

# Historical Landscape Evolution and Pattern Characteristics of Water System in Yuanmingyuan Garden

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## Research Article

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# Abstract

Yuanmingyuan Garden embodies the outstanding wisdom and cultural and artistic pursuit of Chinese classical royal gardens in water management. The water system has rich morphological changes, vivid waterscape and profound water culture. The overall water system design realises the perfect combination of water function, culture, ecology and landscape. The current water system area accounts for about 30% of the total area of the park, which is a pattern formed after continuous construction, improvement, change and governance in various historical periods. This study adopts the method of combining historical documents, map and modern spatial information system to restore and overlay the water system pattern in the typical historical periods of Yuanmingyuan, such as the initial period, the peak period, the ruin period and the contemporary development period in the same spatial coordinate system. The pattern characteristics and evolution laws of the water system in each historical period were quantitatively analysed and explained by landscape pattern indexes, such as the type area of water patches and the proportion of water patches in water patch number. The causes and cultural connotation of water system pattern characteristics in various historical periods are interpreted in combination with the historical background and design concept.

## 1. Introduction

The water systems in Yuanmingyuan reflect the remarkable construction wisdom and cultural and artistic pursuit of classical Chinese imperial gardens in water governance. These systems feature abundant changes in form, vivid waterscapes and a profound foundation. Accordingly, the design of the overall water system has achieved a seamless combination of functions, culture, ecology and eye feasting. The existing water system accounts for about 30% of the total area of the park and follows a pattern that developed through time as a result of construction, improvement, updating and government. To date, most domestic and foreign researchers have focused their work on the buildings and landscapes in different historical periods. Guo Daiheng et al. [1–3] reproduced the architectural layout of Yuanmingyuan in the Qing Dynasty. Zang Chunyu [4] conducted an all-round statistical analysis of the landscape changes of Yuanmingyuan in 1933–2002. Zhang Enying et al. [5] created layout plans of the various parts of Yuanmingyuan in its heyday according to the plans collected by Yangshi Lei in the Qing Dynasty. Zhang Fengwu [6] reproduced the landscape patterns of Yuanmingyuan according to the charts layout drawings of Yangshi Lei. Bai Rixin [7] drew the pictures of all the 108 scenic spots in the three gardens of Yuanmingyuan in its heyday. By contrast, the relatively less studies that have been conducted on the historical water systems of Yuanmingyuan mainly focus on water sources and the extension of the water system [8], the form and dimensions of the water system [9], the restoration of water ecology [10, 11] and water system culture [12–14]. This study conducts a systematic analysis of the evolution and characteristics of the water system in Yuanmingyuan over typical historical periods. Accordingly, this study will play a basic role in the all-round understanding of the construction ideas, value and characteristics of the water culture heritage of Yuanmingyuan. Moreover, this study has important theoretical and realistic significance in building a model zone of national historical and cultural inheritance in the region of three hills and five gardens [15].

## 2. Materials And Methods

Based on the historical evolution of Yuanmingyuan, this study divides the significant changes in the pattern of water system into four periods: initial construction period (about 1707–1744), heyday period (about 1744–1860), ruins period (about 1860–1976), and contemporary development period (about 1976–present). The ‘Inferred Construction Plan of Yuanmingyuan in the Period of Prince Yin Zhen’, which was created by He Yan on the basis of the ‘12 Poems about Garden Sceneries’ by Yin Zhen and historical literature [1], reflects the water system pattern of Yuanmingyuan in its initial construction period—the period of Emperor Kangxi (about 1744 – 1722). Collection No. 1704 of Beijing Palace Museum—‘Yuanmingyuan Site Map’ records the complete appearance of the ‘Garden of Gardens’ in its heyday in the 44th year of Emperor Qian Long (1779). The ‘Riverway Map of Yuanmingyuan, Changchun Garden and Qichun Garden’ in the 10th year of Emperor Xian Feng (1860), another collection of the Palace Museum, describes the water system pattern of the three gardens before their destruction and is also the only map of their layout in the Qing Dynasty. The ‘Map of Measured Relics of Yuanmingyuan, Changchun Garden and Qichun Garden’ drawn by Beijing Works Bureau in 1933 reflects the conditions of Yuanmingyuan after it became ruins. The measured drawing ‘Relief Map of Areas Near Haidian District, Beijing’ of 1965 reflects the conditions of Yuanmingyuan after its hills and water system were wrecked. The ‘2016 Archaeological Survey Map of Yuanmingyuan’ is a measured drawing that exhibits the current state of Yuanmingyuan as a relics park. Accordingly, this study uses the method of combining historical literature, maps and the modern space information system [16] to reproduce the integrated drawings and the measured drawings under the same space coordinate system on the basis of the important drawings of the above 6 years that convey the information on the space pattern in the four historical periods. Then, this study classifies and extracts the relevant space elements of all typical historical periods, including water systems, buildings, places, wooded hills, grassplots and farmlands (Table 1); selects three landscape pattern metrics (Table 2), including number of patches, patch class area (CA) and percent of landscape (PLAND), to compare the change rate of water area, water surface ratio and number of surface patches in all historical periods; expounds the historical evolution and pattern characteristics of the water system in Yuanmingyuan.

Table 1  
List of landscape types in different historical periods

<b>landscape type</b>	<b>content</b>
Hillside Woods and Grassplots	Including mountains, woodlands and grasslands
Linear water	The width of the water is less than 30 meters, and the length is not limited [17]
Planar water	Including pools, lakes and seas. Pool: The width of the water body is between 30 and 100 meters; Lake: The length and width of the water body are between 100–300 meters; Fuhai
Farmlands	Including rice fields and vegetable fields
Buildings	Yuanmingyuan Palace Architecture and Temple Religious Architecture, Residence and Facilities Architecture, Western Architecture
Sites	Open spaces in the Yuanmingyuan
Others	Mainly wasteland, and the part of the landscape type that cannot be determined through maps and literature information

Table 2  
Parameter indicators and descriptions

Parameter category	Landscape Index	representation	formula	Indicator description
	Number of patches	patch numbers	$N_P = N$	The sum of the number of channels (linear water system patches) and the planar water system patches
Quantitative features	Class area	Water area	$A_c = A_1 + \dots + A_i$	The sum of all patch areas in a certain type of patch, the value range is $A_c > 0$
	Percent of landscape	Surface rate	$P_{LAND} = \sum_{j=1}^n a_{ij} \times 100\%$	$a_{ij}$ is the area of the $ij$ patch; $A$ is the total area of the landscape; When $P_{LAND}$ tends to 0, it means that the type of patch in the landscape is very rare; When $P_{LAND} = 100\%$ , it means that there is only one type of patch in the landscape. The value range is $P_{LAND} > 0$

### 3. Integration Of Drawings And Newly Created Drawings

#### 3.1 Water system pattern from the last years of Kang Xi (about 1707–1722) to the 9th year of Qian Long (1744)

Drawing source: Adapted from the 'Inferred Construction Plan of Yuanmingyuan in the Period of Prince Yin Zhen'

During the last years of Kang Xi (about 1707–1722), the site selection for Yuanmingyuan began, with several islands to be arranged across the rear lake as the center. The main scenic spots completed included Bamboo Courtyard, Phoenix Tree Courtyard, Peony Terrace, Goldfish Pool and Jianyuan. The northern part was mainly devoted to paddy fields, with a linear water system linking up the scenic spots of Peach Blossom Dock, Gengzhixuan and 'Study Room in Willow Forest', marking the initial formation of the water system pattern.

This drawing was adapted by He Yan from the inferred plan for the architectural layout of Yuanmingyuan in the period of Prince Yin Zhen, which was included in the book entitled 'Elapsed Glory: Study and Protection of the Architectural Gardens in Yuanmingyuan' (Fig. 1). This graphics mainly referred to the descriptions about the nascent natural landscapes of Yuanmingyuan in the '12 Poems about Garden Sceneries' in 'Yongdiji' and the judgment of the locations of the early scenic spots of Yuanmingyuan in historical literature, such as 'Yuanmingyuan' and 'Researches on Old Anecdotes'. For example, 'Goldfish Pool' evolved into 'Frank & Open'; 'Huzhongtian' was located in the scenery 'Spring Beauty of Wuling'; 'Jiange' was the later 'Mercy Spreading Protection for All'. The drawing, which is the earliest reproduction of the inferred plan of Yuanmingyuan, used different bright colours to indicate different sights: blue stands for water system, yellow for farmland, green for hillside woods and grassplots, black for buildings. Therefore, the drawing is an important reference for the studies of the early pattern of Yuanmingyuan.

Drawing source: Adapted from 'Collection No. 1704 of Beijing Palace Museum-Site Map of Yuanmingyuan'

After Yong Zheng ascended to the throne, the large-scale construction of Yuanmingyuan was launched, including the expansion and reconstruction of it in the early days of Emperor Qian Long. The 9th year of Qian Long(1744) saw the completion of '40 Landscapes of Yuanmingyuan', marking the entry of the garden into its glorious heyday. The construction style also shifted from the advocacy for simplicity in the periods of Kang Xi and Yong Zheng to extravagance and magnificence.

