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RESEARCH ARTICLE

From natural environment to artificial system: Chang'an and its water system in the Western Han Dynasty

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Symbolic image

Abstract People around the world have shaped societies and urban spaces around water for millennia. They have transformed natural water structures and patterns to serve their diverse needs. The ways in which historical decisions affect contemporary water systems and influence future planning of urban systems still need to be fully recognized. This paper explores the multiple roles of water systems in Chang'an during the Western Han Dynasty. Chang'an, one of the ancient names for the city of Xi'an, was a typical capital city of China and East Asia in early ancient times. This study explores everyday practices pertaining to water as well as its role in defense, gardening, politics and culture.

Drawing upon three historical theories, this study presents findings that water was embedded in the design of traditional Chinese capitals. The siting and construction of capital cities was first based on the *Theory of Choosing the Center* (3rd century BCE) and the *Theory of Conforming to Nature* (5th–3rd century BCE). However, the final maturation of this urban morphology, including the water system, was closely related to the *Theory of Symbolizing and Modeling Heaven and Earth* (4th–3rd century BCE), in a way that manifested the imperial power's organization and control of space and time.

Through close analysis of historical documents, archaeological reports and modern investigations, the paper aims to clarify, analyze and summarize the historical context and evolution, functional and structural characteristics, as well as the economic, political, cultural and military connotations of water systems in Chang'an. It argues that the coordination of urban construction and the water environment was a key foundation for capital city development. It proposes that people shaped urban water supply in many ways, including daily life, waterway transportation, agricultural irrigation, aquaculture promotion, military defense and fire prevention.

The water system in Chang'an also provided an important place for royalty and nobility to go fishing, to hunt and to engage in leisure and naval training. The landscape with this water

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system as the core, including Taiye Lake and Kunming Lake, had also inspired Chinese gardening history, and had a profound impact on future generations. More importantly, the capital's urban morphology design was a miniature of the world recognized by the monarch, as well as the symbolic image of the supreme rulers' political and cultural desire to control and possess *Tianxia*, which essentially means the whole world. In conclusion, the paper calls for a closer study of water-based design as a foundation for urban planning.

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1. Introduction: The water system as the foundation of capital city planning for Xi'an

In ancient China the planning and construction of cities, particularly capital cities, was based on a range of spatial principles that usually expressed cultural practices and natural concepts, including a comprehensive consideration of water in all its forms. Beginning in the 5th century BCE, three theories were crucial to the siting and design of China's capital cities, including national and regional capitals: (1) The *Theory of Choosing the Center*, which posits the selection of the geometric center of a plain area or the entire country as the site for the capital and emphasizes people's will in urban planning; (2) The *Theory of Conforming to Nature* argues that the city has to adapt to and take advantage of its natural environment, especially the physical features of mountains and rivers; (3) The *Theory of Symbolizing and Modeling Heaven and Earth* explains the necessity of simulating the symbolic and typical astronomical phenomena and characteristics of the natural environment in urban morphology design, such as the structures of constellations and the galaxy, the movement tracks of important stars, the position of mountain peaks, and the flow of rivers. Each of the three theories has its own focus and they complement one other. Each theory includes water-based planning concepts.

One example of capital city planning according to these principles is the historic city of Xi'an in central China. Between the 2nd century BCE and 9th century CE, Xi'an was the starting point of the Land-based Silk Road connecting Europe with Asia (Liu, 2018). It was the capital city of thirteen dynasties, among them the Zhou (1046–771 BCE), Qin (770–207 BCE), Han (202 BCE–8 CE) and Tang (618–907 CE) dynasties were the most prosperous periods in Chinese history. Under the rulers of different periods, the city's name changed: It was called Fengjing and Haojing in the Zhou Dynasty, Xianyang in the Qin Dynasty, and Chang'an in the Han and Tang dynasties.

In line with the *Theory of Choosing the Center*, the Xi'an area is located in the geometric center of mainland China. Due to this central location on the inland plains, far from the ocean, rivers played a decisive role in the siting and development of the city. The proper distribution of surface water in the Xi'an area is conducive to agricultural production, not prone to flooding, and can also be used for military defense. These are necessary requirements for large settlements in the early stage of an agricultural society. Thus, the choice of this area as the site of the capital

is in accord with the *Theory of Conforming to Nature*. The final maturation of the city's complex system is, however, closely related to the *Theory of Symbolizing and Modeling Heaven and Earth*, because the urban morphology design is the symbolic image of the supreme rulers' political and cultural desire.

The purpose of this paper is to model the historical analysis of urban planning with a focus on water, using the case of Xi'an. We also aim to introduce planning concepts of early ancient Chinese capital cities and their water systems as a reference for modern urban design. Historical analysis serves as a foundation for future sustainable patterns: the linking of natural and manmade water patterns in urban settings may inspire future landscape design.

This paper highlights the importance of systematic engagement with water in the planning of Xianyang and Chang'an and the surrounding areas in the Qin and Western Han dynasties. The paper shows that a site and the subsequent location of urban functions was carefully selected based on water patterns. Over time, the natural water system was transformed into an artificial network that served a multitude of functions related to the metropolis and landscape.

This paper addresses the following questions: (1) How did the water system embody the *Theory of Symbolizing and Modeling Heaven and Earth*? (2) How was the urban morphology related to the water system? (3) How did the water system contribute to the formation and development of the city in the aspects of economy, politics, culture and defense? (4) How did this system evolve over time?

The paper's research methodology uses historical documents and images, contemporary research and archaeological reports as the basis of an interdisciplinary investigation and comprehensive analysis. The paper analyzes and summarizes the historical context and evolution, functional and structural characteristics by means of diagrammatic pictures; and explores the economic, political and cultural connotations of the water structures in depth.

Research on this topic is challenging for many reasons: (1) The paths of ancient water systems were numerous and complicated. Natural changes have been taking place in geographical terrains and landforms, making it difficult to determine the exact path of streams. (2) Historical documents are incomplete and inaccurate to some extent because mistakes and omissions occurred in their transmission. There are also contradictions between different documents. Therefore, trustworthy information from

almost 2700 years ago is limited. (3) Due to the substantial expansion of modern Xi'an, some ancient ruins have been covered by modern buildings. Thus, archaeological exploration is relatively insufficient. (4) Contemporary research on this topic has been conducted by scholars from a variety of disciplinary backgrounds; they include archaeologists, historical archivists, and humanities scholars. Nevertheless, scholars of architecture and urban planning have paid particular attention to the city walls, palaces and mausoleums of Chang'an (Li, 1997; Yang, 1984; Liu, 1987), as these features hold a prominent status in Chinese urban history. The absence of a comprehensive investigation of water-related planning of Chang'an makes this research necessary.

