

The Implications of the Planning of Beijing’s Imperial  
City for Sustainable Community Development

Hao Li

Examensarbete i Hållbar Utveckling 129

The Implications of the Planning of  
Beijing’s Imperial City for Sustainable  
Community Development

Hao Li

Examensarbete i Hållbar Utveckling 129

# The Implications of the Planning of Beijing's Imperial City for Sustainable Community Development

Hao Li

Supervisor: Per G. Berg  
Evaluator: Eva Friman



# Contents

- 1. Introduction** ..... 1
  - 1.1. Massive urbanization in China ..... 1
  - 1.2. A brief history of planning of Beijing’s imperial city ..... 2
    - 1.2.1. Pre-imperial city history of Beijing ..... 2
    - 1.2.2. Early history of the Imperial City of Beijing ..... 3
    - 1.2.3. Principal imperial city history of Beijing ..... 5
- 2. Methodology** ..... 9
  - 2.1. Aims ..... 9
  - 2.2. Methods ..... 9
  - 2.3. Boundary ..... 9
  - 2.4. Limitations ..... 10
- 3. Inventory analysis** ..... 11
  - 3.1. Physical resources ..... 11
    - 3.1.1. Geography ..... 11
    - 3.1.2. Climate ..... 12
    - 3.1.3. Hydrology ..... 13
    - 3.1.4. Energy ..... 14
  - 3.2. Economic resources ..... 14
    - 3.2.1. The population growth of Beijing in different historical peroids ..... 14
    - 3.2.2. The Grand Canal ..... 15
    - 3.2.3. The city markets in Beijing during Yuan, Ming and Qing Dynasties ..... 15
  - 3.3. Biological resources ..... 17
    - 3.3.1. Soil and Vegetation ..... 17
    - 3.3.2. The Chinese gardens in Beijing during Yuan, Ming and Qing Dynasties ..... 18
  - 3.4. Organizational resources ..... 19
    - 3.4.1. The city layout ..... 19
    - 3.4.2. The transporration system in Beijing imperial city ..... 22
  - 3.5. Social resources ..... 23
    - 3.5.1. The social system in Beijing imperial city ..... 23
    - 3.5.2. The city block system in Beijing ..... 24
  - 3.6. Cultural resources ..... 24
    - 3.6.1. The ceremonies in Beijing daily life ..... 25
    - 3.6.2. The festivals in the Chinese calendar ..... 26
    - 3.6.3. The recreational activities for the civies ..... 26
  - 3.7. Aesthetic resources ..... 27
    - 3.7.1. The beauty of harmony in the city configuration of Beijing imperial city ..... 27
    - 3.7.2. The Eight Scenes of Imperial Beijing ..... 29
- 4. Interdisciplinary analysis** ..... 30
  - 4.1. Micro level: the quadrangle and the green building ..... 30
    - 4.1.1. The origin of the quadrangle ..... 30
    - 4.1.2. The features and components of a quadrangle ..... 30
    - 4.1.3. The software modelling ..... 32
    - 4.1.4. Analysis and discussion ..... 35
  - 4.2. Macro level: the Beijing imperial city planning and the sustainable city ..... 38
    - 4.2.1. The Fengshui theory in ancient Chinese city planning ..... 38
    - 4.2.2. The ecological effect of Fengshui Theory in Beijing imperial city planning ..... 39
    - 4.2.3. The implication of Beijing imperial city planning for building a sustainable city ..... 41
- 5. Conclusions** ..... 42
- 6. Acknowledgement** ..... 43
- 7. References** ..... 44
- Appendix** ..... 46

# The implications of the planning of Beijing's imperial city for sustainable community development

HAO LI

Li, H., 2013: The implications of the planning of Beijing's imperial city for sustainable community development. *Master thesis in Sustainable Development at Uppsala University*, No. 129, 57 pp, 30 ECTS/hp

