	1.28	0.42	−0.04	0.8790
	MP	3.84	1.09	2.06	0.75	0.37	0.2630
	CP	2.29	0.69	1.58	0.47	−0.02	0.9549
CAS (deg)	HP	8.60	0.10	1.92	2.00	−0.34	0.2304
	MP	8.60	0.50	3.13	1.94	−0.04	0.7011
	CP	1.50	0.00	0.34	0.45	0.08	0.9076
CE	HP	0.71	0.47	0.58	0.09	0.27	0.3441
	MP	0.91	0.24	0.60	0.17	−0.31	0.0339
	CP	1.02	0.27	0.60	0.21	0.02	0.9429

See Table 5- 1 and Figure 5- 1 for abbreviations of indicators and garden name.
** $p < 0.01$.

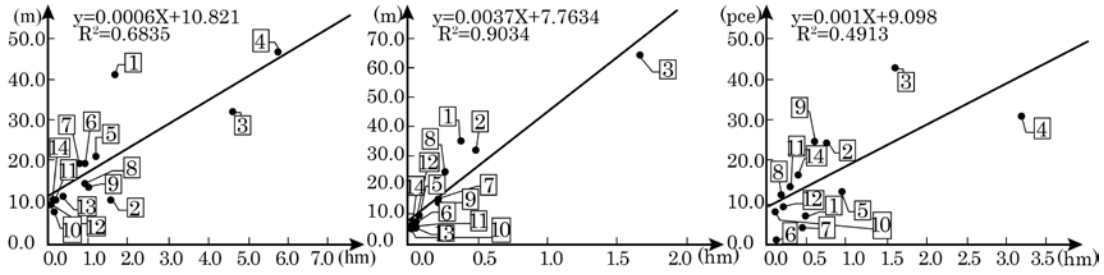


Figure 5- 7 Relationship between Average Connection Length of HP (left) and MP (middle), numbernumber of CP (right) and service area of paths

5 Discussion

5. 1 The Applicability of indicators

Section 2.4 introduced the statistical selection procedure of path quantitative indicators in this study. This procedure is based on the following three principles:

Principle 1: the maximum indicator set entering the preliminary screening is complete for quantifying the garden path. In order to meet this condition, the indicators in the present study have a wide coverage, including large (city), medium (block), and small (garden/park) scales

(Section 1.2).

Principle 2: after indicator screening, the representative indicator set can scientifically and effectively replace the maximum indicator set. First, in the process of screening, the initial selection is made by selecting the indicator with the largest proportion of each factor. Second, it is determined whether the selected indicators are related to other indicators in the same group through correlation, and the irrelevant indicators are added to further improve the representativeness of all indicators. For example, Centrality is added based on this principle.

Principle 3: the selected indicators are easy to operate and implement. The designer can easily control the results of indicators such as path width, length, and number, so as to easily control the design content.

The six representative indicators obtained in this study (Average Connection Length, number of Links, Alpha, Average Width, and Circuitous Angle of One Step) have a simple calculation process and clear guidance for the design content. They not only better represent the largest indicator set, but also frame the characteristics of the garden path from different dimensions such as the overall path network and the individual form. This process achieves the expected effect in completeness, representativeness, and operability.

5.2 The Reasons of Different Characteristics of Paths

From the results of grouping, it shows that the status / occupation of the garden owner, the period and the method of construction tend to be concentrated in the same group, such as all officials or politicians, middle Qing Dynasty, and newly built gardens all distributed in Group A. Although Group A has a large number, it also reflects to some extent the influence of the status / occupation of the garden owner, the construction period and method on the characteristics of the garden paths.

Compared to the prince, the land and financial resources that bureaucrats can control in building gardens are limited, and one of the main manifestations is the scarcity of buildings, which affects the scarcity of garden roads. These bureaucrats are mostly literati and refined scholars, often visiting and composing poems in gardens. They are also more susceptible to the influence of southern gardening techniques, and the paths in the gardens are more winding and varied (Group A). In addition, the middle of the Qing Dynasty was also the most prosperous period. During good festivals, garden owners often held festive activities, invited relatives and friends, and appreciated the mountains and waters in the gardens. During this period, there were many open spaces in the gardens, and the number of garden paths decreased accordingly, while the degree of twists and turns in the garden paths also increased to meet the needs of sightseeing. Among the research subjects, four gardens were newly built, but they were all concentrated in Group A, reflecting to some extent the limitations of the original site conditions on the design of the path during the renovation. At the beginning of the renovation of Langrun Garden, the circular shanshui pattern had basically formed, which resulted in no significant changes to the path network structure in the later stage, maintaining the characteristic of large average length of the garden paths. Compared to newly built gardens such as Ke Garden and Najia Garden, they do not have to be limited by the site and can freely design the form of the garden path. The distribution of outer cities in each group also reflects the weak impact of geographical location on the characteristics of garden roads.

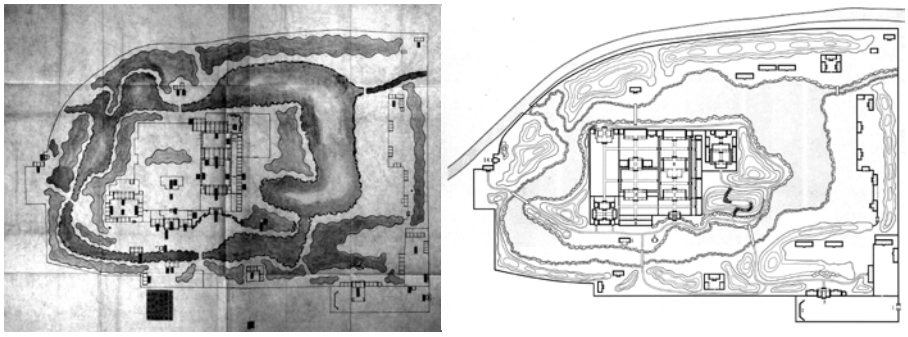


Figure 5- 8 The Plans of Langrun Garden Before and After Rebuild

From a quantitative perspective, there is a linear relationship between the ACL of HP and MP, as well as the L of CP with the scale of the gardens. As the scale of the garden increases, the ACL between HP and MP will also increase, making it easier to meet the coverage capacity of the path network for the garden scape. In addition, the larger the garden, the larger the buildings within it tend to be, and it makes sense that the number of courtyard paths should increase. Contrary to this, the alpha, average width, degree of curvature, and degree of concentration of garden paths do not show significant changes with the increase of the garden scale. They have small variance and often fluctuate around a constant value (Table 5-7). This indicates that the characteristics of these garden paths often depend more on the subjective judgment of the designer or the conventional construction techniques. The average width of HP is 1.28m, MP is 2.06m and CP is 1.58m, which meets the comfort standards of human body size. Moreover, MP are often wider and are usually surrounded by natural stones to meet the needs of climbing. For example, the degree of twists and turns on MP is 3.13, which is much greater than 1.92 on HP and 0.34 on CP. Based on the plan, it can also be subjectively judged that mountain roads are more winding and meander, followed by relatively HP, while CP are the straightest, and the degree of these twists and turns often depends on the individual decision of the garden owner or designer.

5.3 Innovation, Limitations and Prospects

The results of this study show some similarities to those obtained from previous research. For example, as this study finds that the width of the paths is not directly related to the scale of the garden[36], the path width in the contemporary garden is far greater than that in the traditional garden [46], and the road length has a confidence interval[48]. However, there are also some differences. For example, the average width of the HP in this study is 1.28 m, while that of the CP and MP is 1.58 m and 2.05 m, unlike the two-metre value previously identified. This variation may be attributable to the number of samples studied and the fineness of path division. In addition, the curvature indicator in this study does not have a correlation with the garden scale, unlike in the previous research by some Japanese scholars and this may be related to the type of garden. The circuit style garden in Japan is often larger than the appreciation style garden and has different viewing modes. In circuit style gardens, the designer's intent is to encourage visitors to spend more time in the garden, with repeat visits [47]. Hence, it is appropriate for curvature to change with the garden scale. An alternative suggestion in Japan is that with the increase in garden scale, the overall space is divided into more small spaces, and this results in the road curvature not increasing [46].