'Collection No. 1704 of Beijing Palace Museum—Yuanmingyuan Site Map' records the complete appearance of the 'Garden of Gardens' in its heyday in the 44th year of Emperor Qian Long (1779) and its evolution process that spanned nearly a century [17]. According to the public drawings and the researches by scholars, this is the earliest drawing in all the existing drawings of Yuanmingyuan. It uses curves to depict the landscape outline and applies light colours to the water surface. Figure 2 depicts the water system pattern of Yuanmingyuan in the 9th year of Qian Long(1744) on the basis of the comparison made to '40 Landscapes of Yuanmingyuan' drawn in the 9th year of Qian Long (1744), the 'Landscape Map of Yuanmingyuan in the 9th year of Qian Long' inferred by Zhang Fengwu [6] and other relevant literature using the drawing as base drawing.

## **3.2 Water system pattern from 9th year of Qian Long(1744) to 10th year of Xiang Feng(1860)**

Drawing source: Adapted from 'Riverway Map of Yuanmingyuan, Changchun Garden and Qichun Garden'

With the construction of Changchun Garden and the incorporation of Qichun Garden, the three gardens reached their peak in the 19th year of Jia Qing (1814) to become a complete large artificial waterscape system with waters, brooks and hills of different shapes and dimensions complementing one another. The water system pattern was the best at this time .

Figure 3 was plotted on the basis of the 'Riverway Map of Yuanmingyuan, Changchun Garden and Qichun Garden'. The drawing was carefully plotted on a coloured paper. Different colours were used for the rivers,

canal, lakes, hillstones and hills, with green standing for water, yellow for hills and black for scenic spots. A rare one in the drawings of Yuanmingyuan [18] is the only pattern map of the three gardens in the Qing Dynasty. The drawing is an extremely important historical material of precious value for restoring Yuanmingyuan or studying its history.

### **3.3 Water system pattern from 10th year of Xian Feng(1860) to 1949**

Drawing source: Adapted from 'Map of Measured Relics of Yuanmingyuan, Changchun Garden and Qichun Garden'

Yuanmingyuan was burnt down by British–French allied forces in the 10th year of Xian Feng (1860) and rebuilt and renovated in the years of Tong Zhi and Guang Xu. The Eight-Power Allied Forces invaded Beijing in the 26th year of Guang Xu (1900), unveiling the destruction of the water system in Yuanmingyuan.

Figure 4 was plotted on the basis of the 'Map of Measured Relics of Yuanmingyuan, Changchun Garden and Qichun Garden' by Beijing Works Bureau in 1933. With a scale of 1:2000, the drawing shows the plan of rivers, lakes, hills, contour of hillstones and building sites that are basically consistent with that shown in the drawings of Yangshi Lei. The names of most scenic spots are marked in the same way as those in the drawings of Yangshi Lei and are fairly accurate. Since this graphics is a measured drawing that was printed and distributed, it features a large scale and has been a precious historical material in determining the appearance of Yuanmingyuan in its heyday, playing an important role in academic researches and the protection and renovation of relics.

### **3.4 Water system pattern from 1949 to 1976**

During the early period of the people's republic of china, Premier Zhou Enlai gave explicit instructions about the need to protect the relics of Yuanmingyuan. However, production teams got into the relics of Yuanmingyuan and started lake reclamation, causing serious much damage to the water system in Yuanmingyuan.

Figure 5 was completed by the Department of Geological and Topographic Survey, Beijing Urban Planning Administration on the basis of the 'Relief Map of Areas Near Haidian District, Beijing' of 1965. The relief map has true and reliable data and can be used to measure area and length because it was created with modern surveying and mapping methods. The elevation data are more helpful in the research on the 3D space of Yuanmingyuan. Within the scope of Yuanmingyuan ruins, the entities and buildings that already appeared, include Middle School 101, shooting range of the district Department of Military Affairs, municipal Chemical Research Institute and the duck field of the commune. The drawing clearly and accurately reflects the water system pattern of Yuanmingyuan from 1949 to mid-late 1970s.

Drawing source: Adapted from 'Relief Map of Areas Near Haidian District, Bei-jing' of 1965

### **3.5 Water system pattern from 1976 to present**

Drawing source: Adapted from '2016 Archaeological Survey Map of Yuanmingyuan'

In 1976, the Yuanmingyuan Administrative Department was set up and started restoration of the water system in the park. By 2016, the water system had been restored to 4/5 of the area of the water system in its heyday.

Figure 6 was provided by the Administrative Department of Yuanmingyuan and makes a detailed exhibition of the overall state of Yuanmingyuan within the scope of the plan in this period. This drawing was plotted on the basis of '2016 Archaeological Survey Map of Yuanmingyuan' In addition to precise coordinates and elevation information, this drawing also includes some latest archaeological exploration results (e.g. exploration of riverway, buildings and hills).

## 4. Explanations About The Characteristics Of The Water System Pattern In All Historical Periods

### 4.1 Initial construction period of the Imperial Garden (last years of Kangxi(about 1707–1722) – 9th Year of Qian Long(1744))

Site selection for the construction of Yuanmingyuan began in Kang Xi's last years(about 1707–1722). According to the '12 Poems about Garden Sceneries' written by Yong Zheng when he was a prince, most of the garden building works were concentrated around the rear lake, which was later known as 'Peace for All China' and expanded slightly northward to Gengzhixuan and Peach Blossom Dock and eastward to 'Study Room in Willow Forest' [1]. Danlingpan, located to the north of Changchunyuan, was formerly a swamp. Yuanmingyuan was developed by Yin Zhen in response to the natural conditions, with focus on rivers and lakes. The groundwater level was higher and close to the ground surface in nearby places because of the small exploitation quantity of groundwater resources in ancient times. Lake water was continuously replenished by groundwater in the area where Yuanmingyuan was constructed to maintain the sights of the water system. The water-rich advantage of the natural environment allowed for the use of the cut-and-dry rear lake in an approximately square shape as the main part of the garden. At that time, the water system in Yuanmingyuan unfurled around the three sights with a higher groundwater level, including 'Study Room in Willow Forest', Gengzhixuan and Rear Lake; the water system in the scenic zone had six patches, a water area of 9.27 hm<sup>2</sup> and a water surface ratio of 19.03% (Table 3).

Table 3  
Landscape data of Yuanmingyuan in the last years of Kangxi(about 1707–1722)

	Farmland	Linear water	Hillside Woods and Grassplots	Building	Site	Planar water	Other	sum
Area (hm <sup>2</sup> )	0.89	3.55	10.71	0.30	0.17	5.73	27.36	48.71
Proportion	1.84%	7.28%	21.98%	0.61%	0.36%	11.77%	56.16%	100.00%

During Yong Zheng's first year(1723), water was channelled from Wanquanzhuang into the Front Lake of Yuanmingyuan through its southwestern corner and Changchun Garden. The new overall plan arranged the landscape pattern of the whole garden according to the general landscape layout in the nine States of Huaxia to express the imposing momentum of 'the emperor owning all lands under the sun'.

Firstly, the works completed included the addition of a court etiquette area in the south of the former Ciyuan, improvement of the nine States in the Rear Lake and reinforcement of the central axis. The nine isles around the lake symbolise the nine States of Huaxia and are linked up by nine linear water systems to surround a large surface water system. The isles not only symbolise the nine States in geography but also were built under the idea of 'Jiugong Bagua'. In terms of cultural imagery, the isles showed the ancient spiritual belief in heaven and earth and reflected the cosmic outlook of combining time and space in traditional Chinese culture.

Secondly, the lake to the east of Ciyuan was expanded to become the Sea of Blessing, where three isles were built to symbolise the three mountains of Penglai, Fangzhang and Yingtai. The shift from lake to sea was a qualitative leap from a garden conferred upon a prince to an imperial garden [13]. The three isles contrast with the large water surface of the Sea of Blessing to symbolise the lineage of the traditional landscape culture of 'divine mountains and fairy islands' in ancient China with the east expressing the cultural implication that east China faces the sea. The scenery is a reproduction of the imperial palace using the mode of '1 pool and 3 hills' in Jianzhang Palace of Shanglin Garden in Western Han Dynasty [12]. A linear riverway was dug around the Sea of Blessing.

Most scenic spots around the Seal of Blessing focused on Penglai Fairyland as the theme, and their cultural imagery was mostly related to the Taoist legend of Penglai East Sea, such as Guangyu Palace where Mount Tai Goddess Bixiayuanjun was enshrined and worshipped; 'Open to Public' where Lǚ Zu was enshrined and worshipped; 'Place of Unique Beauty', which symbolised alchemy place on Tiantai Hill; Wangyingzhou for cultivation of morality and virtue; and 'Open-Mind & Enlightened' and 'Cottage with Beautiful View' for appreciating sunset glows. In a certain sense, the scenic spots around the Seal of Blessing reproduced the Penglai Fairyland in the legend [13].

At that time, the water system in the scenic zone had 30 patches, a water area of 64.66 hm<sup>2</sup> and a water surface ratio of 32.30% (Table 4).