2. Historical framework before the Han Dynasty: comply and coordinate with natural water environment

Located in the Chinese central plains, the terrain of Xi'an is high in the southeast and low in the northwest. Hundreds of rivers and streams, large and small, form a dense water network in this region. With a short length, most of the rivers are secondary tributaries of the Yellow River, the sixth-longest river in the world. After originating from the Qinling Mountain, the geographical north-south boundary of China, these rivers mostly flow northwestward into the Wei River. The Wei River flows eastward into the Yellow River, and finally into the East China Sea.

2.1. Foundation for the earliest capitals: Fengjing and Haojing, with the Feng River and the Hao River

The symbolic location in the center of the country paired with the availability of fresh water made the initial development of the capital possible. The earliest establishment of ancient capital cities in the Xi'an area can be traced back to the cities of Fengjing and Haojing. These two cities mainly depended on the Feng River and the Hao River, important tributaries of the Wei River.

When Zhou was just a local vassal state of the Shang Dynasty (1600–1046 BCE), King Wen of Zhou (1152–1056 BCE) established Fengjing between the west bank of the Feng River and the east bank of the Lingzhao River (Hu, 1963). Fengjing was built as a military base to defeat Shang and it's likely that there was no city wall (Fu, 2019). Instead, artificial waterways were built to connect the two rivers so that the capital was surrounded by a protective barrier of water (Fu et al., 2018). Because Fengjing offered little space for expansion, King Wu of Zhou (?–1043 BCE), son of King Wen, who unified the entire country and established the Western Zhou Dynasty (1046–771 BCE), built Haojing (Figs. 1 and 2) between the east bank of the Feng River and the west bank of the Hao River. He also intercepted the Hao River to make Hao Lake. The lake was not only an indispensable water source for Haojing, but also a place for nobles to fish, hunt and seek amusement. These activities did not change the natural course of the rivers. From that point on (11th century BCE), the two cities stood side by side, as the only twin capitals in Chinese history

(Tang, 2020). Fengjing was mainly used for ceremony and sacrifice, while Haojing was mainly used for legislation and administration (Lu, 1988). It was a remarkable feature in this period that capitals tended to make use of rivers and mountains as natural barriers rather than building city walls (Xu, 2013).

In 771 BCE, the vassal state Quanrong invaded the capital and killed King You of Zhou (795–771 BCE). Fengjing and Haojing were sacked and destroyed in the war. Fortunately, the natural water system was not damaged. In the next year, King Ping of Zhou (?–720 BCE) moved the capital to Luoyi and established the Eastern Zhou Dynasty (770–256 BCE). Fengjing and Haojing were abandoned, but they became the civilization foundation of modern Xi'an. The names of Fengjing and Haojing came from the Feng River and the Hao River respectively. Modern Xi'an still uses Hao as its abbreviation. Although the Hao River no longer supplies water for the modern city, its influence on urban culture has lasted for more than 3000 years.

2.2. The landscape axis at the capital's center of the first empire: Xianyang and the Wei River

In 350 BCE, the vassal state Qin of the Eastern Zhou Dynasty established Xianyang as its capital city on the north bank of the Wei River. In the traditional *Chinese Fengshui Theory of Yin and Yang*, which originated from *Zhouyi*,¹ the south of a mountain or the north of a river can be called *Yang*, which is the preferable choice for making settlements. This new capital was located to the south of the Jiuxiao Mountain and the north of the Wei River. So it was named Xianyang, which meant double *Yang*.

In 256 BCE, Qin defeated the Eastern Zhou Empire. In 221 BCE, Qin unified other vassal states and established the Qin Dynasty (221–207 BCE). At that point, China became a centralized unified empire for the first time.² During the process of unifying the whole country (230–221 BCE), each time Qin defeated a vassal state, its leaders would imitate the architecture of that country to design its own royal palaces. As a result, the Palaces of Six States with various architectural styles were built on the north bank of the Wei River in Xianyang.

After the completion of reunification, new palaces were built on the south bank of the Wei River (221–210 BCE). Therefore, the Wei River in this period acted as a landscape axis in the city center (Figs. 3 and 4), with a large number of palaces densely distributed on its both sides. However, this landscape feature did not survive over the centuries. After reunification, the broad area surrounding the capital became an exclusive zone for the royalty, known as Shanglin Royal Zone.

Although Xianyang was close to the Wei River, which was convenient for water intake and navigation, the north bank had more sediment and fewer tributaries, which meant

¹ *Zhouyi* is a book created by King Wen of Zhou to interpret the internal characteristics and laws of nature, the theoretical root of Chinese traditional philosophy.

² Beginning at this time, the title of emperor was given to the supreme ruler of the Chinese empire, while the title of king signified the ruler of affiliated countries within the empire.

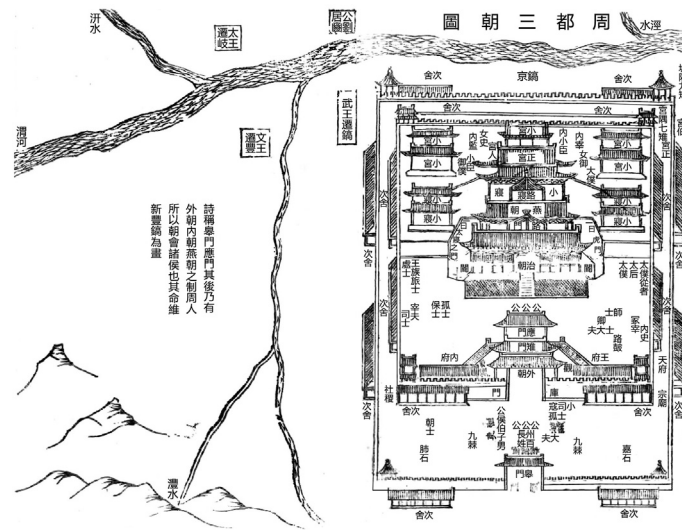


Fig. 1 The lay out of the royal court in Haojing of the Western Zhou Dynasty. Source: Jia and Li, 1667.

that the water supply condition on the south bank was better. The plains on the north bank offered limited land for urban development, which was even further reduced by the northward migration of the Wei River, which eroded the land, making it prone to collapse. Therefore, Xianyang mainly expanded on the south bank during the late Qin Dynasty (Cui, 2009).

It took more than one hundred years (350–210 BCE) for the site selection and construction of Xianyang, including the Pre-Qin and Qin stages. The concept of Xianyang continued to expand, as the spatial form evolved from a city to a broader area (Tang, 2020).