## **Abstract:**

China is experiencing the unprecedentedly rapid urbanization hence how to build a sustainable city with Chinese features becomes a common challenge for city planners and researchers in the field of sustainability. Beijing has been the imperial capital of China for more than eight hundred years and is deeply embedded within ancient Chinese urban planning theories and thoughts; for this reason it is chosen as the subject of this study. The history of Beijing as an imperial city from the Yuan Dynasty to the Qing Dynasty (1267-1912) is reviewed under the framework PEBOSCA, an assessment framework of sustainable community development which derives from UN HABITAT Agenda. The state of the seven resources of sustainability is outlined to demonstrate the sustainability of Beijing's imperial city planning history. Following this, sustainability was assessed at micro- and macro-levels: first the quadrangle as the basic unit of the city is documented and assessed with the Green Building Assessment Standard of China and the LEED for Homes Ranking system in a qualitative approach; then the city as a whole was analyzed to assess the interrelationships between the ancient Chinese urban theory – the Fengshui Theory – and urban ecology to understand its implications for the sustainable city planning.

The study shows that although sustainable development is becoming a global issue, the key to the challenges faced is local. Integrated with modern technologies, the quadrangle design and the Fengshui Theory will inspire future sustainable community planning and sustainable development.

**Keywords:** Sustainable Development, Ancient City Planning, China, PEBOSCA, Interdisciplinary Analysis

*Hao Li, Department of Earth Sciences, Uppsala University, Villavägen 16, SE- 752 36 Uppsala, Sweden*

# The implications of the planning of Beijing's imperial city for sustainable community development

HAO LI

Li, H, 2013: The implications of the planning of Beijing's imperial city for sustainable community development. *Master thesis in Sustainable Development at Uppsala University*, No. 129, 57 pp, 30 ECTS/hp

## **Summary:**

How to build a sustainable city with the local features is becoming a common challenge for most emerging cities. The rational behind this study is to look back to the city's history and find the implications for sustainable community development. Beijing has been the capital of China for more than eight hundred years and it was deeply embedded with the ancient Chinese urban planning theories and thoughts hence to be chosen as the subject of this study.

The history of Beijing imperial city planning was first reviewed and analyzed with from seven dynamic resources of sustainability, including physical, economic, biological, organizational, social, cultural and aesthetic resources, which are included in the PEBOSCA framework. Then an interdisciplinary analysis focusing on two issues, the quadrangle as the basic unit of the city and the Beijing imperial city itself is made to address its implications. By a tentative assessment with the Green Building Assessment Standard of China and the LEED for Homes Ranking System in a qualitative approach, the quadrangle was proved to be a local one of green building mode since it adapted to the local environment and living needs. Then the Fengshui Theory as the guidelines of ancient Chinese city planning as well as Beijing imperial city planning is analyzed and interpreted in an urban ecology language to squeeze its implications for the future sustainable community development.

**Keywords:** Sustainable Development, Ancient City Planning, China, PEBOSCA, Interdisciplinary Analysis

*Hao Li, Department of Earth Sciences, Uppsala University, Villavägen 16, SE- 752 36 Uppsala, Sweden*



# 1. Introduction

## 1.1. Massive urbanization in China

China is undergoing a massive transformation. The Reform and Open Policy<sup>1</sup> launched three decades ago has greatly changed the country. The national GDP of China increased from 364.52 billion in 1978 to 47288.16 in 2011 (National Bureau of Statistics of China, 2012). As a result, people's living standards have increased significantly and there has been a great movement of population from the countryside into the cities.

The impacts of this great transformation can be seen everywhere. Firstly, the population in urban China increased from 172.45 million in 1978 to 690.79 million in 2011 while the urbanization rate increased from 17.92% in 1978 to 51.27% in 2011 (Figure 1). Secondly the number of cities with more than two million people increased from 10 in 1995 to 45 in 2011 (National Bureau of Statistics of China, 2012).