Table 4  
Landscape data of Yuanmingyuan in the 9th Year of Qian Long(1744)

	Farmland	Linear water	Hillside Woods and Grassplots	Building	Site	Planar water	Other	sum
Area (hm <sup>2</sup> )	4.87	23.52	31.79	13.22	12.60	45.16	69.03	200.19
Proportion	2.43%	11.75%	15.88%	6.60%	6.29%	22.56%	34.48%	100.00%
<i>4.2 Heyday of the Imperial Garden (9th year of Qian Long(1744) – 10th year of Xian Feng(1860))</i>								

In the 10th year of Qian Long (1745), Hong Li started the construction of Changchun Garden, another waterscape, in the east of Yuanmingyuan. The ‘Eternal Memory Studio’ and Yingzhou fairyland— Haiyuekaijin were on the lake’s two isles in the west; The Zelan Hall, Wisdom Temple and Lion Forest, which were modelled after the traditional gardens in Suzhou, were located on the northern bank of the lake; The Jade Exquisite Hall, Qianyuan and Ruyuan were located in the east of the lake and on its southern bank. The belt area in the north of the garden was developed into a scenic zone of distinctive buildings constructed in the style of European palaces and gardens, including Wan Flower Maze, Haiyantang, Yuanyingguan, Guanshuifa and Xianfa Hill, which combined Chinese and Western elements and appeared novel and delicate. These structures reflected a high level of garden-building art and became the representative works combining Chinese and Western cultures. A riverway was dug to the north of ‘High Hills and Long Rivers’ of the Yuanmingyuan to introduce water from the west of the garden. Another riverway was dug from ‘Ninghe Town’ to ‘Xiuqing Village’ to the southeast of the Sea of Blessing. The riverway to the north of ‘Depths of Cave’ was levelled up.

With the construction of Changchun Garden and the incorporation of Qichun Garden, the three gardens, including Yuanmingyuan, reached their peak in the 19th year of Jia Qing (1814). In the Changchun Garden, sandbars, isles, bridges and dykes were used to divide the large water surfaces into a number of sections of different shapes and pleasant dimensions, which were connected into a whole. The water surfaces, each about 200 m wide, provided a 200 m range of visibility so that people could clearly see the objects on the opposite bank. The artistic style of such a water space is entirely different from that of an open large water space or deep and serene zigzagging streams [19]. Qichun Garden has already lost the connotation of the imperial culture of Yuanmingyuan and Changchun Garden in the overall plan. Except for the two water surfaces of medium scale in the northeast, most part of the garden was a collection of small water bodies in a pattern where each sight occupied one isle. The sights were separated by water surfaces of different sizes, including brooks, pools and lakes. The different shapes and sizes of the isles resulted in the changing contours of the water bodies.

From the first year of Dao Guang(1821) to the 10th year of Xian Feng (1860), adjustments were made only in partial places: the water pool in the south of ‘Nature Scenery’ was levelled up; and a new riverway was

dug in the north of 'Far Northern Mountain Village'. At that time, the water system in the scenic zone had 59 patches, a water area of 123.26 hm<sup>2</sup> and a water surface ratio of 35.15% (Table 5).

Table 5  
Landscape data of Yuanmingyuan in the 10th Year of Xian Feng(1860)

	<b>Farmland</b>	<b>Linear water</b>	<b>Hillside Woods and Grassplots</b>	<b>Building</b>	<b>Site</b>	<b>Planar water</b>	<b>Other</b>	<b>sum</b>
Area (hm <sup>2</sup> )	4.87	25.51	55.02	22.44	27.50	97.24	118.06	350.64
Proportion	1.39%	7.27%	15.69%	6.40%	7.84%	27.73%	33.67%	100.00%

### 4.3 Ruins period of the Imperial Garden (10th year of Xian Feng(1860) – 1976))

In the 10th year of Xian Feng (1860), Yuanmingyuan was ransacked and destroyed by British–French allied forces, who burnt down most of the buildings in the garden and seriously damaged the flowers, grasses and trees, excluding the hills and water system that remained intact. In the 26th year of Guang Xu (1900), the Eight-Power Allied Forces invaded Beijing, and Yuanmingyuan was wrecked again. After 1917, numerous farmers arrived in Yuanmingyuan for land reclamation, causing damage to the hills and water system. The water system in the north of the scenic areas of 'More Farm Works As Coming Clouds' and 'High Hills & Long River' was expanded into linear riverways. At that time, the water system in the scenic zone had 59 patches, a water area of 122.61 hm<sup>2</sup> and a water surface ratio of 34.97% (Table 6).

Table 6  
Landscape data of Yuanmingyuan in 1933

	<b>Linear water</b>	<b>Hillside Woods and Grassplots</b>	<b>Building</b>	<b>Site</b>	<b>Planar water</b>	<b>Other</b>	<b>sum</b>
Area (hm <sup>2</sup> )	25.53	53.24	22.17	27.58	97.08	125.03	350.64
Proportion	7.28%	15.18%	6.32%	7.87%	27.69%	35.66%	100.00%

In the early days after new China was established, Premier Zhou Enlai gave explicit instructions about the need to protect Yuanmingyuan ruins. In 1956, Beijing Bureau of Parks and Woods launched tree planting in Yuanmingyuan ruins, thus initially altering the desolate scenes there. In the period of 'agriculture learning from Dazhai', a large number of hills and water systems in Yuanmingyuan ruins were converted to farmland. Consequently, the water system pattern changed beyond recognition, and the original garden functions were destroyed. At that time, the water system in the scenic zone had 28 patches, a water area of 24.38 hm<sup>2</sup> and a water surface ratio of 6.95% (Table 7).

Table 7  
Landscape data of Yuanmingyuan around 1965

	Farmland	Linear water	Hillside Woods and Grassplots	Building	Site	Planar water	Other	sum
Area (hm <sup>2</sup> )	102.23	10.49	82.48	4.65	25.51	13.90	111.39	350.64
Proportion	29.16%	2.99%	23.52%	1.33%	7.27%	3.96%	31.77%	100.00%

## 4.4 Contemporary development period of the Garden (from 1976 to present)

In 1976, the Yuanmingyuan Administrative Department was set up. In 1985, the related departments completed the dredging of the Seal of Blessing, some 500 mu of water surfaces around it and the construction of 1200 m of diversion canals. Since 1987, the renovation and restoration works covered the water surface sights in the Seal of Blessing, Qichun Garden and other parts [20]. In 2000, the State Administration of Cultural Heritage officially approved the 'Plan for Yuanmingyuan Site Park'. From then on, the archaeological excavation and protection practices at Yuanmingyuan have made great progress, including the restoration of the hills and water systems, protection of building relics, exploration of the ways for effective exhibition and interpretation of the site. At the end of 2007, the recycled water from Qinghe Regenerative Water Plant started to be used as the water for the sights in Yuanmingyuan, thus effectively alleviating the water supply difficulty in the garden. By 2016, the water systems in the three gardens, including Yuanmingyuan, had 36 patches, a water area of 102.05 hm<sup>2</sup> and a water surface ratio of 30.46% (Table 8).

Table 8  
Landscape data of Yuanmingyuan in 2016

	Farmland	Linear water	Hillside Woods and Grassplots	Building	Site	Planar water	Other	sum
Area (hm <sup>2</sup> )	4.72	15.93	171.05	9.71	16.62	88.03	28.99	335.05
Proportion	1.41%	4.75%	51.05%	2.90%	4.96%	26.27%	8.65%	100.00%

## 5. Analysis Of The Evolution Of The Water System Pattern In All Historical Periods

### 5.1 Evolution of the water system pattern of all landscapes

From the last years of Kang Xi (about 1707–1722) to the 9th year of Qian Long (1744), the water systems in Yuanmingyuan maintained a basically consistent trend of changes in quantity characteristics (i.e. a

sustained increase). The number of patches in the water systems increased to 23, the water area to 55.39 hm<sup>2</sup> and the water surface ratio to 13.27%. This result was closely related to the construction works carried out in the years of Yong Zheng and Initial Year of Qianlong(about 1736–1744).

From the 9th year of Qian Long (1744) to the 10th Year of Xian Feng(1860), the indexes of all the water systems in Yuanmingyuan continuously increased. The number of patches in the water systems increased to 27, the water area to 58.6 hm<sup>2</sup> and the water surface ratio to 2.85%. This situation was due to the incorporation of Changchun Garden and Qichun Garden in the middle to late period of Qian Long and in the years of Jiaqing, which enriched the water system pattern.

From the 10th Year of Xian Feng(1860) to 1933, the number of water system patches increased by three, the water area decreased by 0.65 hm<sup>2</sup>, and the water surface ratio fell by 0.18%. Although 93.07% of the water systems were preserved, most of the reduced water systems was turned into wasteland. Most of the farmland that completely disappeared became wasteland, and a small part of it became a water system, hillside woods or grassplots, and 4.4% of the former farmland and 5.84% of other landscapes were converted to a water system (Table 9).