3. The water supply pattern in the Han Dynasty: refining the artificial water system of Chang'an

3.1. Continuity in the early stage and fundamental changes in the midterm

In 207 BCE, the Qin Dynasty perished in the peasant uprising against oppression. Xianyang was seriously damaged, especially the numerous luxurious palaces on both sides of the Wei River. In 202 BCE, the Western Han Dynasty (202 BCE–8 CE) was founded. Since then, Han has become the name of the main ethnic group in China and has been used continuously to this day. The Western Han Dynasty inherited the previous institutional system in terms of politics, the army, economy, culture and more.

The Han Dynasty preserved and renovated the southern part of Xianyang on the south bank of the Wei River; then expanded and renamed it as Chang'an, which meant "eternal peace". In a continuation between dynasties, Chang'an remained the capital of the new empire. In 200 BCE, the modification and reconstruction of Xingle Palace of the Qin Dynasty was completed; and it was renamed Changle Palace

of the Han Dynasty, and its name meant "forever happiness". Meanwhile, Weiyang Palace was constructed, the name of which meant "the empire never ends". The water supply system project in the city started at this time (Fig. 5).

The construction of the Chang'an city wall began in 194 BCE and was completed in 190 BCE. According to archaeological surveys, the city's layout was an irregular square. In order to make use of the Wei River and the Xue River as moats for military defense, the west and north sides of the city walls were constructed in an irregular zigzag form following the natural river courses (Liu, 1996). While the walls on the east and south sides did not face such restrictions, so they were relatively straight. This shows that in the initial stage of the capital construction for the new empire, the natural water system around the capital was not modified greatly; people tended to comply and coordinate with the natural water environment rather than attempting a massive transformation.

It was during the reign of Emperor Wudi (156–87 BCE), the midterm of the Western Han Dynasty, when most large-scale construction projects of Chang'an and its water system occurred. In 138 BCE, Shanglin Royal Zone, including many artificial waterways and lakes, was enlarged and enriched to approximately 2000 km². (Hao, 2015). In 129 BCE, Cao Canal was built for transportation from the eastern part of the empire to the capital. The Kunming Lake system was first built in 120 BCE and expanded in 114 BCE for military and daily uses. In 104 BCE, Jianzhang Palace (Fig. 6), the name of which meant "monarchs' meritorious deeds", with the Taiye Lake system inside of it, was built on the western side of Chang'an. The Kunming Lake - Chang'an City - Jianzhang Palace water supply system fundamentally changed the natural water system pattern (Figs. 7–10). Over a period of one hundred years, Chang'an of the Western Han Dynasty gradually matured (Fig. 10). After Emperor Wudi, the later emperors made few improvements to the water system because it was already well designed and sufficient.

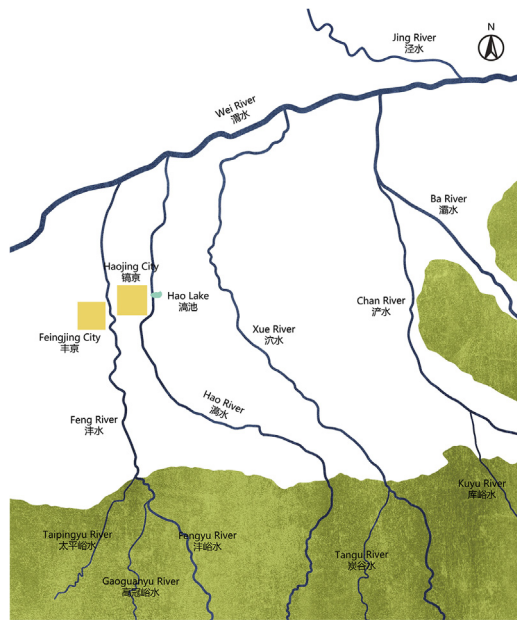


Fig. 2 Haojing, Fengjing and their surrounding water system in the Western Zhou Dynasty. Source: the author.

3.2. An innovative pattern: the general structure of the natural-artificial water system

The source of Chang'an's artificial water system mainly came from the Xue River, the Hao River, the Feng River and the Wei River, but especially from the Xue and Hao. Kunming Lake acted as the supreme reservoir. Under its control were secondary reservoirs: Jieshui Lake, the name of which meant "a reservoir to raise the water level"; and Hechi Lake, the name of which meant "a reservoir to store water from rivers and lakes". Cang Lake, Taiye Lake and other water bodies formed tertiary reservoirs. Water was supplied through numerous crisscross channels that ran through palaces, gardens and residential houses like veins (Figs. 7–10). It should be noted that the surface water system was not the sole water source of the city. According to archaeological surveys, many wells were dug in the city to collect groundwater.

In the Western Han Dynasty, Chang'an created an innovative pattern of water system utilization: the Wei River was used to drain rainwater and sewage, its south bank tributaries were used as water sources, and Cao Canal was used for transportation (Cui, 2009). Although the location of the city constantly changed in the Xi'an area, this pattern has been followed by later generations to this day. However, in the Qin Dynasty, the construction and operation of Xianyang mainly depended on the Wei River, which also acted as a landscape river, while most of the tributaries on the river's south bank were rarely utilized. We thus see great differences between the Qin Dynasty and the Han Dynasty in the utilization mode of the natural water system. The main reason for this change was that the Wei River's water quality had deteriorated after many years of human activities, so people had to use upstream tributaries

as a water source. It shows that protecting the natural environment, especially water resources, was essential for maintaining a city's stability and resiliency.

3.3. Supreme reservoir: Kunming Lake in Shanglin Royal Zone

The water of Kunming Lake flowed from the Hao River, on the lake's south side. The lake discharged water to the other three directions: (1) To the west, water flowed into the Feng River. (2) To the east, part of the water flowed into Hechi Lake and the rest flowed northeast along a channel into Cao Canal on the east side of Chang'an city. This channel was called Kunming Old Canal and considered a branch of Cao Canal. (3) To the north, part of the water flowed into adjacent Hao Lake that was founded in the Western Zhou Dynasty, and then into Biao Lake, and then into the Wei River. The rest flowed northward into Jieshui Lake and became a supplementary water source for Cao Canal. This structure showed that the artificial water system newly constructed in the Western Han Dynasty included and integrated the existing artificial system (Figs. 8–10).

According to an archaeological report from 2005, Kunming Lake covered an area of about 4.25 km from east to west, 5.69 km from north to south, and had a circumference of 17.6 km and an area of 16.6 km². Besides, there were four highlands in the lake, which should be islands (Liu, Zhang, 2006).

3.4. A water system in the royal courts, with symbolism: Cang Lake, Jiu Lake and Taiye Lake

The water system inside Chang'an city took Cang Lake and Jiu Lake as the center. The name of Cang Lake meant "dark blue", for its clear water. It was located in the southwestern part of Weiyang Palace. There were High-platform Buildings on the island in the lake. Apart from serving gardening purposes, the lake's major function was to regulate and store water from Kunming Lake and Jieshui Lake, so as to supply water to all the palaces in the city. Archaeological surveys show that Cang Lake was about 500 m from north to south and 400 m from east to west, with a total area of 0.196 km² (Li, 1995).