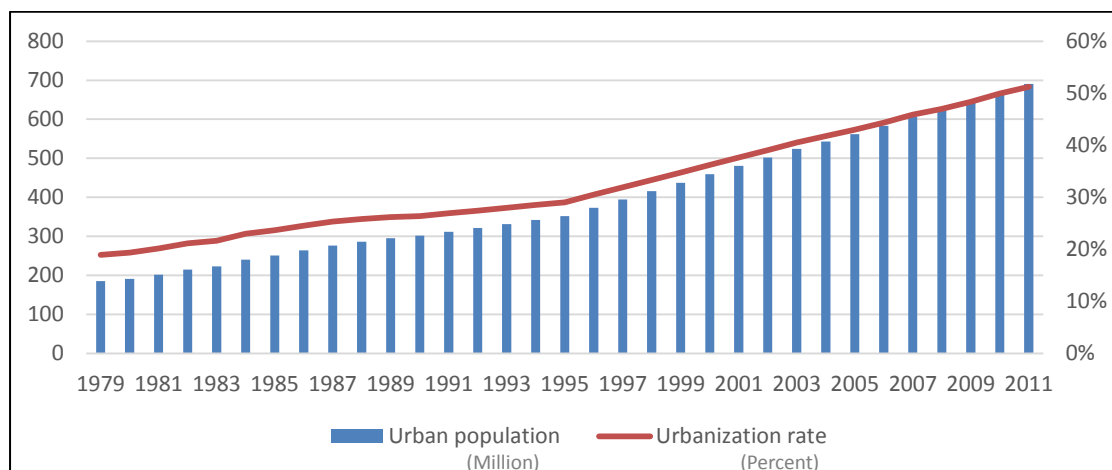


Figure 1. The change of urban population and urbanization rate in China from 1978-2011. Data source: National Bureau of Statistics of China.

Moreover, the urban population in China will keep increasing for the next two or three decades (McKinsey, 2009). Another 350 million people will join the urban population in China by 2025 while the number of cities with more than one million people will be 221 out of the 939 Chinese cities. In contrast in 2009 there were only 35 cities with more than one million people in Europe. There will be 1 billion people living in Chinese cities by 2030 (McKinsey, 2009).

However, rapid urbanization in the last three decades has also placed a great pressure on Chinese cities. The environment in urban areas is deteriorating. Poor air quality, untreated waste water discharge and traffic congestion are also having negative impacts on inhabitants' health and well-beings (Picture 1:a,b). More and more avant-garde architecture is springing up in the cities, making the cities appear superficially similar (Picture 2: a,b), but what is happening to the cities as places to live? Do they remain comfortable and livable for their residents?



Picture 1: a. Air pollution in Beijing (upper left); b. Traffic jam in Beijing (upper right)

Source: a: [http://www.gq.com.cn/topic/album\\_1221f4ca912a8d5c-4.html#id-1](http://www.gq.com.cn/topic/album_1221f4ca912a8d5c-4.html#id-1);

b: <http://gb.cri.cn/27824/2010/09/19/882s2996375.htm>

<sup>1</sup> Reform and Open Policy refers to the Chinese economic reform which started in December, 1978. It represents the shift of the Chinese economy from a planned economy to a market economy.





Picture 2: a. The CBD area of Beijing (upper right); b. CCTV Tower (right).

Source: a: <http://www.nipic.com/show/1/48/6026655keca11bbf.html>;

b: Zhu Dake, <http://www.winetour.cn/html/1005/2010052836494421.html>

Sustainable development is a topic of great and increasing importance on the global agenda. The same is true in China. Beijing, the present capital of China, was once the largest city in the world. It has been the capital of China for more than eight hundred years. It was praised as “the master piece of world urban history” (Liang, 1986) and a Danish architect, Steen Eiler Rasmussen, once commented: “Beijing, the capital of old city! Has there ever been a more majestic and illuminative example of sustained town-planning.” (Rasmussen, 1951)

The history of Beijing as the imperial city of China embodies ancient Chinese urban planning theories and approaches; hence it is a valuable example for the sustainable development of China and the future of Chinese and global sustainable community development.

## 1.2. A brief history of planning of Beijing’s imperial city

### 1.2.1. Pre-imperial city history of Beijing

According to archaeological findings in 1921, *Homo erectus* or “Peking Man” which lived in the caves of Dragon Bone Hill near Zhoukoudian in Fangshan District (southwest area of Beijing municipality) from 700,000 to 200,000 years ago, was the earliest species of human in the area and thus the origin of human habitation in the area of present day area of Beijing (UNESCO, 2013).