Table 9  
Landscape Transfer Matrix from Late Xianfeng to 1933

	<b>Water</b>	<b>Hillside Woods and Grassplots</b>	<b>Building</b>	<b>Site</b>	<b>Other</b>	<b>Sum</b>
Water	93.07%	1.40%	0.11%	0.01%	5.41%	100.00%
Hillside Woods and Grassplots	1.76%	87.56%	0.03%	0.00%	10.65%	100.00%
Building	0.41%	0.69%	95.16%	0.89%	2.85%	100.00%
Site	1.29%	0.84%	0.98%	94.51%	2.38%	100.00%
Farmland	4.40%	7.06%	0.00%	0.00%	88.55%	100.00%
Other	5.84%	3.95%	0.18%	0.14%	89.90%	100.00%

From 1933 to 1965, the number of water system patches decreased to 31, the water area to 98.23 hm<sup>2</sup> and the water surface ratio to 6.95%. According to the landscape transfer matrix, only 14.56% of the water surfaces was left by 1965, and most of it was converted to farmland or fell into disuse (Table 10). Although these changes were the results of natural factors, including rain or snow erosion and deposition of sandy soils, the main reason was the production activities in the gardens: firstly, some channel segments were levelled up to facilitate traffic, thus damaging the linear water systems (e.g. rivers and canals). Secondly, land was created out of water systems, including lakes, pools and the Sea of Blessing [21].

Table 10  
Landscape transfer matrix from 1933 to around 1965

	Water	Hillside Woods and Grassplots	Building	Site	Farmland	Other	Sum
Water	14.56%	5.11%	0.09%	1.57%	65.35%	13.31%	100.00%
Hillside Woods and Grassplots	1.45%	50.79%	1.06%	4.26%	5.94%	36.49%	100.00%
Building	3.89%	26.87%	4.00%	22.30%	6.32%	36.62%	100.00%
Site	3.15%	31.24%	5.93%	32.98%	2.68%	24.03%	100.00%
Other	3.23%	27.58%	1.17%	5.89%	13.43%	48.70%	100.00%

From 1965 to 2016, the number of water system patches increased by eight, the water surface increased by 77.67 hm<sup>2</sup>, and the water surface ratio was restored to 30.46%. In 2016, only 63.84% of the water surfaces remained, with the most of them converted to hillside woods and grassplots or falling into disuse; 70.46% of the farmland and landscapes were changed to water systems, with the majority of the remainder converted to hillside woods and grassplots. Moreover, hillside woodlands and grassplots replaced 40.34% of the buildings and 43.49% of the sites (Table 11).

Table 11  
Landscape Transfer Matrix from around 1965 to 2016

	Water	Hillside Woods and Grassplot	Building	Site	Farmland	Other	Sum
Water	63.84%	22.61%	2.69%	1.33%	1.94%	7.58%	100.00%
Hillside Woods and Grassplot	3.09%	80.50%	1.94%	5.30%	1.19%	7.98%	100.00%
Building	0.82%	40.34%	25.08%	17.02%	0.06%	16.68%	100.00%
Site	1.58%	43.49%	15.88%	17.86%	0.06%	21.12%	100.00%
Farmland	70.46%	22.85%	0.53%	0.30%	2.36%	3.50%	100.00%
Other	11.18%	60.88%	4.94%	6.21%	0.75%	16.04%	100.00%

## 5.2 Evolution of the water system pattern of the scenic zone

Our study uses the division of all parts of the scenic zone in the 'Panoramic Views of Yuanmingyuan' [5] and the 'Drawings of 108 Sights in the Heyday of Yuanmingyuan' [7] as an auxiliary reference in its judgment of the boundaries of the scenic spots in Yuanmingyuan and division of the 53 waterscapes inside or outside the spots. The water bodies inside a scenic spot constitute its primary waterscapes, including the planar water systems of larger dimensions and the small water bodies of small dimensions inside courtyards; the water bodies outside a scenic spot are the water network that connects or separates the scenic spots.

In the last years of Kang Xi (about 1707–1722), six scenic spots were set off by waterscapes in the three gardens. The number increased to 28 by the 9th year of Qian Long (1744) and to 53 in the 10th Year of Xian Feng (1860) with the incorporation of Changchun Garden and Qichun Garden, except that the oval water pool in the 'Nature Scenery' scenic spot was levelled up. From the 10th Year of Xian Feng (1860) to 1933, the number of the scenic spots remained unchanged despite the minor change in the area of their water systems. From 1933 to 1965, waterscapes completely disappeared in 30, were partially levelled up in 11 and enlarged in 9 scenic spots. From 1965 to 2016, the water system was restored in 13 scenic spots and remained to be restored in 21 (Table 12).

Table 12

Changes of internal water system area of each scenic spot in Yuanmingyuan from the end of Kangxi(about 1707-1722) to 2016 ( )

scenic name	in the Last Years of Kang Xi(about 1707-1722)	in the 9th Year of Qian Long(1744)	in the 10th Year of Xian Feng( 1860)	in 1933	In 1965	In 2016
Open to the Public	6611	5249	5249	6364	---	6220
Nature Scenery	2857	2349	---	---	---	4348
Simple Life and Peaceful Surroundings	7949	8397	8397	7896	---	7377
back lake	40278	38883	38883	40490	30565	40887
The Spring Beauty of Wu-Ling	2653	10964	10964	10857	---	9735
Be-Frank and Open	1123	2648	2648	2648	2286	2335
Great Kindness and Eternal Blessing	---	2065	2065	1924	3783	---
Living in Cloud under the Moon	---	2739	2739	2459	---	---
Wine-shop in an Apricot Flower Village	---	1531	1531	1531	845	1592
Clear Water and Rustling Tress	---	2074	2074	2074	---	---
Reflection of Water on Bridge and the Roaring of Waterfall	---	5920	7685	7152	---	7424
front lake	---	6617	6617	7812	8223	8662
Purple-Blue Mountain House	---	1249	1249	1249	---	---
Huifangshuyuan	---	18873	18873	17872	---	---
Lian-xi's Wonderful Place for Study	---	15382	15382	14890	---	15889
Wanfang anhe	---	12303	12303	12719	---	12777

scenic name	in the Last Years of Kang Xi(about 1707-1722)	in the 9th Year of Qian Long(1744)	in the 10th Year of Xian Feng( 1860)	in 1933	In 1965	In 2016
Ever-spring Fairy House	---	4723	4723	2734	5657	4914
In Depths of a Cave	---	3116	3116	2657	3375	---
Winery Yard and Lotus Pool	---	22268	22268	17537	---	18153
The Far-Northern Mountain Village	---	2769	2769	2611	---	---
Fish Leaping and Bird Flying	---	3221	3221	3592	---	---
The pavilion in Sail Shape	---	10725	10725	9170	---	---
Tianyukongming	---	11020	11020	10127	---	---
A Studio for Four Season	---	10791	10791	8796	---	6665
A Wonderland on Fang-hu Island	---	18661	18661	18859	---	19060
Cottage with Beautiful View	---	3645	3645	4171	5101	3588
Fuhai	---	274351	274351	275270	---	269284
A Place of Unique Beauty	---	3202	3202	3202	---	2751
Seaweed Garden	---	---	953	589	---	---
Wenyuange	---	---	665	999	---	---
High Mountain and Long River	---	---	4047	5283	---	---
Wan Flower Maze	---	---	3025	3025	3146	3445
Amusement Palace	---	---	3163	2786	3551	2397
Square Guan	---	---	968	968	1990	977
Xianfa Mountain	---	---	6560	6994	---	7665
Changchunyuan Lake	---	---	280927	283099	---	269096

scenic name	in the Last Years of Kang Xi (about 1707–1722)	in the 9th Year of Qian Long (1744)	in the 10th Year of Xian Feng (1860)	in 1933	In 1965	In 2016
Ruyuan	---	---	2270	2270	---	---
Qianyuan	---	---	434	434	---	---
Jianyuan	---	---	1009	1009	---	---
Chunyushanfang	---	---	7124	6734	5344	---
Songfengluoyue	---	---	35918	35851	31749	35301
Fenglinzhou	---	---	52071	50680	40302	46194
Xinjingxuan	---	---	7489	6954	---	---
Jianbiting	---	---	23620	30737	---	27007
Chunze Studio	---	---	1589	1589	1602	1490
Shengdongshi	---	---	2634	2634	---	2742
Zhanqingxuan	---	---	33101	33003	27791	26370
Chenxingtang	---	---	21873	21770	18773	15663
Qingxiazhai	---	---	1129	1129	1388	---
Yanyinglundao	---	---	3266	3423	2688	---
Hanhuilou	---	---	22679	22547	21275	---
Lumanxuan and Changhetang	---	---	11683	19097	13119	7205
Zhengjue Temple	---	---	1706	1751	1870	1917

The external water systems connecting the scenic spots reached their peak in the 10th Year of Xian Feng, showing that a complete water system pattern had taken shape by then. Since then, the area of the connecting water systems continuously decreased until it was less than 1/5 of the heyday area by around 1965. The riverways started to be restored after the establishment of the Yuanmingyuan Administrative Department. By 2016, the external riverways outside the Yuanmingyuan scenic zone had been restored to 65.84% of what they were in its heyday, with 6.11 hm<sup>2</sup> remaining to be restored (Table 13).