Jiu Lake meant "a lake of wine", and it was in the northeastern part of Changle Palace. This lake had much more political significance than practical function. Emperor Wudi ordered to construct the High-platform Buildings on the lake's north bank and to plant trees on the island in the lake where meat roasts took place. Jiu Lake was one of places for emperors to feast and entertain diplomatic missions from affiliated and foreign countries. In ceremonies, monarchs conveyed the political idea that the empire's regime had no boundary and the world was one family.

The water system in Jianzhang Palace that outside the city was mainly composed of Taiye Lake, Tangzhong Lake and Lin Lake. Taiye Lake, the name of which meant "expansive water area", was located in the northern part of the palace. Tangzhong Lake and Lin Lake were located to

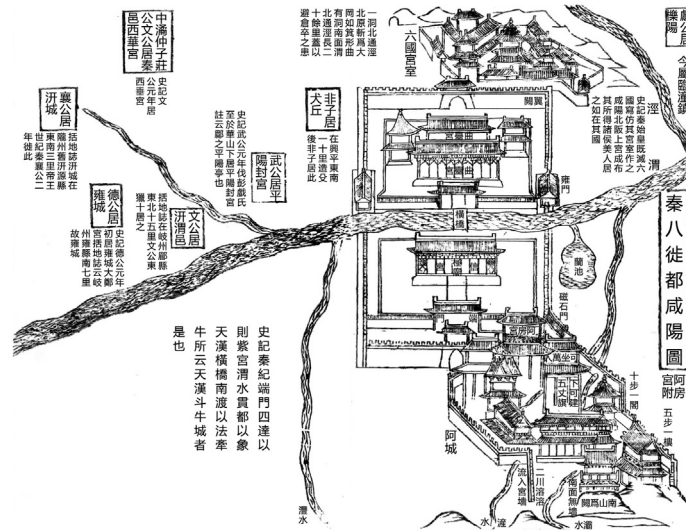


Fig. 3 The lay out of the royal court and its surrounding water system in Xianyang, in the Qin Dynasty. Source: Jia and Li, 1667.

the south and west of Taiye Lake respectively (Yan, 2011). Archaeological surveys show that Taiye Lake was about 450 m from north to south and 510 m from east to west, with a total area of 0.152 km² (Hou, 2020). In addition to luxurious buildings along the lakeside, there were also a large number of metal and stone statues of whales, dragons, rare birds and strange beasts that symbolized the monarchs' will to rule foreign and exotic regions (Yan, 2016). Among these statues, only the Stone Whale remains to this day (Fig. 11).

3.5. Transportation mode: an artificial canal replaces the Wei River

During the Qin Dynasty and the early Western Han Dynasty, the Wei River was used to transport goods as tax and tribute from all over the empire to the capital. They entered the city from the north side in general. The East Market and the West Market were located at the northwest corner of the city in order to benefit from water transportation (Fig. 10). However, the Wei River was shallow and tortuous, with deep sediment, which made it difficult to sail. As a result, Cao Canal, completely artificial, was excavated on the south side of Chang'an to supplement and meet the waterway transportation needs.

Cao Canal was composed of a main channel and several branches. The main body flowed into the Yellow River from west to east, which was almost parallel with the Wei River (Shi, 1996). On the one hand, huge ships from the eastern part of the empire, which carried much tax revenue, could directly reach the south of the capital city through the canal, where the most important royal palaces were located. On the other hand, the canal that embracing the south and east city walls also acted as a moat for military defense. Therefore, this section was also called Wang Canal, which meant "monarchs' moat". Cao Canal took the Wei River as its main water source, and Kunming Lake as a

supplement. However, sediment accumulation in the Wei River made its course swing frequently. So Cao Canal's water diversion project was difficult to maintain for a long time and the canal itself was also prone to silting up (Xin, 1989). As a result, this artificial canal needed to be dredged continually.

4. The water system and urban morphology design: economic, military, gardening, political and cultural significance

4.1. Economic significance: a solid foundation for the capital city

The coordination of urban construction and water environment in Chang'an laid a solid foundation for the capital city's development in the Western Han Dynasty (Wu, 2013). Ancient East Asia, including China, Japan and Korea, was a typical agricultural society, different from the nomadic pattern of Central Asia and the marine orientation of Europe. In this agricultural society, site selection near the main tributaries of large rivers, rather than the main stream itself, was one of the necessary elements of large-scale settlements. Chang'an was typical of this kind of settlement. This was reflected in the phenomenon that the artificial water system was constructed and improved simultaneously with the development of the city. On the one hand, the planning and construction of Chang'an made full use of natural water resources and transformed them into an artificial water system that met residents' needs, including for drinking and sewage in daily life, agricultural irrigation, fishery production, waterway transportation, military defense, fire control, landscape construction and leisure. On the other hand, the actual mode of agricultural production and waterway transportation was also decided

by the artificial water system. Its construction and improvement process could be summarized as the development from a natural water environment to an indispensable artificial water system within an urban structure. (Pei, Lin, 2010) (Figs. 2, 4 and 9).

Chang'an's water system developed in relation to natural water bodies, which were then intensively transformed. Huge and continuous investment in maintenance was indispensable for keeping its operation stable, which also meant a lack of resilience. Resilience is an important goal because the vulnerability of technological and social systems cannot be fully predicted (Foster, 1997). After the Tang Dynasty (618–907 CE), Chang'an was no longer the imperial capital. Due to lack of maintenance, this huge and complex water system gradually silted up and shrank during the following era, returning to its initial state of a fertile plain. However, until the water system was completely annihilated, it would continue to serve people's needs, serving agricultural irrigation, aquaculture promotion, climate regulation, ecological improvement, fire prevention, and so on.

4.2. The nominal purpose of naval training: short-lived, but exemplary

The nominal naval training function of this water system was short-lived but exemplary for future. For the first time, Kunming Lake moved naval exercises into the royal garden, which was a striking development in Chinese gardening history (Yang, 2007).

The construction of Kunming Lake in 120 BCE, according to historical records, resulted from a diplomatic mission regarding trade sent by Emperor Wudi to the Kingdom of Yuandu, which was ancient India. This mission was obstructed by the Kingdom of Kunming, which was not an affiliated country of the Han Empire at the time. As a result, Emperor Wudi decided to attack and annex the Kingdom of Kunming and its neighboring small kingdoms so as to turn them into a province and expand his empire. In the present, this region is called Yunnan Province. The Kingdom of Kunming had Dian Lake in its capital city, which is still called Kunming and still the provincial capital. In order to practice water warfare, Emperor Wudi decided to excavate a vast artificial lake to symbolize Dian Lake. This lake was named after the enemy as Kunming.