Quantitative indicators can also have defects or errors, and the indicators selected in this study are no exception [57]. For example, visibility field analysis (FVA, AVD, and MVD) often ignores the influence of plants on people's line of sight. In order to obtain more accurate sight distance measurement results, it is necessary to measure trees' positions, crown heights, trunk thicknesses, the light transmittance of the leaves, etc.—all of which require an increased workload. In general, research using spatial syntax theory will not carry out such high-accuracy work, so the application

of similar indicators in the field of landscape architecture has limitations [51]. Another similar example is precise path classification. The separation of the three types of paths simplifies the network structure for each type of path more than that of the whole garden, resulting in nil or negative values for indicators suitable for measuring the complex path network (such as Alpha, Beta, and Gamma). It shows a very simple road network structure, which is very rare[82].

The model also has limitations in operation. Although the calculation of indicators can be generated directly using parameter software, the extraction process for image rendering generates a huge workload that is both time consuming and labour demanding. In addition, the design parameters differ for different regional environments. There are several variations in the scale of gardens in the north and south. At the start of designing, it is necessary to resample the surrounding gardens and obtain numerical information for the reference indicators, which increases the computational workload. At this time, it is particularly important to improve the efficiency of image rendering, reduce the time requirements (such as image automatic generation technology), and share data information. This is a critical process and a key step in the future implementation of this model, which will eventually be extended to more garden types and serve many designers.

In comparison with previous research, this study takes a further step to improve the comprehensiveness, quantity, and quality of indicators for the analysis of garden paths in traditional gardens. One example is in the classification of garden paths, highlighting the impact of altitude on the line of sight from the path, thereby reducing the error in the results in comparison with previous line of sight analysis in space syntax [51]. In addition, the geographical environment of private gardens in Beijing also suggests that the error in line of sight indicators has been reduced, because

the plants in the Beijing gardens are mostly large trees such as locust, willow, and poplar unlike those in gardens in southern China. Moreover, their crown heights are higher level from the ground, and their leaves are dry in winter [40]. These cannot, therefore, effectively block the sightlines of visitors and can be ignored. In contrast, the compression results from the indicators do not include the indicators for spatial vision, which avoids the occurrence of errors. The results of the calculation process using representative indicators display a good relationship to the garden size and clearly and accurately represent the characteristics of the garden paths. This is a prerequisite for the smooth promotion of indicators and models in future applications.

In contrast to previous studies of garden paths (Section 1.2), this study proposes a broader range of indicators to explain garden path characteristics. Although the quantitative indicators are clear, it is not advisable to implant the quantitative results into the reference sizes of traditional gardens. Garden design is a reciprocating process that is influenced, restricted, and balanced [83] by various garden elements. Garden path design should also be considered in combination with the layout of various elements in the garden or park, the functional requirements of the users, the follow-up operations and management, the climatic environment of geographical areas, etc. The quantitative results should be appropriately adjusted as a reference.

In addition, the quantitative research focuses on the physical space of the path, whereas the traditional Chinese garden is a combination of physical space and an artist's particular conception of space [84]. When the design of a path takes into account the artist's spatial concepts, this will limit the quantitative approach. To highlight a solemn atmosphere, for example, the paths along the central axis should be as wide and straight as possible. To pursue the mysterious quietness and be pleasantly surprised, the road will

inevitably become tortuous and varied [85]. Aesthetic conceptions of space in garden path design are too important to be put aside in pursuit of quantitative results.

6. Conclusions

The objective of this paper is to determine a minimal indicator set describing the spatial characteristics of private traditional garden paths in Beijing and to use the results as a reference guide for path design of contemporary antique gardens. In this study, 28 quantitative path indicators were selected to analyse the characteristics of three types of paths in 14 private gardens in Beijing. Among them, the characteristics of paths in five aspects of Average, Scale, Network, Wide, and Aggregation can be expressed by six representative simple indicators: average connection length, number of path sections, alpha index (a), average width, average tortuous angle, and concentration degree. The 28 quantitative path indicators can be compressed to the six representative indicators.

The makeup of the indicator relates to the overall network and the individual form of the path, reflecting the mathematical characteristics behind the phenomenon of winding paths and the changing of views with each step that is found in traditional gardens. The results suggest that the representative indicators clearly distinguish the differences in garden paths. The selected indicators performed well for generality, representativeness, and implementation. This makes it possible to improve the contemporary antique garden by applying the wisdom from traditional gardens. Future studies can carry out in-depth research on the basis of the six indicators according to the specific control type.

Finally, the cluster results between the traditional garden path in Beijing was calculated using representative indicators, and the difference between the two was intuitively reflected. With reference to the linear and non-linear

results of the service area and indicators, clear suggestions are put forward for the improvement of paths in contemporary antique gardens. The 28 path indicators are not affected by the design process and can be used during design and repair. This study also has limitations in terms of representativeness and operability, so future work should also consider garden samples of different types and from different regions.

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Chapter 6

Conclusions

1 Summary of Core Chapter

1.1 The Spatial Characteristics of Buildings

Classical Chinese gardens, whether in the southern or northern regions, place great emphasis on architecture, and architectural elements account for a significant proportion of the garden's overall design. These structures serve not only as spaces for living and recreation, but also as an integral part of the garden's landscape and are considered indispensable.

During the Qing Dynasty, the private gardens in Beijing were characterized by a typical northern official style in terms of their layout of halls, pavilions, fangs, and other architectural elements. These gardens paid close attention to hierarchies, strict symmetry, and adhered to strict axes and construction rules, which were markedly different from the architectural styles of the southern gardens.

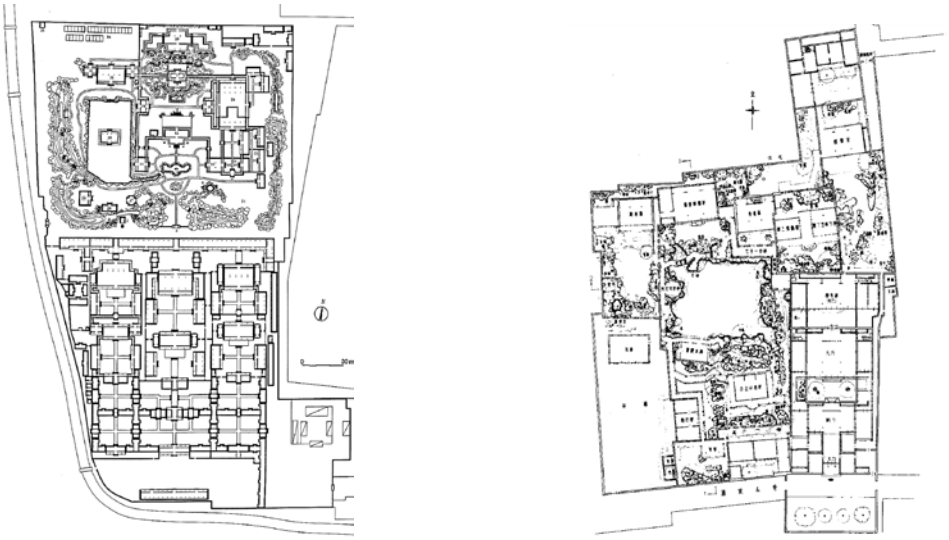

Figure 6- 1 Comparison of the Architectural Layout of Gongwangfu Garden (Left) in the North and the Wangshi Garden (Right) in the South

In general, the architectural layout forms of private gardens in Beijing can be classified into three types.