Table 13

Changes in the area of external water systems in the Yuanmingyuan Scenic Area from the end of Kangxi(about 1707–1722) to 2016( )

scenic name	in the Last Years of Kang Xi(about 1707–1722)	in the 9th Year of Qian Long(1744)	in the 10th Year of Xian Feng(1860)	in 1933	In 1965	In 2016
Yuanmingyuan	31705	139243	141781	140470	20413	107567
Changchunyuan	---	---	10656	10340	---	1213
Qichunyuan	---		24748	25662	13786	7246

## 6. Discussions

### 6.1 Accuracy of the newly plotted drawings in need of further explorations

Firstly, in this work, the water system pattern of Yuanmingyuan in its initial construction period (i.e. the years of Kang Xi(about 1707–1722)) was completed according to the ‘Inferred Construction Plan of Yuanmingyuan in the Period of Prince Yin Zhen’, which was inferred by He Yan [1] on the basis of the ‘12 Poems about Garden Sceneries’ created by Yin Zhen. Further research is needed to determine whether or not this pattern accurately reflected the water system pattern in the historical period.

Secondly, the ‘Map of Measured Relics of Yuanmingyuan, Changchun Garden and Qichun Garden’ drawn by Beijing Works Bureau in 1933, the ‘Relief Map of Areas Near Haidian District, Beijing’ of 1965 and the ‘Archaeological Survey Map of Yuanmingyuan’ of 2016 are all the measured drawings completed with modern surveying and mapping technology. Accordingly, these maps reflect relatively complete and accurate information about surface features. However, collections ‘No. 1704 Yuanmingyuan Site Map’ and ‘Riverway Map of Yuanmingyuan, Changchun Garden and Qichun Garden’ of the Beijing Palace Museum before 1933 are maps that were plotted using the style of Chinese landscape paintings. These maps are relatively unclear in depicting the details of the sceneries and have caused difficulty in the digitalisation of historical maps. This condition will cause certain errors in precision, thereby affecting the results of the subsequent analysis. Therefore, the studies of the historical pattern of Yuanmingyuan contained herein can only be deemed as initial achievements.

#### *6.2 Insufficiency of drawings and literature caused ambiguities in the water system pattern in important historical periods*

In the 19th year of Jia Qing (1814), the three gardens, including Yuanmingyuan, reached their peak, and the pattern of their water systems was the most complete at that time. However, in the 70 year period from ‘No. 1704 Yuanmingyuan Site Map’ in the 44th year of Qian Long (1779) to the ‘Riverway Map of Yuanmingyuan, Changchun Garden and Qichun Garden’ in the 10th year of Xian Feng (1860), landscape drawings can be found only in a certain year for some scenic spots in Yuanmingyuan. At present, no

drawings and literature can depict the panorama of the three gardens or verify the pattern of the Yuanmingyuan water systems in their most full state. The study should be broadened in the future.

## 7. Conclusions

The water systems in Yuanmingyuan have evolved over more than 300 years, including the preliminary creation in the initial construction period of the imperial garden, the continuous improvement in its heyday, the man-made destruction in the ruins period and the repair in the contemporary development period. Our study expounds the evolution characteristics of the water system pattern in important historical periods by using quantitative data and has arrived at the following conclusions:

With the large-scale expansion from Kang Xi's last years to Xian Feng's decade(1860), the area of the water systems increased from 9.27 hm<sup>2</sup> to 123.26 hm<sup>2</sup>, but decreased to 24.38 hm<sup>2</sup> around 1965 due to continual destruction. Then, the area returned to 102.05 hm<sup>2</sup> in 2016, which is equivalent to 82.79% of the area in its heyday, as a result of water system repairs undertaken following the establishment of Yuanmingyuan Administrative Department.

In terms of the water surface ratio, the index was only 19.03% in the initial construction period of Yuanmingyuan and reached 35.15% during the heyday of the three gardens, including Yuanmingyuan. Accordingly, these gardens became a large-scale waterscape resort. Around 1965, a substantial portion of the waterscapes was converted to farmland, reducing the water surface ratio to 6.95%. The renovation of the hills and water systems in Yuanmingyuan began in 1976. By 2016, the ratio has recovered to 30.46%, leaving approximately 5% potential for full recovery.

The increased number of scenic spots in Yuanmingyuan resulted in a large number of linear and planar water patches, which substantially increased from the Kang Xi's last years(about 1707–1722) to the 10th Year of Xian Feng (1860) until it reached 59 in the heyday. Around 1965, the linear water systems (e.g. rivers and canals) were levelled up, while the planar water systems (e.g. lakes, pools and the Sea of Blessing) were converted to farmland, reducing the number of patches to 28. Then, after a 40 year recovery, the number of patches reached 36 by 2016, although it was still 23 less than the number in the heyday.

Meanwhile, the number of scenic spots set off by waterscapes increased from 6 in the Kang Xi's last years(about 1707–1722) to 52 in the 10th Year of Xian Feng(1860). Around 1965, the number of waterscapes drastically declined, including 30 completely disappearing and 11 partially levelling up, with only 9 experiencing an increase in the water area. After the Yuanmingyuan Administrative Department was established, 13 scenic spots of waterscapes were restored, with 21 yet to be restored in the scenic spots in the north of Yuanmingyuan, including approximately 2.67 hm<sup>2</sup> in the 'Purple-Blue Mountain House', 'Fish Leaping & Bird Flying', 'Far Northern Mountain Village', 'Ruofan Zhige' and 'Tianyu Kongming'; about 0.37 hm<sup>2</sup> in Ruyuan, Qianyuan and Jianyuan of Changchun Garden; the riverway in an east–west extension in Xiyanglou scenic spot; and 4.17 hm<sup>2</sup> in 'Xinjingxuan', 'Spring Rain Mountain House', 'Yanying Lundao', 'Hanhuilou' and 'Qingxiazhai' of Qichun Garden.

## Notes:

.This article is to be read at the “2021 International Academic Seminar on the Research and Protection of Yuanmingyuan”.

.Before plotting the map in the last years of Kang Xi(about 1707–1722), the inferred plan for the architectural layout of Yuanmingyuan in the period of Prince Yin Zhen and the water system pattern map in the 9th year of Qian Long(1744) were compared for geographical matching to extract and find landscape elements.

.The designers in the Style House of the Qing Court corrected the drawings of previous dynasties or covered the corresponding positions of the original drawings with reconstruction plans of equal proportion and scale to reduce drawing-plotting workload. Therefore, the resulting drawings record all the major changes that occurred in Yuanmingyuan from the 44th year of Qian Long(1779) to the 11th year of Dao Guang(1831).

.The local landscape drawings of Yuanmingyuan in the period from the 19th year to the early years of Xian Feng describe individual scenic zones only and cover sporadic years until the last years of Xiang Feng, when the “Riverway Map of Yuanmingyuan, Changchun Garden and Qichun Garden” clearly describes the complete pattern of the three gardens.

## Declarations

**Author Contributions:** X.X is responsible for project conceptualization; X.X and S.Z is responsible for methodology; S.Z is responsible for software and he completed the writing of the original manuscript; X.X and S.L have been reviewed and edited the writing of the manuscript; X.X. and S.H. is responsible for validation and supervision. All authors have read and agreed to the published version of the manuscript.

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**Conflicts of Interest:** The authors declare no conflict of interest.

**Availability of data and materials:** Data are available via request [xixuesong@cau.edu.cn](mailto:xixuesong@cau.edu.cn)