In fact, training the navy to attack a distant kingdom on the southwest border of the empire was merely the nominal purpose. Constructing such a large and complex artificial water system was not only for monarchs to show off power; the actual intention and fundamental usage involved regulating, storing and supplying water to palaces and the city, as well as to develop waterway transportation, which mainly served the monarch and his royal court.

The actual use of Kunming Lake for training the navy lasted for quite a short time, only during the reign of Emperor Wudi (156–87 BCE) of the Han Dynasty and under Emperor Gaozu (566–635 CE) of the Tang Dynasty. It cannot be neglected that, in the Three Kingdoms Era (220–280 CE), the Kingdom of Sunwu built Xuanwu Lake in its capital city, Jiankang, which is now called Nanjing. Meanwhile the Kingdom of Caowei also built Xuanwu Lake in its capital city,

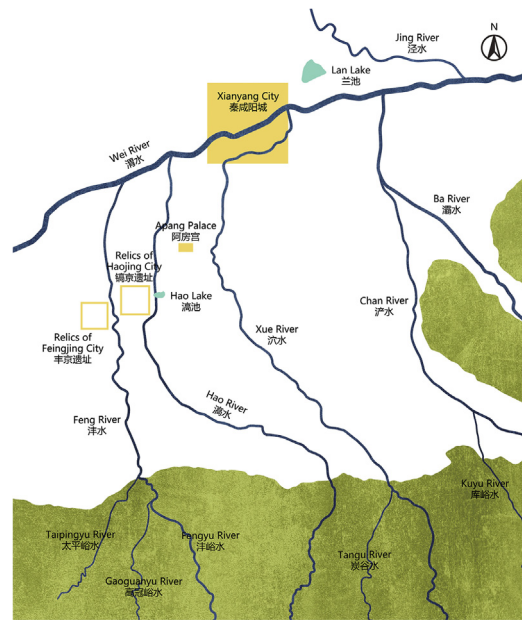


Fig. 4 Xianyang and its surrounding water system in the Qin Dynasty. Source: the author.

Yecheng. Both lakes were used for entertaining, sightseeing and naval training. In the Southern and Northern Dynasties Era (420–589 CE), the Kingdom of Liusong inspected its navy in Xuanwu Lake of Jiankang and a royal edict was issued to change its name to Kunming Lake. Even in the Qing Dynasty (1626–1912 CE), Emperor Qianlong presided over the construction of Qingyi Royal Garden as one of the summer palaces in Beijing, where the natural water body was expanded and renamed Kunming Lake. The royal navy also trained and was inspected there. It can be concluded that Kunming Lake of the Western Han Dynasty had a far-reaching influence on naval training in later times.

4.3. Gardening paradigm: precedents in Chinese history

In the Qin Dynasty, the monarch ordered that water be taken from the Wei River and used to form a lake in Xianyang; he then built Penglai Island in the lake and made stone whales on the island. During Emperor Wudi's reign in the Western Han Dynasty, Taiye Lake was developed further on the former example.

Some ancient historical records stated that Taiye Lake was a symbol of the North Sea. However, China only had the East Sea and the South Sea during the Han Dynasty. The North Sea actually referred to the Lake Baikal³ in the territory of Xiongnu, the northern neighbor of Han, which was later incorporated in the empire. Some historical records state that Taiye Lake was the symbol of Xian Lake, which meant "salt water", where the sun god bathed in early myths and legends.

³ Lake Baikal is the largest lake in Eurasian Continent and belongs to Russia today.

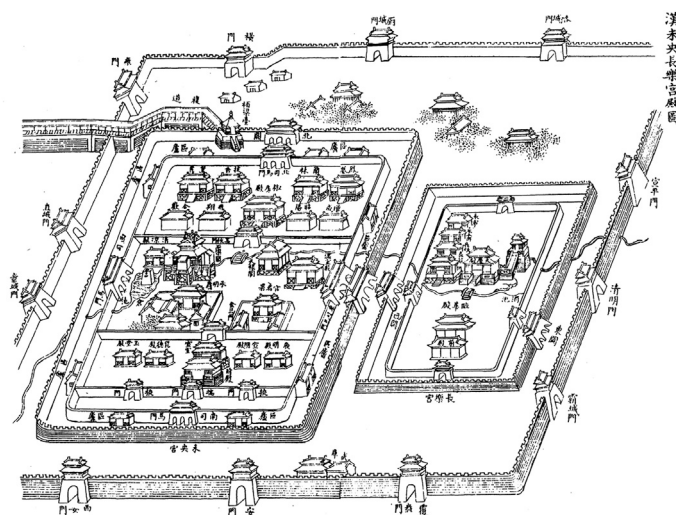


Fig. 5 Chang'e Palace and Weiyang Palace in Chang'an of the Western Han Dynasty. Source: Bi, 1776.

There were three islands (little mountains) in Taiye Lake, namely Penglai in the middle, Yingzhou and Fangzhang on both sides. These islands symbolized the mythical islands inhabited by immortals in the East Sea, who could make magical elixirs that keep mortals from aging and thus were much desired by emperors. The myths and legends are not groundless: Penglai Island is located between the Shandong Peninsula of China and the Korean Peninsula; Yingzhou Island refers to the Japanese Islands; while the origin of the name of Fangzhang Island is still unclear. The design pattern of three mountains in a water area is called "One Lake and Three Islands".

The classic gardening paradigm of *One Lake and Three Islands* started from the symbolic simulation of fairy islands in the sea, which was an innovation in Chinese landscape architecture history and had a profound impact on future generations. As a miniature, *One Lake and Three Islands* reflected the design idea of the capital city water system in the Qin and Han dynasties, which was intended to symbolize and imitate images in myths and legends.

The Kunming Lake water system, as the key part of Shanglin Royal Zone landscape, created another precedent in Chinese gardening history. This new royal gardening pattern took a large-scale water body as the basic element and landscape center to enhance the former gardening mode, which only had hills or High-rise Buildings as the core (Yang, 2007).

The Kunming Lake water system provided important places for royalty and nobility to fish, hunt and seek amusement. Lots of luxurious royal palaces as well as residences for nobles and officials were built on the islands or along the bank. However, the opportunities for entertainment and enjoyment only served the monarch and nobility, who had nothing to do with ordinary people.