The first type is characterized by a courtyard layout, with a smaller overall scale. The building encloses the viewing area, with buildings of

different sizes in the four directions of the front, east, west, and south and north. Generally, the building volume in the north is the largest, with smaller building volumes in the east and west, forming an axis with the northern building. However, this axis does not control the layout of the landscape on the south side and in the park, making it slightly different from the traditional rigorous and upright Beijing quadrangle dwellings.

The second type also features a viewing area surrounding the building, with a similarly grand scale. However, the axis of the building is deviated from the axis of the Shanshui, and the layout of the two has no obvious primary and secondary relationship.

The third type is characterized by the building being surrounded by Shanshui (mountains and water), plants, and other viewing areas, with the axis of the building controlling the layout of the landscape in the garden. Such gardens were often built by princes and nobles, with a grand scale and a solemn layout.

Overall, these three types of architectural layouts in Beijing's private gardens demonstrate different design principles and styles, reflecting the cultural and historical context of the time and the personalities of the garden's owners (Figure 6-2).

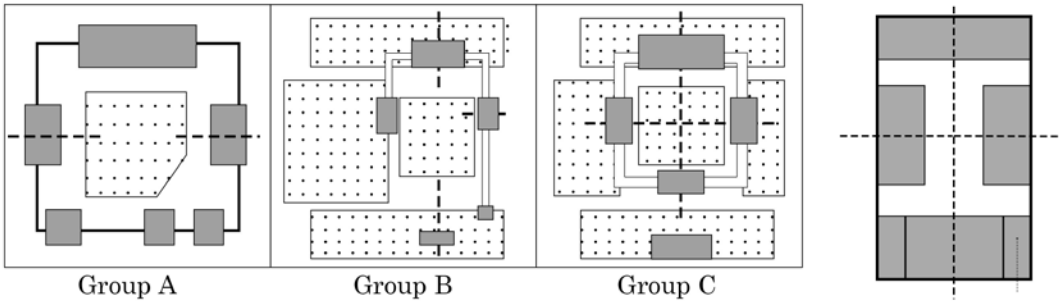

Figure 6- 2 Comparison Between the Architectural Layout of Beijing's Private Gardens and Traditional Quadrangle Dwellings

1.2 The Spatial Characteristics of Shanshui

In comparison to the southern region, the Beijing area has fewer water

resources, leading many private gardens in the north to focus more on mountain scenery. As a result, mountains and rocks hold a more prominent position in the layout of northern gardens, rather than water scenery. The rockeries in private gardens in Beijing are often made of earth hills and are quite large, serving to enclose the space and divide the inside and outside of the garden. Poplar, willow, and locust trees, which are commonly found in the northern regions, are planted on these earth hills, and the method of stacking the mountains is quite distinct from that in the south. Additionally, stone rockeries can also be found in private gardens in Beijing, with local bluestone being the primary material used due to its flake shape and tough lines. Nonetheless, influenced by southern gardens, Beijing's private gardens also utilize lake stones and pay attention to the aesthetic tendency of "thin, transparent, exposed, and wrinkled." This aspect is similar to the south, but most of the stones used come from the Fangshan area of Beijing. (Figure 6-3).

Figure 6-3 The Blue Stones of Liwang Garden and the Lake Stones of Guichun Garden

Despite the scarcity of water in Beijing, there are still water features in gardening. Natural water sources such as Kunming Lake outside the Beijing city and Shichahai inside the Beijing city have become key areas for concentrated gardening. The most common method of incorporating external water bodies into the garden to create a natural lake or river is

used in private gardens in Beijing. In urban areas, the scale of water bodies is generally smaller, and there has been an increase in the types of ponds being used.

The ShanShui layouts of Beijing's private gardens can be categorized into four types. The first type is a large-scale garden featuring earth hills and streams as the main ShanShui elements. They are arranged around the garden to provide a barrier against the noise of the outside world. In the second type, earth hills also surround the garden, but the water features inside consist of planar lakes and ribbon streams. The third type combines earth hills, earth-stone mountains, and stone mountains, with planar lakes and a small number of ribbon streams in a disorderly patchwork layout. The fourth type is dominated by banded stone mountains and planar ponds that complement each other. This type is influenced by the southern style of private gardens and is characterized by a small-scale layout.

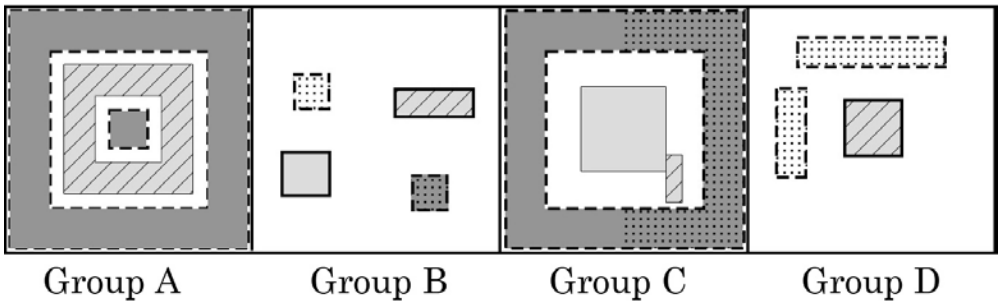

Figure 6- 4 ShanShui Layout Pattern

1.3 The Spatial Characteristics of Paths

The garden path is an essential element in organizing and guiding visitors to appreciate the scenery in a private garden. It is a vital part of the garden landscape, together with other elements such as buildings, rocks, water bodies, and plants. The courtyard layout of Beijing private gardens is unique, and therefore, the types of garden paths inside these gardens often differ from those in the south. As a tourist route, it is important to provide visitors with an excellent view of the scenery and a comfortable viewing

experience. Moreover, the garden paths need to efficiently connect various buildings and facilitate the daily life of the garden owner. The designer also needs to focus on creating small paths on the mountain that enable convenient climbing and provide a spectacular view.

In general, the household paths network structure of Beijing Private Garden is the most complex, while garden paths and mountain paths are attached to the household paths layout. These paths can be described using six indicators: average connection length, number of path sections, alpha index, average width, average tortuous angle, and concentration degree.

These gardens can be divided into three types of layout. The first type is the most common form of garden path, with a moderate household paths width (1.34m) and a turning point on average every 19.8 meters. The second type of household paths have the smallest connection length (12.94m) and the largest number of courtyard paths. It has a moderate degree of twists and turns and is the garden path form with the most intersections and the most routes for pedestrians to choose. The third type of household paths, mountain path, and courtyard path has the longest path length and the smallest degree of twists and turns, which forms the gentlest path network structure.

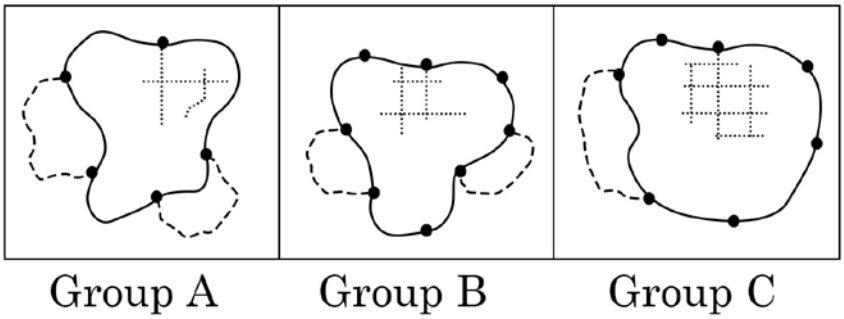

Figure 6- 5 Path Layout Pattern

1.4 The correlation between buildings, shanshui and paths

Based on the analysis conducted in Chapters 2, 3, and 4, it becomes apparent that the identity of the garden owner significantly influences the

spatial characteristics of buildings and shanshui. Conversely, the identity of the garden owner has a lesser impact on the characteristics of the garden path. This suggests that there may be a stronger correlation between architecture and shanshui, whereas garden paths exhibit a relatively weaker correlation with them.