After achieving victory in the battles with Shang Zhou Wang – the last emperor of Shang Dynasty (1600 B.C.–1046 B.C.) in the 11th century B.C., Zhou Wu Wang, the first emperor of the Zhou Dynasty (1046 B.C.–256 B.C.), named the son of Duke Shao, Ji Ke, as the ruler of Yan state and Beijing became the city of Yan State, known as the Ji City. Ji Ke was named as the Duke of Yan and was regarded as the founder of the Yan State in 1045 B.C. according to the Records of Grand Historian and therefore the year of 1045 B.C. had been deduced as the official birth year of Beijing (Hou, 2009). (Figure 2)

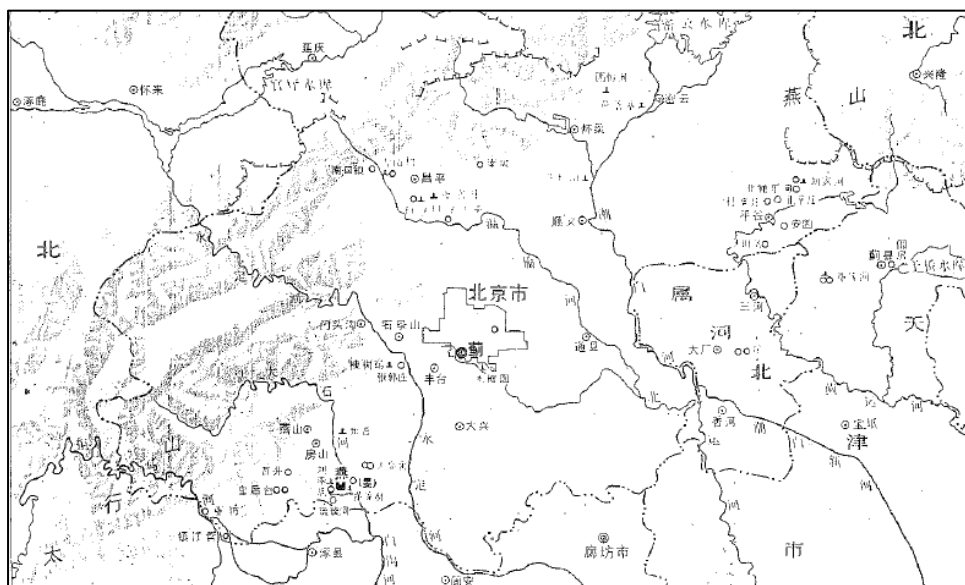


Figure 2: Beijing during the Shang and Zhou Dynasties Source: Beijing lishi dituji. (Hou, 1997)

For several centuries before the Qin State conquered the other six states and unified China in 221 B.C., Beijing was the capital of the Yan State. After the first centralized administrative system appeared in China<sup>2</sup>, Qin Shi Huang, the first emperor of Qin Dynasty (221 B.C.–206 B.C.) declared Beijing as the capital of Guangyang Commandery, one of 48 commanderies of China, and visited it in 215 B.C. In order to defend against the invasion of northern nomads, Qin Shi Huang ordered construction of the Great Wall and the Juyong Pass. Moreover, a national roadway was built to link the Beijing Plain with the Central Plain, the contemporary center of China, during the same period. It represents the first major initiative of consciously built construction in the area of Beijing since the first human settlements developed in this region. In 106 B.C., Han Wu Di, the seventh emperor of Han Dynasty (206 B.C.–220 A.D.), which followed the short-lived Qin Dynasty, divided the whole country into 13 prefectural-provinces and Beijing was declared as the capital of Youzhou Prefecture. In the Three Kingdoms Period of China (220-280) after the Han Dynasty, the first irrigation system was built to irrigate the Beijing Plain. The irrigation system included Lilingyan, a dam across the Yongding River, and the Chexiang Canal, a diversion canal that carried the water west into the north, east and southeast of Beijing city. It was an important project in the pre-imperial history of Beijing because it helped to increase food production and thus feed the population of the city (Figure 3). After China was reunited by the Sui Dynasty (581-619) in 589, Youzhou Prefecture was renamed Zhuo Commandery and Beijing remained its capital. In order to mount a punitive expedition to Goguryeo (today's Korea) and to promote better governance of Southern China, Sui Yang Di, the last emperor of Sui Dynasty levied taxes heavily to build the Grand Canal, one of most famous ancient Chinese projects, which linked Beijing with the prosperous Yangtze River Delta. This spurred the economic development of the region.