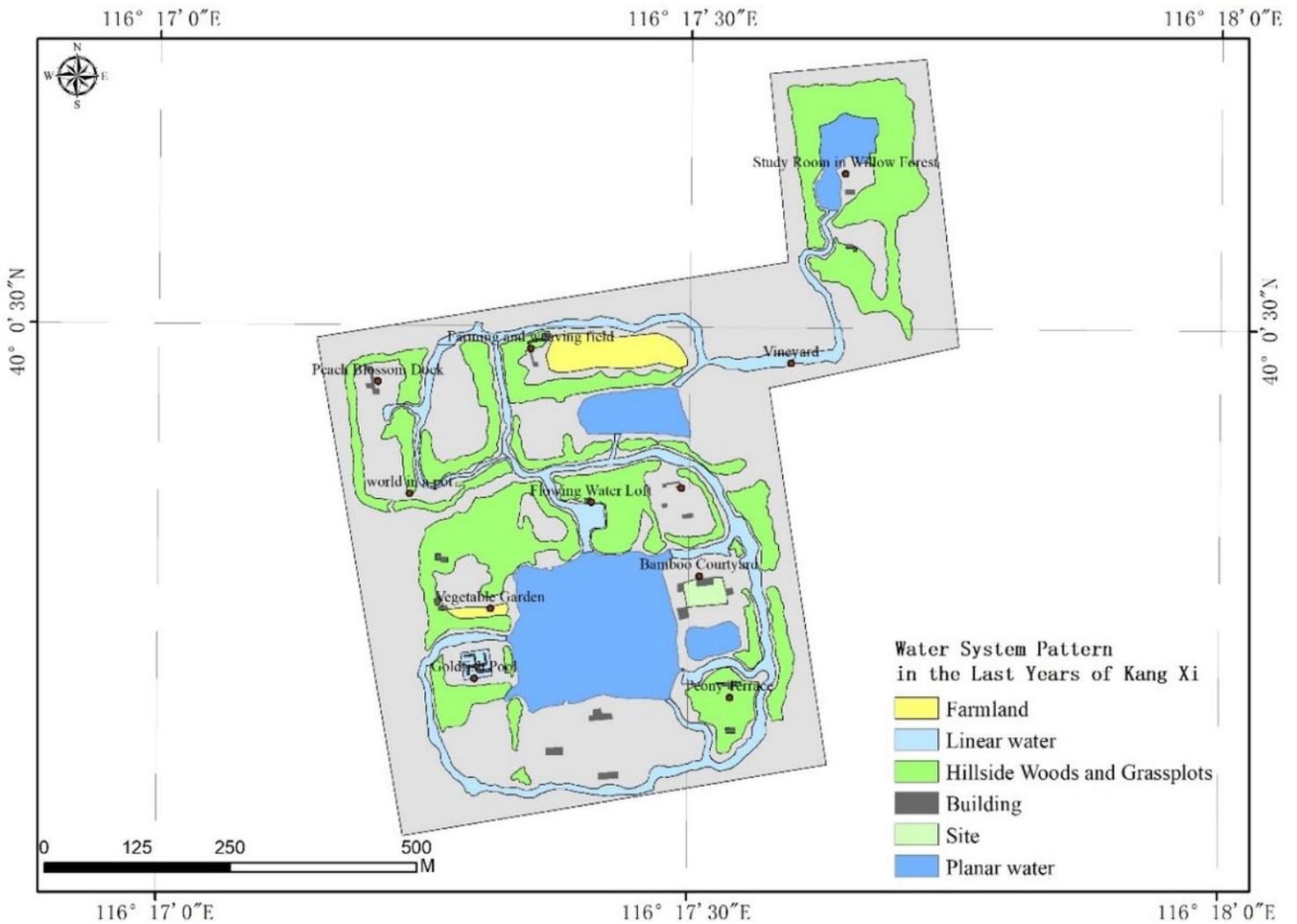
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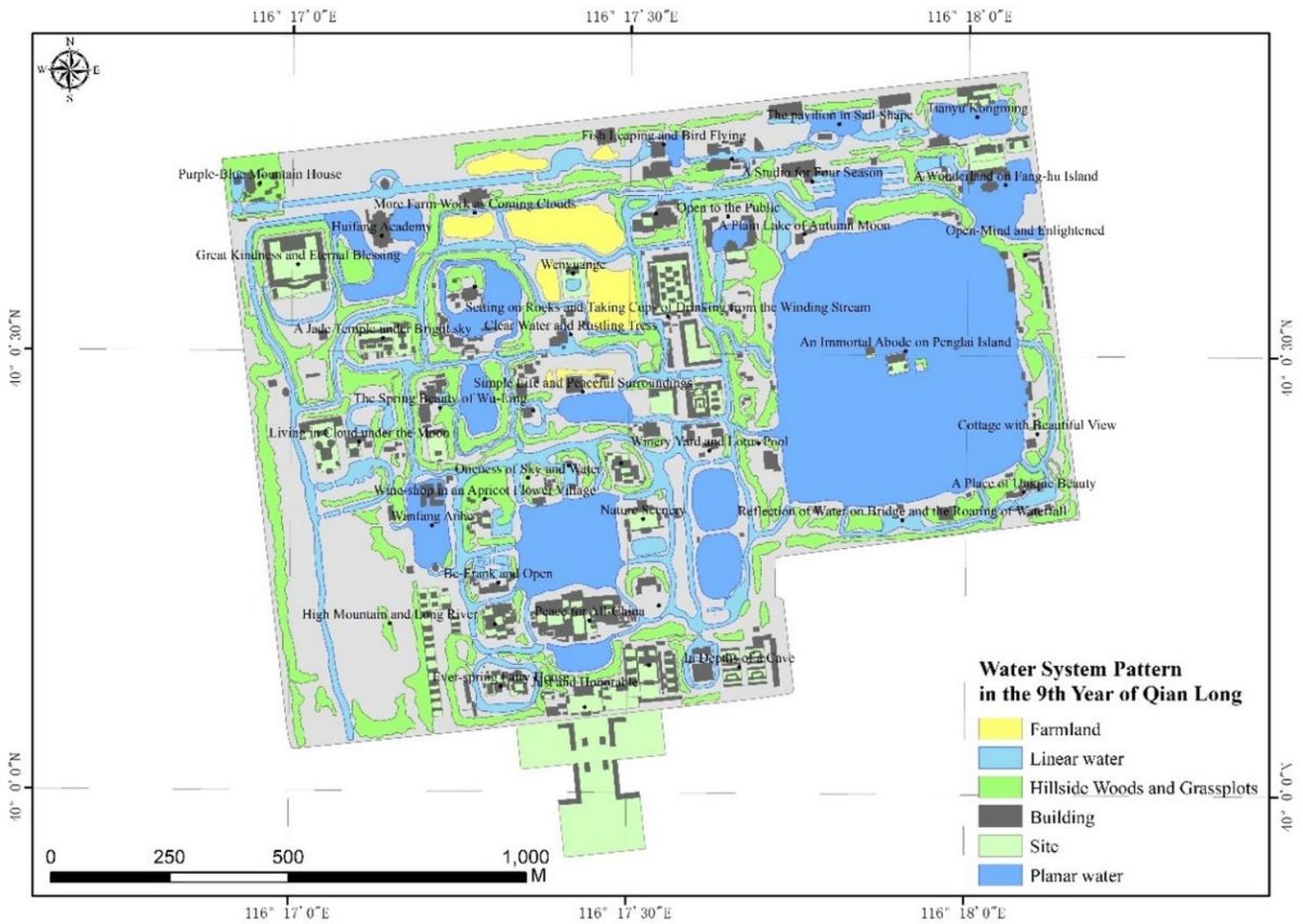
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## Figures



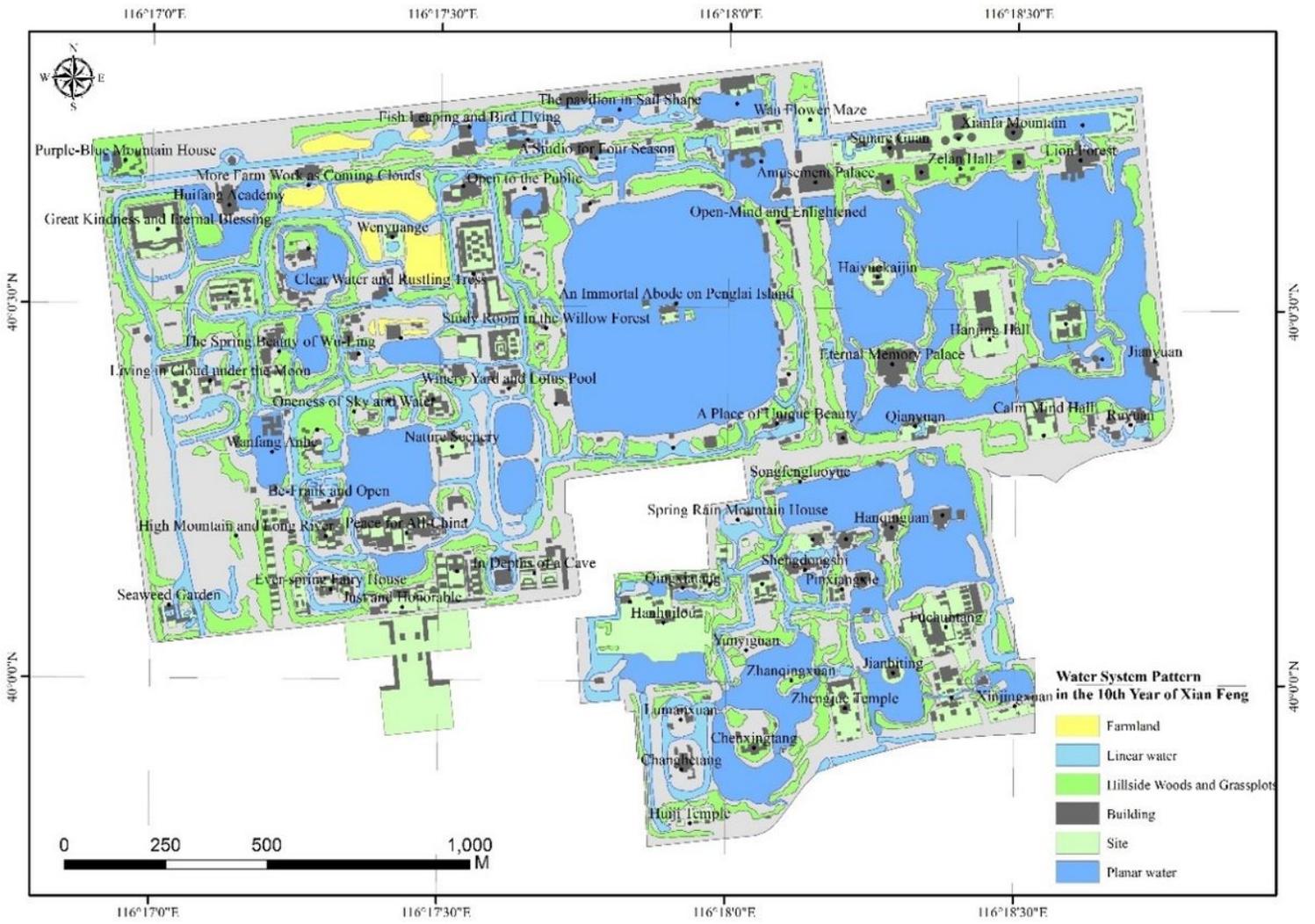
**Figure 1**

Water System Pattern in the Last Years of Kang Xi(about 1707-1722)