Table 6- 1 Association of Patterns Between Elements

No.	Buiding	Shanshui	Path
10	A	D	A
11	A	D	A
12	A	B	A
13	A	D	A
14	A	D	A
2	B	C	B
3	B	A	C
5	B	A	A
9	B	C	B
1	C	A	A
4	C	C	A
6	C	B	A
7	C	C	A
8	C	C	B

According to the table presented above (gray area), a clear correlation exists between architecture and shanshui. The Group A architectural model often corresponds to the Group D model of mountains and waters, while the Group B model of architecture corresponds to both the Group A and C models of shanshui. The Group C of architectural model corresponds to the Group C model of mountains and waters. In other words, when a building follows the Siheyuan style, its internal shanshui is typically scattered in a disordered distribution. On the other hand, buildings with semi-enclosed courtyard spaces tend to have shanshui in the form of circular enclosures, distributed around the building's periphery. Additionally, when buildings are arranged in the Siheyuan layout, the shanshui predominantly consists of a combination of earth and stone elements surrounding the buildings.

Conversely, there appears to be relatively little correspondence between the Garden Road and other indicators (red content). Within the Group A of Garden Path, Group A and C buildings are primarily associated with shanshui Group D mode. However, other building forms exhibit a more chaotic correlation with landscape configurations. This suggests that when the garden path is more winding and less densely populated, buildings tend to adopt the layout mode of long Siheyuan, and the shanshui takes the form of rings and scattered points.

In conclusion, the table analysis demonstrates a strong connection between different building models and shanshui configurations. The Group A, B, and C architectural models each exhibit distinct correlations with specific landscape types, underscoring the significance of thoughtful architectural design in shaping the surrounding environment. However, the garden path stands out with its unique characteristics and limited correlations with other indicators, highlighting its individuality in architectural and landscape interactions.

In order to validate these findings, cluster analysis was performed on the characteristic indicators of building, shanshui, and building, shanshui, and garden paths, respectively, in this section. The resulting outcomes are presented in Figure 6-6 and Figure 6-7.

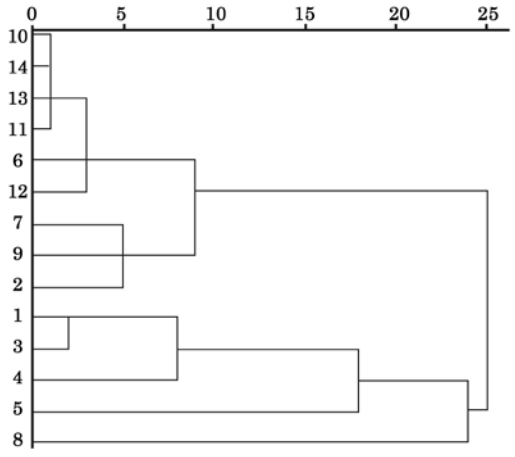

Figure 6- 6 Clustering Results of Buildings and Shanshui

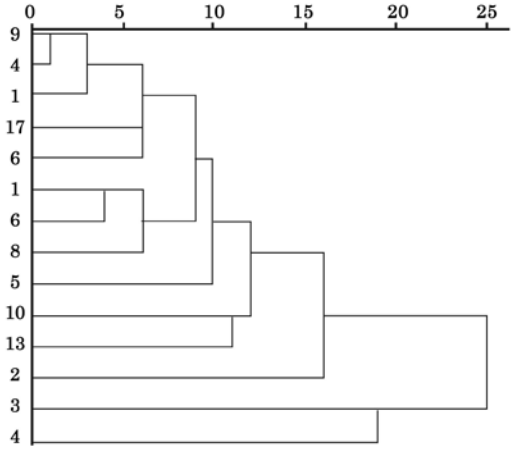

Figure 6- 7 Clustering Results of Buildings, Shanshui and Path

The findings demonstrate that when only buildings, mountains and water are clustered and grouped, the results are highly satisfactory, with distinct differences between the groups, making them easily distinguishable. However, when the indicators of garden paths are included in the cluster analysis along with the aforementioned indicators of buildings, mountains and water, the results become more ambiguous, and the differences between the groups become harder to discern. This suggests that the spatial characteristics of buildings and shanshui are intricately influenced by the identity of the garden owner, and they share a close relationship. Often, a specific pattern in shanshui space corresponds to a matching building space design, while the spatial pattern of garden paths lacks a clear association with the spatial patterns of building and shanshui.

Upon correlating the clustering results of buildings and shanshui with the clustering results presented in Chapter 3 and 4, a significant connection between them becomes evident. The comprehensive clustering results can be categorized into four distinct groups: Group A, Group B, Group C, and Group D (Figure 6-8).

Among these groups, Group A consists of nine gardens, with each garden having three spatial modes: Group A, C, B for buildings and Group D, B, C for shanshui. The building mode in Group A exhibits a high level of integrativeness with the scattered shanshui layout mode in Group C,

resulting in a spatial configuration of scattered shanshui within the courtyard. The buildings in Group C fuse with the shanshui in Group B, forming a courtyard and scattered shanshui layout pattern. The samples in the semi-open building model (Group B) and the circular semi-earth mountain and semi-earth stone mountain shanshui model (Group C) are predominantly similar, creating a layout pattern characterized by semi-open courtyards and circular semi-earth stone mountains.

Group B consists of three gardens, encompassing two modes: building Group C, B and shanshui Group A, C. The degree of sample consistency between building Group C and shanshui Group A modes is relatively high. This configuration represents a spatial pattern characterized by a courtyard surrounded by mountains and rivers.