4.4. A monarch's political ambition: to control and possess Tianxia

Emperor Wudi of the Western Han Dynasty displayed his political and cultural ambition in the planning and design of

Shanglin Royal Zone, including the water system surrounding the capital. Shanglin Royal Zone represented his wish to control and possess *Tianxia*. *Tianxia* is a unique and essential concept in East Asian culture: generally, it means the monarch aspires to rule everything under the heaven until the end of the world that he knows, no matter whether his empire actually controls this space.

During this period, the construction of Shanglin Royal Zone was closely related to four concepts: (1) Groups of necromancers and alchemists, who were active in the royal court, provided Emperor Wudi with knowledge of the universe and fairyland. (2) Lots of famous literary works presented an idealized distant strange space and blueprint for Emperor Wudi, such as *the Paeon of Shanglin* composed by Sima Xiangru (179–118 BCE). (3) At the beginning of Emperor Wudi's reign, he already had the political and academic cognition, including to establish a legal system within the empire, to defeat and subjugate other uncivilized nations and vassal states outside the empire, the influence and appeal of the empire should have no boundary, and the world should be one family. His ideas and expertise provided the psychological inspiration for his construction of Shanglin Royal Zone. (4) From the Pre-Qin Era to the early Han Dynasty, the existing palaces and water landscape offered Emperor Wudi visual models and references (Liu, 2014).

Shanglin Royal Zone was the epitome and miniature of the world recognized by Emperor Wudi. Through shaping and molding by visual arts, the world he knew was miniaturized and became a visual landscape near the capital city that could be controlled and constructed according to his will. Most of the visual landscapes in Shanglin Royal Zone symbolized his control and possession of the whole world of *Tianxia*, as did the utensils that were made according to his preferences. However, the major functions of Shanglin Royal Zone began changing after Emperor Wudi's reign.

The world of *Tianxia* as comprehended by Emperor Wudi included different levels of space, such as realities, foreign and exotic regions, fairylands and so on. In other words, the world of *Tianxia* in the Qin and Han dynasties referred to

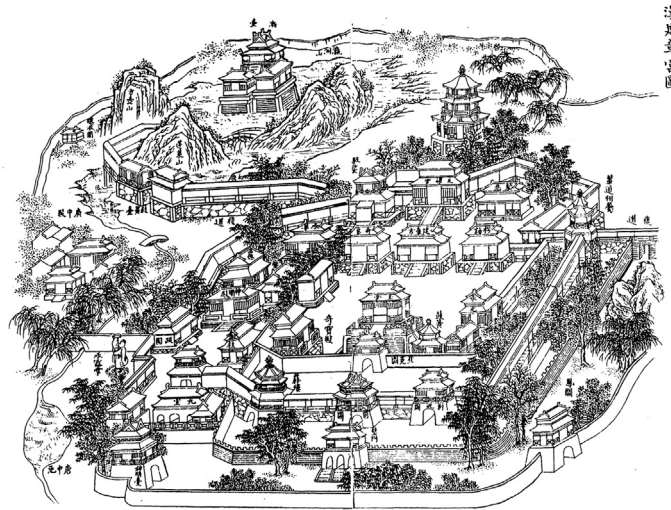


Fig. 6 Jianzhang Palace of the Western Han Dynasty. Source: Bi, 1776.

territories that could be effectively controlled by the imperial government in a narrow sense; however, it also referred to an idealized world that included frontier areas, foreign and exotic regions, fairylands and anything under the heaven in a broad sense (Liu, 2014). This explains why in the capital city the emperors of this era always moved and copied objects far away from their own territories in the form of miniaturization, so as to display their thoughts regarding *Tianxia*. It should be noted that such kind of visual landscape expression did not necessarily reflect actual control of the relevant objects; it sometimes reflected only the ambition to control them.

As a matter of fact, using visual expression to show a miniature world in the capital area might have existed in embryonic form before the Han Era. For example, as mentioned earlier, during the Qin Dynasty's unification of the empire, the emperor imitated other defeated vassal states' palaces and built Palaces of Six States on the north bank of the Wei River in Xianyang. After the unification was finished, the defeated vassal states' capitals were demolished to demonstrate the new empire's exclusive control over the world of *Tianxia*. In addition, Lan Lake in Xianyang was also the symbol of the emperor's control over the East Sea (Hou, 2020). However, the methods and techniques involved in creating miniature landscapes during the reign of Emperor Wudi. They were more complicated and mature than had been seen earlier.

4.5. Cultural connotation: Symbolizing and Modeling Heaven and Earth

In the Qin and Han dynasties, the principle of *Symbolizing and Modeling Heaven and Earth* was the important starting point of the capital urban morphology design, especially for the water system. This principle is a traditional philosophy in East Asia. When it acted as the theoretical basis of urban planning, it mainly included the artistic conception of

Correspondence between Heaven and Earth, Integration of Time and Space, Building and Living in a City that Draws Lessons from Heaven and Earth. The application of this principle in urban morphology design varied a lot in different countries and periods.

The pattern of *Symbolizing and Modeling Heaven and Earth* in Chang'an in the Western Han Dynasty was based on the following suppositions: (1) The heaven pole should correspond to the center of the earth, which meant the imperial ancestral temple and the imperial palace; (2) The four orthodox directions of sky should correspond to the directions of the earth; (3) The palace's layout should be in line with constellation and galaxy structure; (4) The starting positions of important stars' movement tracks should be marked with stone statues of Niulang⁴ (cowboy) and Zhinv⁵ (Weaver Girl), both of whom are also important characters in ancient myths; (5) Earth and sky should be connected with corridors in the air; (6) High-rise Buildings should be built to serve imaginary gods (Xu, 2016).

Before the First Opium War (also known as the Anglo-Chinese War, 1840–1842CE) China had long played the dominant role in the *Tributary System of East Asia*, which was a special hierarchical international political order before modern times. In the Chinese language, China means the central and civilized country; therefore, the capital city has to be *the Center of Heaven and Earth*. In order to realize the imperial power's organization and control of space and time, the urban planning and layout of the capital city with the surrounding area had to reflect the relationship between important constellations, to be coordinated with the geographical features of mountains and rivers, and to echo the time calendar. Thus, people living in the capital area could experience the human residence culture of *Drawing Lessons from Heaven and Earth*. The urban planning method of *Symbolizing and Modeling*

⁴ This statue was mistakenly identified as Zhinv before modern research.

⁵ This statue was mistakenly identified as Niulang before modern research.