**Figure 2**

Water System Pattern of Yuanmingyuan in the 9th Year of Qian Long(1744)



**Figure 3**

Water System Pattern of Yuanmingyuan in the 10th Year of Xian Feng(1860)



Figure 4

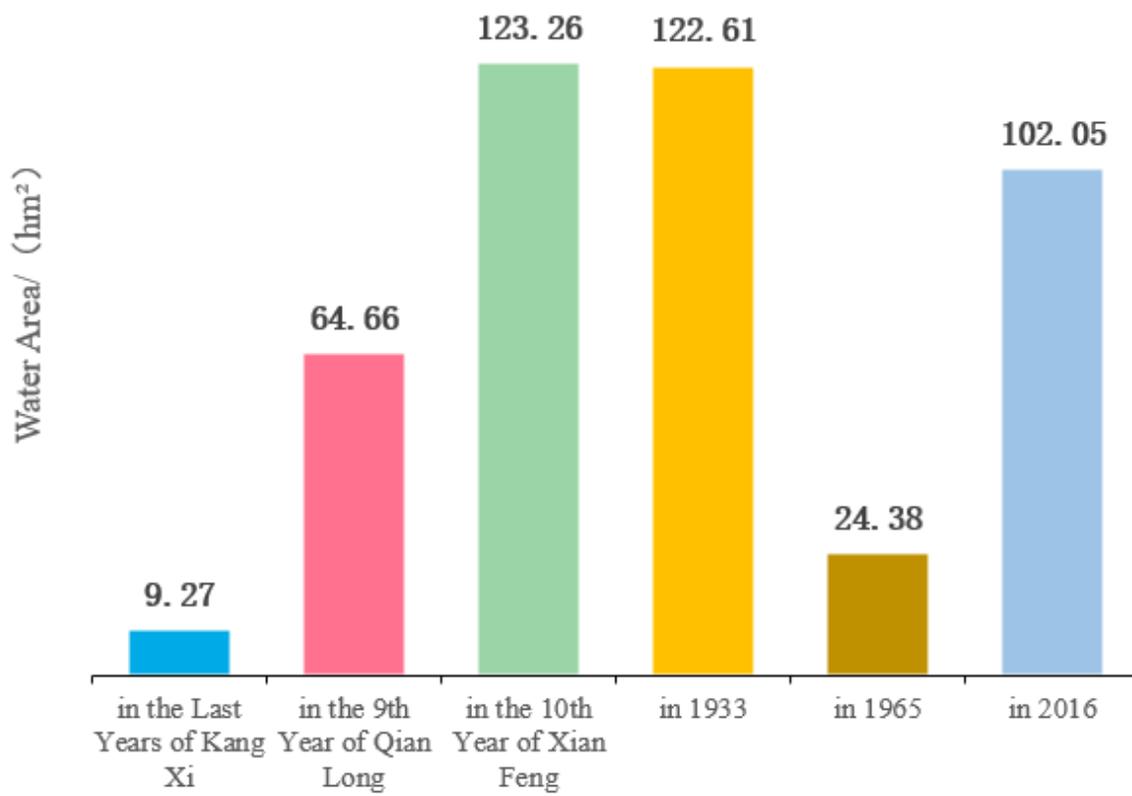
Water System Pattern of Yuanmingyuan in 1933



**Figure 5**

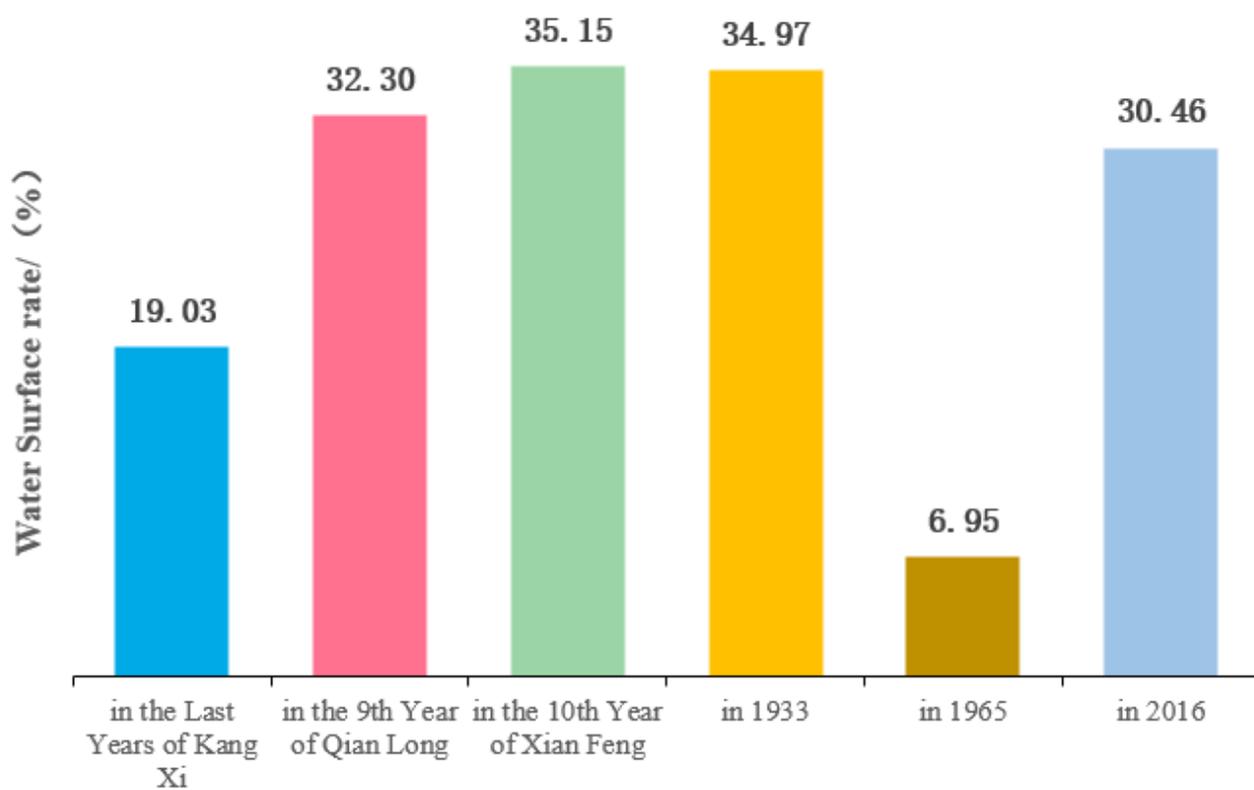
Water System Pattern of Yuanmingyuan Around 1965