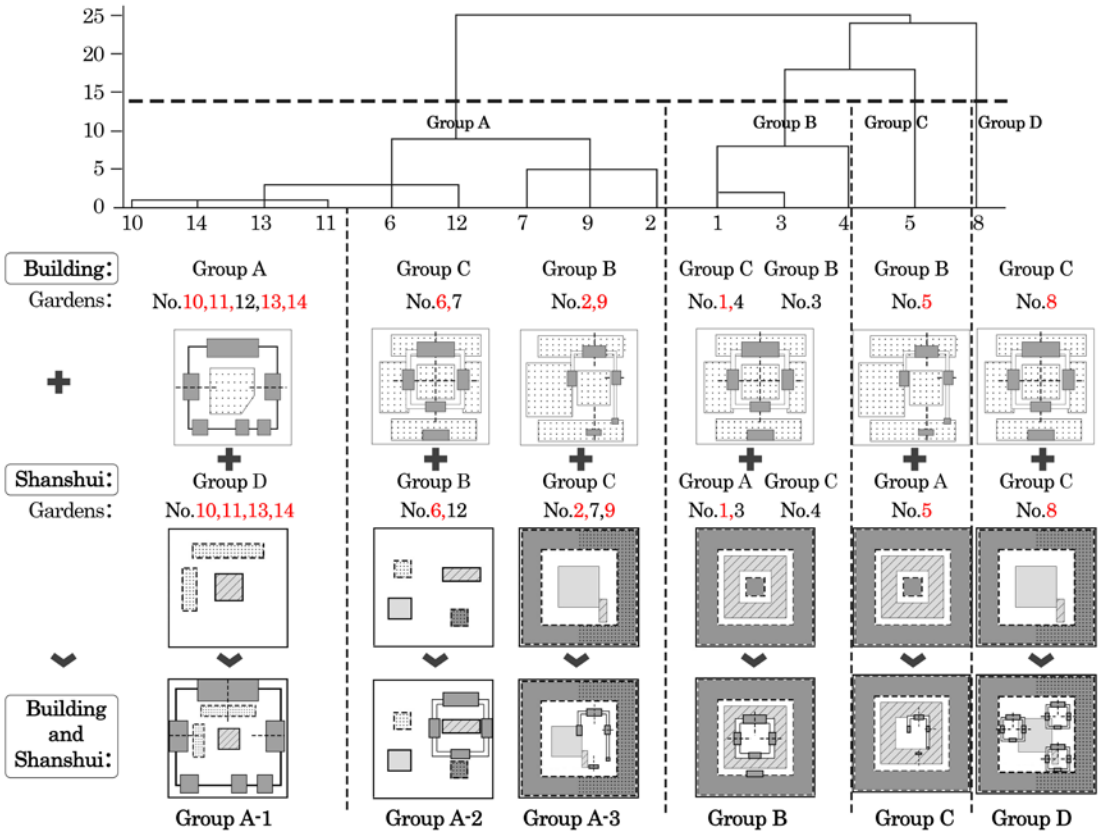

Figure 6- 8 Clustering and Patterning Results of Building and Shanshui

On the other hand, both Group C and Group D feature a single garden sample. Group C comprises building Group B and shanshui Group A,

presenting a semi-open architectural courtyard layout enclosed by soil, mountains, and water. Meanwhile, Group D consists of building Group C and shanshui Group C, which is a distinct and unique attribute with a layout pattern where multiple courtyards are scattered around circular mountains and rivers.

2 The Relationship Between Attribute s and Garden Characteristics

By analyzing the clustering results of buildings, shanshui, and garden paths, it is possible to distinguish the identity of the garden owner. The construction of the garden shows a tendency to group together in terms of shanshui and garden paths, while the location of the garden exhibits a clustering tendency in terms of building and shanshi.

However, during the construction period, only the garden paths were concentrated in the same group. It can be concluded that the owner's identity has a significant impact on the garden's characteristics, while the construction situation and garden location have a certain influence on the layout of buildings, shanshui, and garden paths. On the other hand, the construction period has the weakest impact on the garden's overall layout.

Table 6- 2 Grouping of Buildings, Shanshui and Paths

Building	No.	Owner	Location	Period	Ways	Shanshui	No.	Owner	Location	Period	Ways	Path	No.	Owner	Location	Period	Ways
A	10	OP	IN	Middle	RB	A	1	RN	IN	Late	RB	A	1	RN	IN	Late	RB
A	11	OP	IN	Late	NB	A	3	RN	OUT	Late	RB	A	4	RN	OUT	Middle	RB
A	12	OP	IN	Late	RB	A	5	RN	OUT	Middle	RB	A	5	RN	OUT	Middle	RB
A	13	OP	IN	Late	NB	B	6	RN	IN	Late	RB	A	6	RN	IN	Late	RB
A	14	OP	IN	Late	NB	B	12	OP	IN	Late	RB	A	7	RN	IN	Late	NB
B	2	RN	IN	Late	RB	C	2	RN	IN	Late	RB	A	10	OP	IN	Middle	RB
B	3	RN	OUT	Late	RB	C	4	RN	OUT	Middle	RB	A	11	OP	IN	Late	NB
B	5	RN	OUT	Middle	RB	C	7	RN	IN	Late	NB	A	12	OP	IN	Late	RB
B	9	RN	OUT	Late	RB	C	8	RN	IN	Late	RB	A	13	OP	IN	Late	NB
C	1	RN	IN	Late	RB	C	9	RN	OUT	Late	RB	A	14	OP	IN	Late	NB
C	4	RN	OUT	Middle	RB	D	10	OP	IN	Middle	RB	B	2	RN	IN	Late	RB
C	6	RN	IN	Late	RB	D	11	OP	IN	Late	NB	B	8	RN	IN	Late	RB
C	7	RN	IN	Late	NB	D	13	OP	IN	Late	NB	B	9	RN	OUT	Late	RB

C	8	RN	IN	Late	RB	D	14	OP	IN	Late	NB	C	3	RN	OUT	Late	RB
① Owner: status / occupation of the garden owner. RN : royal or nobility, OP: officials or politicians ② Location: The location of the gardens in Beijing. IN: inside of the city, OUT: outside of the city.③ Period: construction period. The Early Qing Dynasty(Early):1643—1722, The Middle Qing Dynasty(Middle):1723—1850, The Late Qing Dynasty(Late):1850—1912. ④ Ways: construction Ways. NB : newly built, RB : rebuilt.																	

2.1 Occupation of Garden Owner

The identity of the garden owner has had a significant impact on the characteristics of the three elements of Beijing private gardens: buildings, ShanShui, and paths. The scale and layout of the gardens, buildings, ShanShui, and paths are closely matched to the status of the garden owner. Large-scale gardens were typically owned by top princes and nobles, while middle-class officials and wealthy businessmen built medium-sized gardens. Ordinary people usually lived in simple courtyard houses and rarely had access to their own gardens.

In summary, the size and complexity of a garden's elements were typically determined by the social and economic status of its owner. This trend is evident in the diverse range of private gardens found in Beijing throughout history.

During the Qing Dynasty, Beijing was the capital of China and the home to wealthy and influential individuals with high social status and strong economic power. Building private gardens in Beijing was expensive due to the high costs of labor, materials, and land, making it challenging for ordinary people to afford their own gardens. As a result, it is not surprising that most private gardens were owned by dignitaries and senior officials.

In the middle and late Qing Dynasty, the ornateness of gardens was seen as a crucial criterion for measuring the level of garden construction and the social status of garden owners. A small number of private gardens were owned by members of the royal family, with most of them being awarded by the emperor or cut from the royal gardens. These gardens were grand in

scale, majestic in layout, and featured luxurious architectural decorations. The style of these gardens was also heavily influenced by the royal garden's temperament.

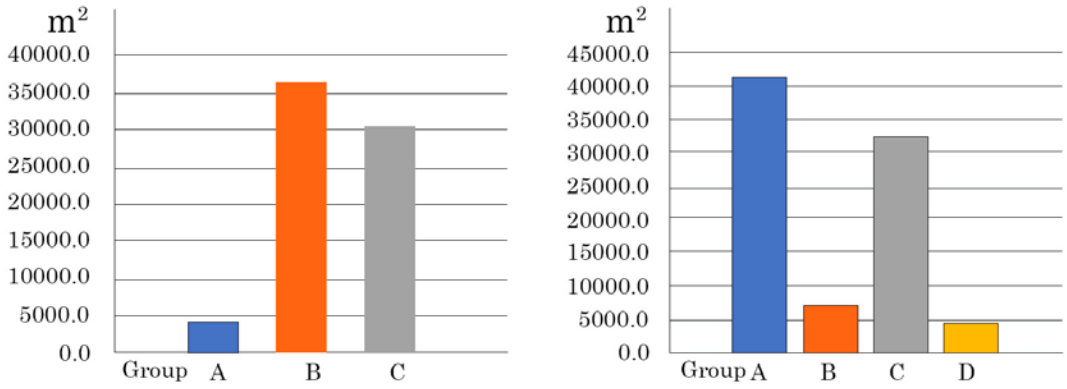

Figure 6- 9 Scale and Grouping of Gardens

Through the grouping of building and shanshui, it becomes evident that gardens with a rigid axis and circular shanshui patterns tend to have a larger scale, typically exceeding 3 hectares. Conversely, gardens with scattered shanshui layouts predominantly have a narrower scale. This implies that when garden owners have ample space to construct a garden, the shanshui within the garden tends to be designed in a circular layout pattern, often incorporating earthen mountains. The courtyard layout also follows a strict design with a clear axis.