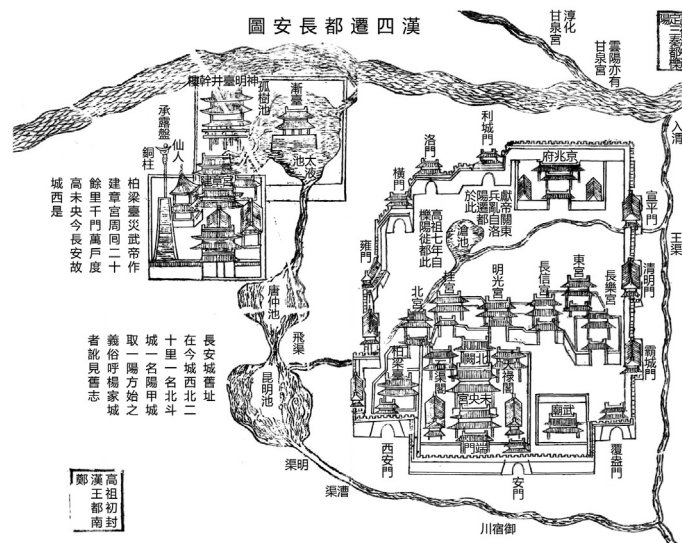


Fig. 7 Chang'an and its water system in the Western Han Dynasty. Source: Jia and Li, 1667.

Heaven and Earth focused on the fundamental meaning rather than the specific detail. It did not simply map the pattern of starry sky to the ground, or directly arrange the urban form and important buildings according to constellations' structures, but intelligently formed a new creation by means of relative orientation and position.

In Chinese culture, Niulang and Zhinv are not only mythical characters, who are separated by the Milky Way and connected by Magpie Bridge, but also stars in the night sky, which are called Altair and Vega. In the Qin and Han dynasties era, there were two times that the capital city imitated the celestial phenomena and myth of Niulang and Zhinv in the aspects of urban form and landscape construction. The first time was when Xianyang and the imperial palace of the Qin Dynasty expanded from the north bank to the south bank of the Wei River. The river running from west to east in the middle of the city symbolized the Milky Way; the bridges across the river symbolized Magpie Bridge; and the northern part and southern part of the city symbolized Niulang and Zhinv respectively. The second time occurred in Kunming Lake of the Western Han Dynasty, when the lake symbolized the Milky Way and stone statues of Niulang and Zhinv were placed on the east and west sides of the lake. The line that connected the geometric centers of the city of Chang'an and Kunming Lake was similar to the line that connected the celestial pole and the midpoint of Altair and Vega. At the same time, the water flow direction of the Kunming Lake system was basically the same as the movement of the Milky Way. The symbolizing connotation of the Kunming Lake water system to the Milky Way was strengthened by marking the relative position of Altair and Vega through two stone statues. It can be seen that celestial phenomena and myth had a significant influence in this period.

In addition to the simulation of the Milky Way, the Stone Whale (Fig. 11) also made this artificial lake a miniature of the ocean although in fact Chang'an was far away from the seaside. In the vision of people in the Han Dynasty, no matter the Milky Way in the sky, or strange and exotic creatures in remote and foreign areas, they could all be

moved to the capital city with the aid of visual arts. Beginning in the Western Han Dynasty, Chinese culture formed a tradition of visual expression to depict the image of objects by visual arts, in order to achieve the effect of reality and psychichness.

Xianyang of the Qin Dynasty and Chang'an of the Han Dynasty were the two oldest capitals of the Chinese Empire. Their spatial forms and planning methods served as models for new capitals in the later era. The urban planning idea of *Symbolizing and Modeling Heaven and Earth* revealed the traditional Chinese and East Asian artistic conception of *Building and Living in a City with the Correspondence between Heaven and Earth, the Integration of Time and Space*, as well as the spirit of *Drawing Lessons from Nature* (Xu, 2016).

4.6. Negative effects: surface water overflow and soil salinization

The water system made the development of Chang'an possible, but it also caused pressure and threat. Established on the south bank of the Wei River, Chang'an was in the first terrace while Kunming Lake was in the second terrace. The city site was below the elevation of Kunming Lake, which was the necessary requirement for the lake to supply water to the city. However, the impoundment of Kunming Lake also led to the rise of groundwater, which resulted in surface water overflow and soil salinization. In the Western Han Dynasty, the Hao River and the Xue River had much more water than today. The purpose of transforming their original courses and leading them to enter the Feng River (Figs. 8 and 9) was to control the amount of water in Kunming Lake, stabilize the height of groundwater, and eliminate surface flooding, so as to alleviate the problem of dampness and standing water in the city. It should be noted that this was quite different from the situation of surface water depletion and scarcity in the Ming and Qing dynasties

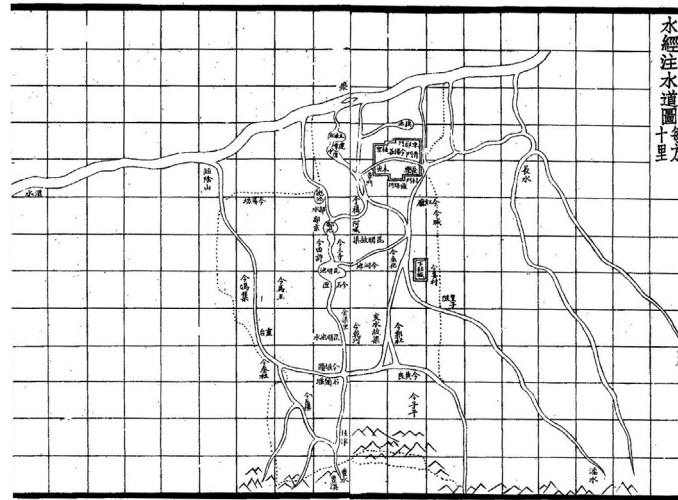


Fig. 8 The water system paths of Chang'an. Source: Zhang, Dong (1812).

(1368–1912 CE). In fact, water overflow and ground dampness disasters did happen frequently in Chang'an according to historical records (Li, 2008). In addition, the long-term water immersion made groundwater salty, bitter, and not suitable for drinking. This was also one of the reasons why this site was abandoned and a new capital located on its southeast third terrace took its place during the Sui and Tang dynasties (Fig. 12). Nevertheless, the original water system, including Kunming Lake, Cang Lake, and Cao Canal, were all used during this period (Wang, 2009; Li, 2009). After the Sui and Tang dynasties, villages evolved on the relics of Chang'an. The water system continued to be reused in the village environment and its

function changed to supply villagers' needs, including for farmland irrigation (Zhai and Xu, 2019).

The artificial water system that was newly constructed in the Western Han Dynasty included and integrated the previous artificial system, such as Hao Lake. As a matter of fact, the establishment of Kunming Lake caused serious damage to the original site of Haojing of the Western Zhou Dynasty, part of which was submerged under the lake. In *Commentary on the Water Classic* (Li, 2020) and *Yuanhe Maps and Records of Prefectures and Counties* (Li, 1983), it was clearly pointed out that the excavation of Kunming Lake destroyed the site of Haojing. *Maps of Chang'an and Surrounding Areas* (Li, 2013) also recorded that ash from the fires of an ancient city were discovered when excavating Kunming Lake, which confirmed the event that Haojing was plundered and burned by the vassal state Quanrong at the end of the Western Zhou Dynasty, as mentioned before. Contemporary archaeological research has confirmed this assessment.