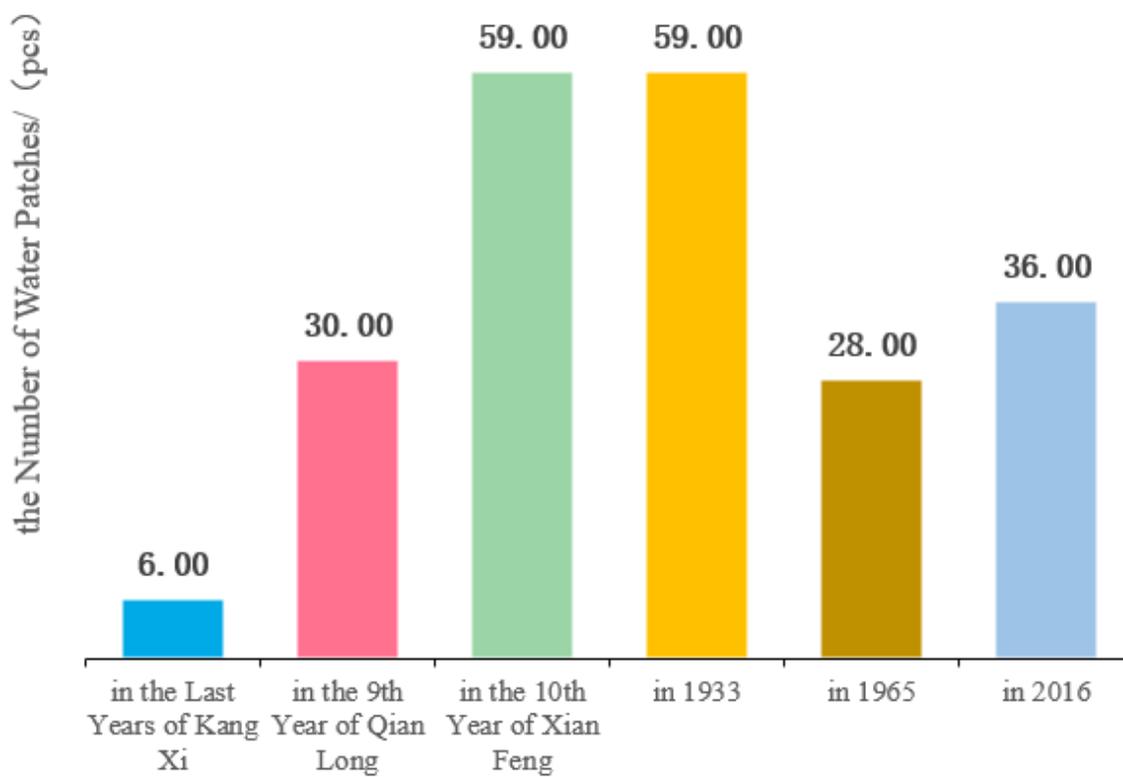
**Figure 7**

Chart of Changes in the Water System Area of Yuanmingyuan



**Figure 8**

Changes in the Water Surface Ratio of Yuanmingyuan



**Figure 9**

Changes in the Number of Water Patches of Yuanmingyuan

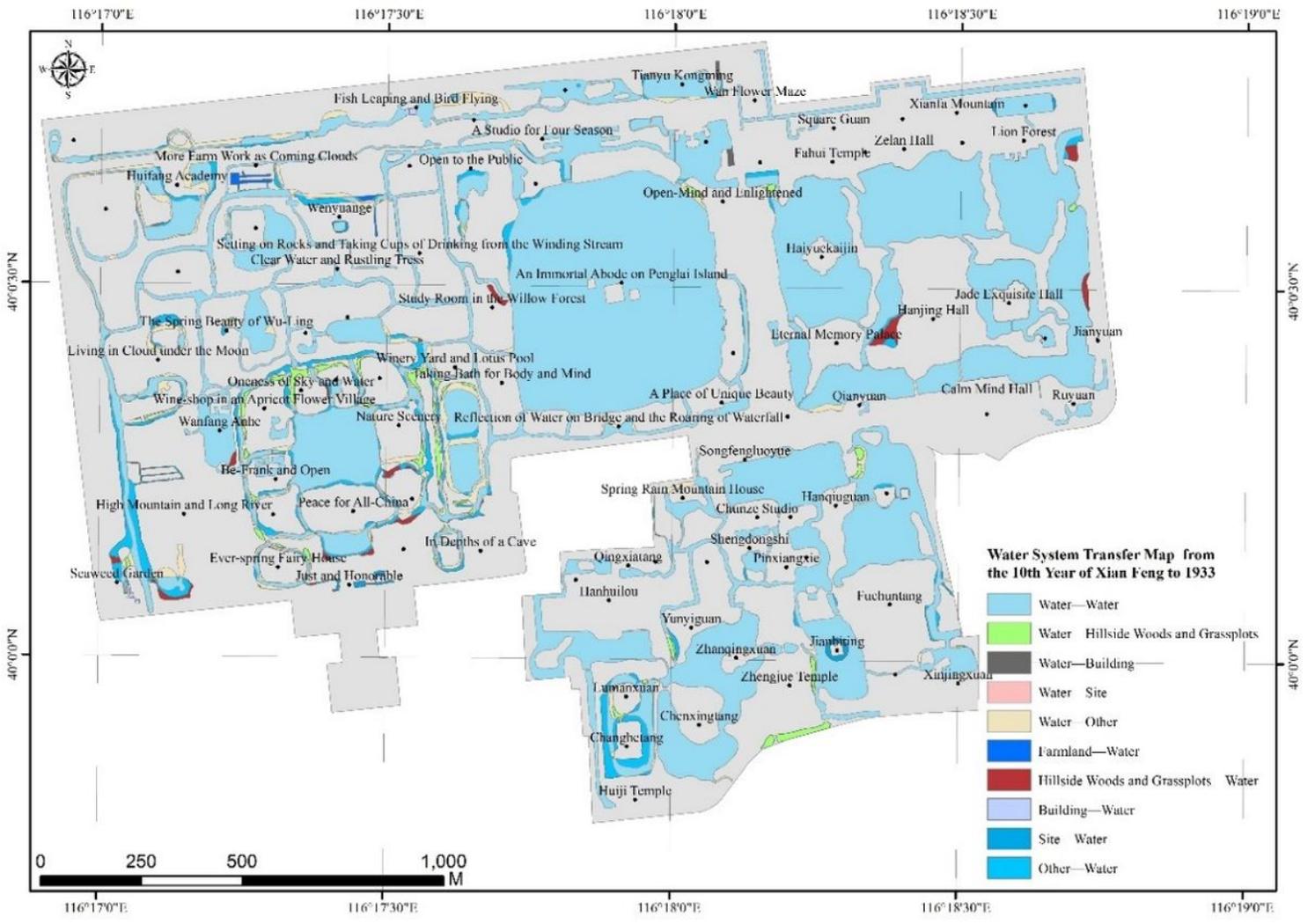
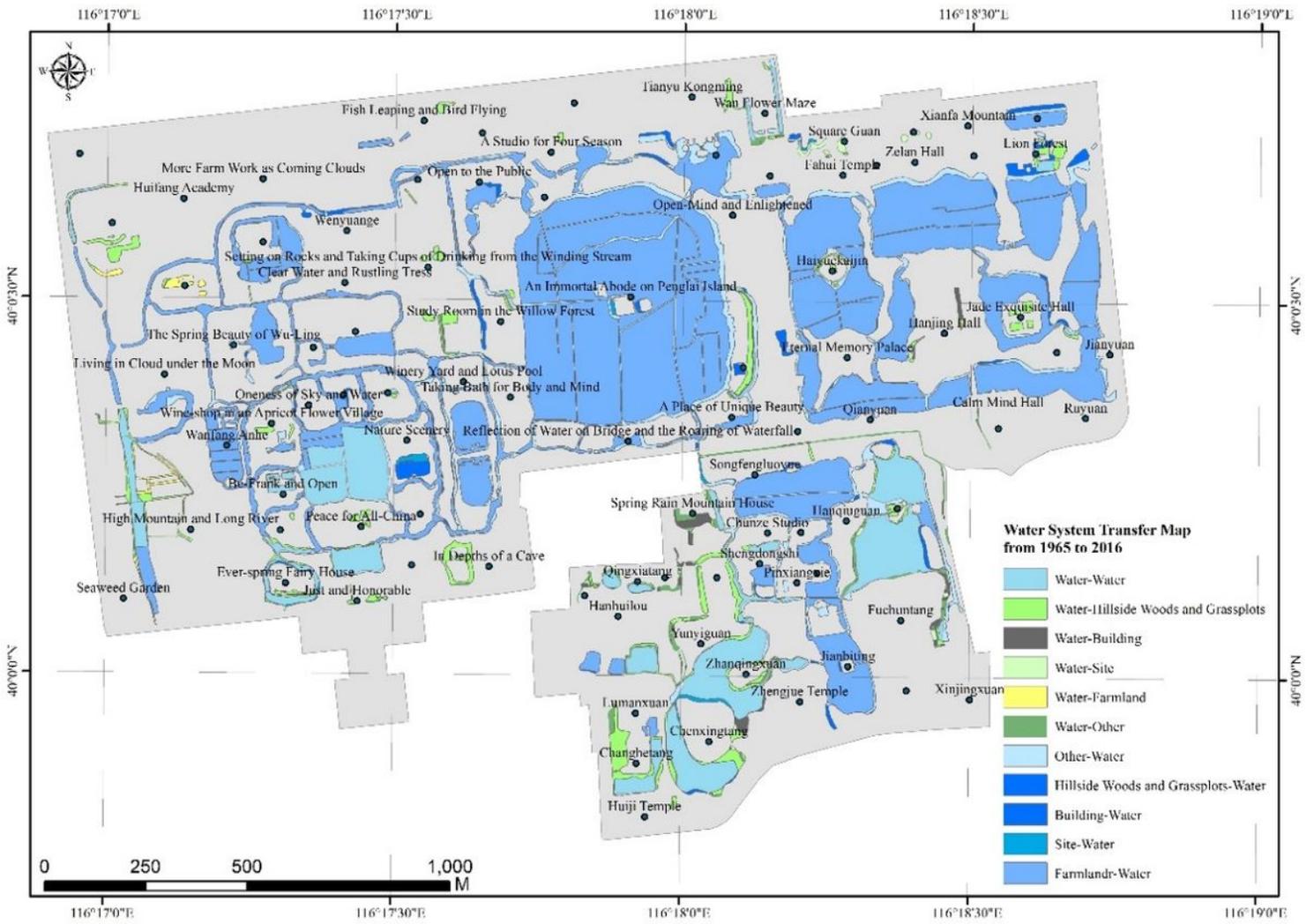


Figure 10

Water System Transfer Map of Yuanmingyuan from Last Years of Xian Feng(1860) to 1933





**Figure 12**

Water System Transfer Map of Yuanmingyuan from 1965 to 2016