However, when the garden site is smaller in scale, designers are constrained to utilize the scattered shanshui layout as a focal point within the courtyard enclosed by the buildings. The scale of the site is influenced by the identity and economic capacity of the garden owner, and it greatly determines the layout mode of both buildings and shanshui.

In addition, officials in Beijing lived in close proximity to the emperor, and due to the strict hierarchy of the Qing Dynasty, they generally exhibited a respectful and prudent attitude towards life. As a result, the scale and form of garden architecture and landscapes were restricted by more hierarchical systems. If a garden was built too grandly and did not match

the owner's status, it could be targeted by political opponents and become evidence of corruption or treason.

For example, Shuchun Garden, formerly known as Shihu Garden, was the residence of Heshen, a scholar in the Qianlong period who was once favored by the emperor and collected money, becoming rich as an enemy. It was a magnificent garden and the largest noble garden, but it indirectly led to the death of the owner, He Shen.

Additionally, the Qing Dynasty had regulations prohibiting private water diversion, and only a few palace gardens with special approval could introduce external water sources. This had a significant impact on the design of water bodies in private gardens of ordinary officials and made the Shichahai area the most important water source, occupied by princes and nobles. In contrast, the water features of other gardens in Beijing became extremely precious, and the water source in these gardens could only come from wells or rainwater, which greatly affected their beauty.

The use of stones in gardens was also restricted by the identity of the garden owner. Several precious stone-producing places in the north were occupied by the royal family and high-ranking officials, which restricted the materials used for stone extraction in ordinary houses and gardens.

These high-ranking officials were not only powerful but also cultured, often well-versed in literature and the arts. As refined scholars of their time, they had a deep appreciation for aesthetics, which greatly influenced the style, scale, and layout of their private gardens in Beijing. Some officials even imitated the elegant style of southern gardens or pursued a natural, wild aesthetic. For example, the Half-Mu Garden, owned by the poet Lin Qing during the middle of the Qing Dynasty, may have been small in scale, but it reflected a sophisticated use of space and featured elegant winding paths.

Thus, the occupation of the garden owner played a crucial role in shaping

the character of Beijing's private gardens. The social status, cultural background, and personal tastes of the owner all had a decisive impact on the design and layout of the garden's buildings, Shanshui, and paths.

2.2 Construction Ways

The construction Ways used for private gardens in Beijing also play a role in shaping their architectural and Shanshui characteristics. Many rebuilt gardens have continued their original architectural layout and landscape framework, such as Langrun Garden, Chengze Garden, and Qinghua Garden, which all maintain the pattern of being surrounded by mountains and rivers while expanding the buildings. However, with newly built gardens, there is more freedom in terms of design and layout.

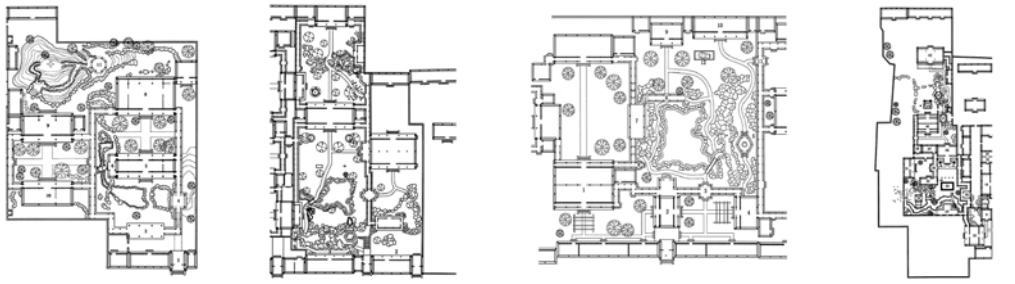

Figure 6- 10 Layout of Zang, Ke, Najia and Banmu Garden

It is crucial to acknowledge that the construction Ways utilized in creating a garden have a significant impact on its style. But it is entirely possible that the form of the newly built garden will be the same as that of the renovated garden. For example, although Ke Garden and Najia Garden are newly built, their building layout style is similar to the renovated Zang Garden, with asymmetric quadrangles and local axis features. The same situation exists in terms of the characteristics of mountains and waters. The newly built Ke Garden and Najia Garden have small pools, springs, and stone mountains, which are interdependent. However, the renovated

Banmu Garden also has pools, springs, and stone mountains, with similar layout methods. Thus, while construction Ways are not the sole determinant of a garden's style, they do play a crucial role in shaping its overall aesthetic.

2.3 Location of Gardens

The location of a garden also impacts the layout of the buildings and ShanShui within it to a certain degree. In Beijing's geographical environment, the scarcity of water and the Qing Dynasty's regulations prohibiting the private importation of water from outside the garden have resulted in Kunming Lake and the vicinity of Shichahai becoming gathering areas for large-scale water gardens. Furthermore, due to the abundance of water sources outside the Beijing, the water bodies in gardens outside the city are often more expansive, such as Langrun Garden, Chengze Garden, Qinghua Garden and Gunbeizifu Garden. However, the scale of the waters in Gunbeizifu Garden is still relatively small compared to those of gardens outside the Beijing. Additionally, there are notable differences in the mountain configuration outside and inside of Beijing. The mountains outside the city are often more extensive and primarily constructed of earth, whereas those inside the city are typically smaller in scale, with a greater focus on the application of earth and stone mountains to maximize the available garden space.

2.4 Periods of Gardens

Based on the analysis of the shanshui and architectural features of private gardens in Beijing, it can be concluded that the period of garden construction has minimal influence on these features. However, it does have a greater impact on the characteristics of garden paths. From a societal perspective during the Qing Dynasty, the gardens in the early Qing Dynasty were largely rebuilt from gardens of the previous dynasty (Ming Dynasty).

During the middle Qing Dynasty, when society was stable and the economy prosperous, a plethora of new garden forms emerged. In the later period, when the economy was in decline, most gardens were built based on early and mid-term garden designs. Moreover, the Qing Dynasty's duration of more than 200 years is relatively short for the establishment of diverse garden styles. Consequently, the garden architecture and shanshui design characteristics of the three periods remain relatively uniform.

Towards the end of the Qing Dynasty, the introduction of Western culture brought about the use of Western-style buildings as decorative elements in courtyards, as seen in Zhenbeizifu and Gongwangfu Garden. One of the most notable examples of the fusion of Western and Chinese styles is Taobeilefu Garden, which features a path network structure characterized by geometric straight lines, a typical Western technique. However, the garden's landscapes and buildings still maintain a traditional Chinese style, creating an overall Chinese atmosphere with a certain level of innovation.

Altogether, the influence of Western styles in the late Qing Dynasty brought about certain changes in the layout of private gardens in Beijing. Most of these Western elements appeared as embellishments, which did not significantly conflict with the traditional layout, but they have not yet become commonplace.

3 Final Summary

Based on the aforementioned research, several key findings emerge:

① Consistency of Quantitative and Qualitative Results:

The research reveals that the results obtained through quantitative methods generally align with previous qualitative findings. However, it also highlights that quantitative approaches often yield more detailed conclusions. Combining both qualitative and quantitative methods can lead to a more comprehensive understanding of the subject matter, enriching the

research outcomes.

② Distinct Layout Differences in Beijing and Sourthen Private Gardens:

The study underscores significant layout disparities among private gardens in Beijing during the Qing Dynasty, royal gardens in Beijing, and traditional private gardens in the southern region of China. Notably, private gardens in Beijing distinguish themselves by utilizing circular earth mountains and streams to enclose the space, a characteristic rarely observed in traditional southern gardens. This feature serves as a defining element of the northern region's garden design.