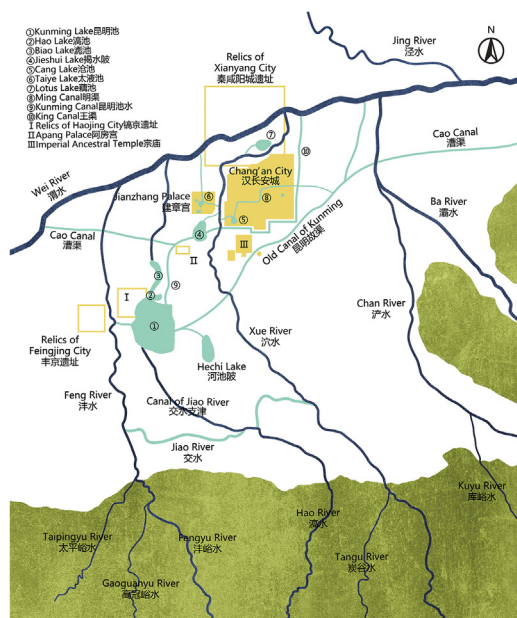


Fig. 9 Chang'an and its surrounding water system in the Western Han Dynasty. Source: the author.

5. Discussion and conclusion: indispensable foundation from daily use to cultural connotation

The historic cities of Xi'an gradually developed based on natural and artificial water systems: (1) The earliest establishment of the cities of Fengjing and Haojing of the Western Zhou Dynasty depended on the Feng River and the Hao River. Modern Xi'an still carries the name of the Hao River as the city's abbreviation. (2) Xianyang was first founded on the north bank of the Wei River as the capital of the Qin Dynasty; its expansion to the south bank occurred mostly after the reunification of the empire. The Wei River in this period acted as a landscape axis in the city center, with a large number of palaces densely distributed on both sides. (3) In the beginning of the Western Han Dynasty, part of Xianyang on the south bank of the Wei River was preserved, renovated, expanded and renamed as Chang'an, and remained the imperial capital. The natural water system around the capital was not modified greatly in the initial stage of the



Fig. 10 Map of Chang'an in the Western Han Dynasty. Source: the author.

new empire. (4) It was during the reign of Emperor Wudi in the mid-term of the Western Han Dynasty when much of the large-scale construction of Chang'an and its water system occurred. The Kunming Lake - Chang'an City - Jianzhang Palace water supply system fundamentally changed the pattern of the natural water system.

Chang'an of the Western Han Dynasty created an innovative pattern of water system utilization that has been followed to this day, in which the Wei River has been used to drain rainwater and sewage, its south bank tributaries used as water sources, and Cao Canal used for transportation. More specifically, the source of Chang'an's artificial water system mainly came from the Xue River, the Hao River, the Feng River and the Wei River. Kunming Lake acted as the supreme reservoir, and under its control there were Jieshui Lake and Hechi Lake, which acted as secondary reservoirs. And then there were tertiary reservoirs, like Cang Lake, which directly provided water for various palaces in the city, and Taiye Lake, which supplied water to Jianzhang Palace. Water was supplied through numerous crisscross channels.



Fig. 11 The Stone Whale. Source: the author.

The construction and improvement process of the water system can be summarized as the development from a natural water environment to an indispensable artificial water system of the urban structure. The coordination of urban construction and water environment was a key foundation for capital city development, and shaped the urban water supply in many ways, including drinking and sewage in daily life, agricultural irrigation, fishery production, waterway transportation, military defense, fire control, climate regulation, landscape construction and leisure.

In the Qin and Han periods, the overall scale of royal gardens reached its peak in ancient China, which further increased the demand for water in the capital city. The emergence of a very large artificial water area (Kunming Lake) and the increase in the number of water areas reflected this trend (Hou, 2020). Taiye Lake developed the classic gardening paradigm of *One Lake and Three Islands* with the symbolic simulation of fairy islands on the sea from myths and legends. Shanglin Royal Zone took Kunming Lake as the landscape center, created a new pattern and enhanced gardening forms. Both lakes saw innovations in Chinese landscape architecture history that had a profound impact on future generations.

The artificial water system involved highly symbolic images that displayed the monarchs' political and cultural ambition to control and possess *Tianxia*, which essentially means the entire world. Shanglin Royal Zone, with strong political significance expressed through miniature visual forms, was the epitome of the world recognized by the monarch, not just a place for entertainment and rest. Besides, the nominal naval training function of this water system was short-lived but represented a future trend. For the first time, Kunming Lake moved a naval exercise into the royal courts.

What's particularly important, the planning and construction of Chang'an was based on a range of spatial

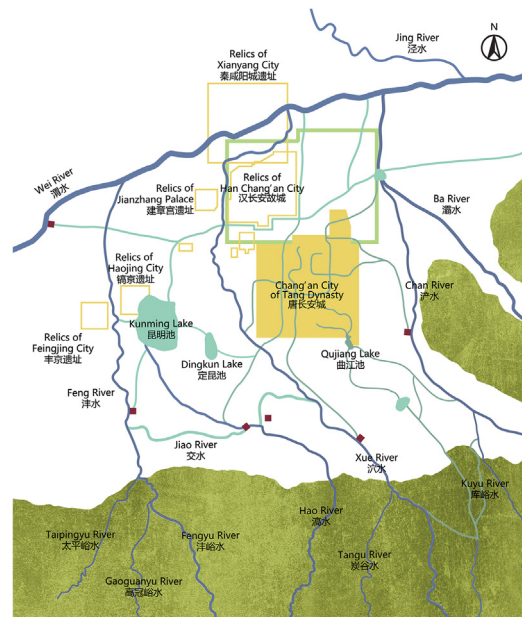


Fig. 12 Chang'an and its surrounding water system in the Tang Dynasty. Source: the author.

principles, including the *Theory of Choosing the Center* and the *Theory of Conforming to Nature*. The final maturation of the city's complex system and urban morphology, including the water system, was closely related to the *Theory of Symbolizing and Modeling Heaven and Earth*, so as to realize the imperial power's organization and control of space and time in a symbolic sense.

The spatial forms and planning concepts of Xianyang and Chang'an established models for all of East Asia. Historical analysis can provide a foundation for future sustainable patterns because prior attempts to link natural and man-made water patterns in urban settings can provide insights and references for city and landscape design of the future. We need more systemic investigations on urban planning through the lens of history, so this research has meaning beyond this one case.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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