③ Relationship Between Buildings and Shanshui:

Private gardens in Beijing demonstrate a close relationship between their architectural structures and the layout and design of mountains and waters. These gardens often adhere to fixed layout patterns that correspond one-to-one with the surrounding shanshui elements. In contrast, the layout of the garden path lacks a fixed pattern and remains more flexible, primarily influenced by human body size and the preferences of the designer.

④ Influence of Garden Owners' Identity and Status:

The research highlights the crucial role of the garden owner's identity in determining the garden's design and layout. High-status officials, who typically possess greater financial resources, tend to create larger and more grandiose gardens. Circular earth mountains become the preferred layout choice for such expansive gardens. Conversely, limited economic means result in smaller garden scales, leading to the preference for scattered stone hills in the design.

4 Future Research

This study utilizes quantification to clarify the scale, form, and layout characteristics of private garden buildings, ShanShui, and paths in Beijing. It also summarizes the spatial patterns of these elements and analyzes the

causes of the characteristics of the four garden attributes, including the occupation of the garden owner, the Ways of construction, the location, and the construction period. The results of this study are consistent with the qualitative descriptions of predecessors such as Jia, Zhou and Wang, and further clarify the characteristics and mechanisms of formation of private gardens in Beijing in a more scientific, objective, and accurate manner based on previous research.

While this study provides a comprehensive analysis of the characteristics and formation mechanisms of private gardens in Beijing, there are some limitations that should be acknowledged. Firstly, due to various historical factors, many private gardens in Beijing have been destroyed, which limits the number of objects available for this study. Additionally, there is a lack of historical reference materials, which may have limited the accuracy of the analysis. Secondly, compared to the abundant samples available for southern gardens, the number of samples available for Beijing garden is relatively small, which may result in incomplete coverage of the spatial model. Nonetheless, this study represents the largest and most comprehensive analysis of private gardens in Beijing, and provides valuable insights into their unique characteristics and formation mechanisms.

It is worth noting that there may be limitations in the bilding and shanshui analysis, such as missing or incomplete quantitative indicators. For example, the third section of this study only includes indicators related to the size, layout, and orientation of buildings, but not their style or appearance. In reality, during the late Qing Dynasty when Western culture influenced private gardens in Beijing, there were significant changes in the appearance of individual buildings, with some gardens featuring flat-roofed bungalows. However, such changes in style cannot be fully reflected in indicators such as layout, size, and orientation, making it challenging to identify significant impacts of the construction period on garden style.

Nonetheless, the indicators for path layout do express morphological characteristics, allowing for the identification of significant impacts on garden path layout during the construction period.

As a space for living and entertainment, a garden is a three-dimensional physical space. However, current research indicators only focus on the two-dimensional spatial characteristics of gardens, which lacks analysis and clarity on the three-dimensional spatial characteristics. In future research, it would be meaningful to develop a three-dimensional space evaluation index and system to better evaluate the characteristics of Beijing's private gardens.

Additionally, this study did not use parameters and methods to describe the spatial characteristics of private gardens in Beijing in the research results. In future research, characteristic parameters can be directly applied to garden design to guide the construction and practice of traditional gardens in Beijing more scientifically and accurately, and finally apply theory to practice.

Contents of Figures

Appendix

Table 6- 3 Data Information of Paths

No.	Type	ACL	AL	ASP	ALP	VPL	FVA	VVD	MVD	AVD	CAP	L	N	TL	P
1	HP	41.57	39.83	15.50	70.30	33.49	18316.27	23.21	105.26	37.41	116.13	18.00	20.00	716.97	1434.57
	MP	34.97	34.97	20.70	77.70	25.24	20617.45	44.93	155.76	68.20	288.30	4.00	8.00	139.88	302.75
	CP	9.90	9.88	6.00	12.80	3.50	912.36	6.69	26.53	15.90	0.00	7.00	9.00	69.19	140.43
2	HP	10.83	11.88	5.80	21.30	10.57	15624.62	26.60	172.40	44.50	27.54	51.00	54.00	605.81	1196.11
	MP	31.75	27.42	13.90	44.20	17.97	19704.23	41.86	184.68	57.80	215.99	9.00	10.00	246.79	500.37
	CP	6.71	7.65	4.90	12.50	4.39	3201.77	12.52	51.49	23.30	6.75	25.00	30.00	191.33	382.93
3	HP	32.00	34.65	15.50	75.60	36.57	45890.80	62.02	282.24	72.30	54.87	44.00	46.00	1524.60	3035.62
	MP	64.82	64.82	64.80	64.80	0.00	47007.50	21.52	151.65	84.20	412.68	1.00	2.00	64.82	137.26
	CP	9.44	10.70	5.30	17.20	8.29	10680.26	15.48	74.92	22.40	2.06	43.00	52.00	460.19	913.67
4	HP	46.93	49.02	19.20	83.90	36.86	57703.04	51.68	221.66	70.10	94.36	13.00	18.00	637.20	1267.39
	CP	9.19	8.92	6.50	13.30	3.84	9520.80	7.84	34.29	18.90	11.62	31.00	41.00	276.60	560.33
5	HP	21.36	21.10	7.49	37.73	18.24	12180.47	30.81	166.50	40.98	58.08	20.00	23.00	421.94	853.77
	MP	9.35	9.35	9.40	9.40	0.00	13001.90	24.53	183.04	149.80	42.56	1.00	2.00	9.35	33.12
	CP	11.30	10.05	5.80	61.20	14.89	5940.92	22.13	140.16	15.80	27.59	13.00	20.00	130.63	279.28

6	HP	19.61	20.61	12.60	44.70	15.79	8958.10	36.86	153.97	57.90	3.36	16.00	21.00	329.73	671.55
	MP	7.32	9.76	6.10	8.60	1.39	9422.41	41.85	143.66	80.50	64.70	3.00	8.00	29.28	69.19
	CP	9.16	9.16	9.20	9.20	0.00	213.47	0.00	21.65	21.60	0.00	1.00	2.00	9.16	22.64
7	HP	19.63	18.13	11.30	31.90	13.22	8022.58	19.60	103.55	32.80	103.52	18.00	24.00	326.30	661.38
	MP	15.52	15.04	6.80	31.60	13.79	10412.57	23.15	124.23	52.10	56.73	18.00	18.00	270.69	747.45
	CP	10.63	10.63	9.30	11.10	0.77	1105.32	0.69	22.35	21.60	0.00	4.00	5.00	42.52	85.17
8	HP	14.12	14.93	6.30	24.00	10.49	9535.70	24.73	124.31	34.30	55.77	45.00	47.00	671.91	1325.81
	MP	24.73	23.50	9.80	33.80	11.96	12145.95	29.59	164.60	64.50	169.08	7.00	12.00	164.50	382.68
	CP	4.92	4.88	4.20	5.80	0.97	308.57	2.15	11.57	9.40	0.00	12.00	16.00	58.52	117.02
9	HP	13.88	16.25	5.90	28.40	15.69	9920.65	19.00	92.47	24.70	60.37	37.00	37.00	601.20	1190.85
	MP	14.00	13.42	6.50	16.90	5.27	12108.40	7.90	47.90	26.80	71.65	3.00	5.00	40.27	93.06
	CP	9.83	9.54	6.70	15.30	5.32	2540.04	12.89	52.79	22.80	16.25	25.00	27.00	238.50	286.11
10	HP	7.66	8.26	3.10	13.40	6.18	1806.40	8.76	26.16	8.60	145.50	4.00	5.00	33.05	68.05
	MP	5.20	4.69	2.80	8.40	3.05	2167.94	7.99	29.28	14.60	72.00	6.00	9.00	28.17	73.78
	CP	4.46	4.67	2.90	6.40	2.21	315.53	4.10	19.18	8.70	15.86	8.00	10.00	37.35	76.20
11	HP	10.34	10.41	4.90	25.00	11.90	1728.95	8.34	39.61	14.00	47.36	11.00	14.00	114.50	217.54
	MP	5.94	5.94	5.80	6.20	0.20	1986.61	17.07	48.06	21.50	6.61	3.00	6.00	17.82	48.69
	CP	8.49	8.69	6.40	12.80	3.42	1409.63	5.81	37.21	18.10	0.00	14.00	16.00	121.70	259.96
12	HP	9.29	9.61	3.60	15.60	8.13	784.31	5.60	22.35	8.40	85.50	8.00	11.00	76.85	201.32
	MP	6.81	7.05	4.40	13.00	5.02	904.48	9.62	39.42	20.80	68.02	13.00	12.00	91.60	207.72

	CP	7.00	7.16	5.20	9.50	2.33	892.06	6.08	22.30	14.20	0.00	9.00	12.00	64.47	133.16
13	HP	11.13	12.18	7.00	25.20	9.94	2178.70	9.06	35.81	15.80	56.48	14.00	17.00	170.47	348.91
	MP	5.85	5.98	2.10	9.10	4.34	2544.94	15.23	50.31	30.00	45.92	9.00	11.00	53.83	140.64
14	HP	10.48	11.02	6.50	18.60	6.73	1624.90	10.62	39.02	17.60	78.13	16.00	19.00	176.36	359.04
	MP	6.67	6.54	5.10	12.30	2.97	1914.84	12.66	55.19	33.80	56.02	5.00	6.00	32.69	69.18
	CP	8.41	7.51	3.90	12.60	6.46	1394.74	16.60	63.88	22.80	15.80	17.00	22.00	127.60	255.55

No.	Type	SP	A	SHA	α	ß	ANC	γ	IDA	AW	PAR	FREC	CAS	D	CE
1	HP	95.00	731.36	7.69	-0.03	0.90	1.80	0.33	89.90	1.02	1.96	1.75	1.20	0.04	0.59
	MP	29.00	278.66	2.67	-0.27	0.50	1.00	0.22	0.00	1.99	1.09	1.51	4.40	0.04	0.79
	CP	7.00	141.50	2.09	-0.08	0.78	1.55	0.33	89.20	2.05	0.99	1.35	0.00	0.02	0.29
2	HP	96.00	708.15	4.21	-0.02	0.94	1.85	0.33	85.70	1.17	1.69	1.51	0.90	0.04	0.47
	MP	55.00	425.91	4.43	0.00	0.90	1.80	0.38	83.50	1.73	1.17	1.63	3.00	0.05	0.63
	CP	29.00	235.99	2.70	-0.07	0.83	1.67	0.30	88.90	1.23	1.62	1.48	0.30	0.03	0.49
3	HP	160.00	2166.29	18.94	-0.01	0.96	1.91	0.33	89.30	1.42	1.40	1.77	0.50	0.03	0.65
	MP	13.00	186.20	3.05	0.00	0.50	1.00	-	0.00	2.87	0.74	1.43	2.60	0.00	0.24
	CP	45.00	832.78	2.63	-0.08	0.83	1.69	0.29	89.40	1.81	1.10	1.35	0.10	0.03	0.35
4	HP	59.00	798.89	6.24	-0.13	0.72	1.44	0.27	73.60	1.25	1.59	1.82	1.20	0.01	0.66
	CP	35.00	480.96	2.11	-0.12	0.76	1.51	0.26	89.60	1.74	1.17	1.38	0.50	0.01	0.75
	HP	61.00	635.63	6.54	-0.05	0.87	1.74	0.32	89.87	1.51	1.34	1.64	1.14	0.03	0.52

5	MP	2.00	35.94	1.71	0.00	0.50	1.00	-	0.00	3.84	0.92	1.30	1.90	0.01	0.54
	CP	17.00	90.42	1.81	-0.17	0.65	1.30	0.24	88.60	0.69	3.09	1.32	0.50	0.01	0.60
6	HP	18.00	451.12	3.58	-0.11	0.76	1.52	0.28	89.40	1.37	1.49	1.51	0.10	0.04	0.71
	MP	9.00	36.13	1.77	-0.36	0.38	1.00	0.17	0.00	1.23	1.91	1.53	4.00	0.06	0.57
	CP	1.00	19.75	1.27	0.00	0.50	1.00	-	0.00	2.15	1.15	1.16	0.00	0.01	1.02
7	HP	61.00	419.68	3.47	-0.12	0.75	1.50	0.27	86.50	1.29	1.58	1.56	2.20	0.04	0.51
	MP	58.00	807.57	5.21	0.03	1.00	2.00	0.38	88.80	2.98	0.93	1.51	0.90	0.13	0.57
	CP	4.00	67.46	2.60	0.00	0.80	1.60	0.44	90.00	1.59	1.26	1.46	0.00	0.01	0.48
8	HP	117.00	671.16	15.41	-0.01	0.96	1.91	0.33	85.40	1.00	1.98	1.84	1.70	0.07	0.66
	MP	37.00	330.21	3.14	-0.21	0.58	1.17	0.23	88.52	2.01	1.16	1.50	3.10	0.06	0.53
	CP	12.00	91.28	1.77	-0.11	0.75	1.50	0.29	88.90	1.56	1.28	1.34	0.00	0.03	0.64
9	HP	105.00	544.74	6.88	0.01	1.00	2.00	0.35	75.50	0.91	2.19	1.66	1.10	0.06	0.50
	MP	9.00	84.56	2.16	-0.20	0.60	1.20	0.33	0.00	2.10	1.10	1.41	2.20	0.02	0.41
	CP	33.00	286.11	3.49	-0.02	0.93	1.78	0.33	86.40	1.20	1.00	1.62	0.50	0.04	0.80
10	HP	10.00	31.75	3.42	0.00	0.80	1.60	0.44	0.00	0.96	2.14	1.72	8.60	0.02	0.70
	MP	10.00	30.62	1.94	-0.15	0.67	1.33	0.29	76.30	1.09	2.41	1.71	8.60	0.17	0.63
	CP	11.00	37.44	2.29	-0.07	0.80	1.60	0.33	82.10	1.00	2.04	1.55	1.50	0.04	0.27
11	HP	25.00	136.22	2.94	-0.09	0.79	1.57	0.31	84.40	1.19	1.60	1.50	1.40	0.07	0.47
	MP	4.00	33.03	1.30	-0.29	0.50	1.00	0.25	0.00	1.85	1.47	1.21	0.50	0.03	0.91
	CP	14.00	278.66	1.92	-0.04	0.88	1.75	0.33	89.70	2.29	0.93	1.33	0.00	0.04	0.77

12	HP	23.00	204.97	2.29	-0.12	0.73	1.45	0.30	78.20	2.67	0.98	1.46	2.90	0.10	0.53
	MP	27.00	124.13	5.59	0.11	1.08	2.17	0.43	82.20	1.36	1.67	1.72	2.90	0.19	0.70
	CP	9.00	129.30	1.65	-0.11	0.75	1.50	0.30	88.90	2.01	1.03	1.24	0.00	0.03	0.53
13	HP	39.00	193.62	4.00	-0.07	0.82	1.65	0.31	82.30	1.14	1.80	1.69	1.20	0.05	0.69
	MP	18.00	120.26	2.74	-0.06	0.82	1.64	0.33	87.60	2.23	1.17	1.49	2.30	0.10	0.84
14	HP	43.00	176.79	4.31	-0.06	0.84	1.68	0.31	88.60	1.00	2.03	1.73	2.70	0.11	0.47
	MP	8.00	48.39	3.02	0.00	0.83	1.67	0.42	83.10	1.48	1.43	1.57	4.30	0.12	0.49
	CP	20.00	157.23	2.97	-0.10	0.77	1.55	0.28	89.40	1.23	1.63	1.54	1.00	0.03	0.76