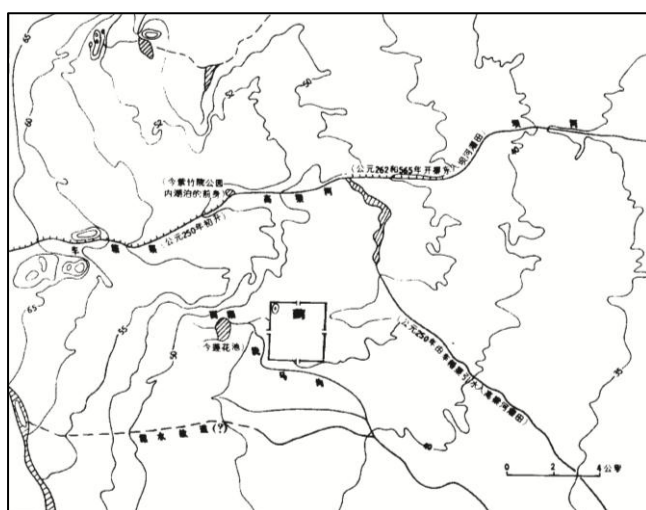


Figure 3: The ancient irrigation system in Beijing: Chexiang Canal. Source: Beijing lishi dituji. (Hou, 1997)

In the first thousand years of China's imperial history, Beijing was a regional capital of northern China. The rebellions in the late Tang Dynasty and the succeeding northern nomadic invasion of the Khitans, Jurchen and Mongols in the Five Dynasties and Ten Kingdoms period (907-979) and later period greatly weakened the central administrative system of China based in Luoyang and Xi'an cities of the Central and Guanzhong Plains. This paved the way for the start of the history of Beijing as the imperial city of China.

### 1.2.2. Early history of the Imperial City of Beijing

Although Beijing was just a regional center of northern China in the first one thousand years of Chinese imperial history, it was an important point of defence against the invasion of the northern nomads and equally a key entryway into the fertile inner land of China for the nomads (Steinhardt, 1999). In 936, Beijing was ceded to the Khitans by Shi Jingtang, the first emperor of Late Jin Dynasty (936-947) as a return for the Khitans' support to found his dynasty. This resulted in the emergence of Liao Dynasty (907-1125) and later dynasties. The importance of Beijing in the imperial history of China grew as the consequence of the shift of capital center of imperial China from the Central Plain to Beijing Plain.

#### 1.2.2.1. Beijing (Nanjing) in the Liao Dynasty (938-1122)

In 938 Beijing became one of four secondary capitals and was renamed Nanjing (the Southern Capital) by Liao Tai Zong, the first emperor of Liao Dynasty (916-1125). The capital of the Liao Dynasty was still at Shangjing (the Upper Capital) in present Inner Mongolia. The site of Liao Nanjing was located at the same site as Ji City.

<sup>2</sup> The unification of China in 221 B.C. by Qing Shi Huang is the start of Chinese imperial history.

Relying on the water supply from the West Lake (today's Lotus Pond), the Khitans built palaces and gardens based around the design of the former Ji City. Liao Nanjing was a very small city and there was thus no massive construction except for the royal palaces.

In 1122, the Song Dynasty which controlled the south part of China at that time sought to reunify the whole of China then reached an agreement with the Jurchens' Jin Dynasty in northeastern China, allowing them to jointly defeat the Liao Dynasty. Although the military alliance collapsed, the Jurchens defeated the Liao and the Khitans fled to Central Asia. Beijing was returned to the Song Dynasty after being looted.

### 1.2.2.2. Beijing (Zhongdu) in the Jin Dynasty (1153-1214)

When the Song Dynasty overthrew the northern Liao Dynasty, the Jurchens from the northeastern part of China formed the Jin Dynasty (1115-1234) in the Liao Dynasty's Upper Capital (near today's Ha'erbin of Heilongjiang Province). After winning the war with the Liao Dynasty, the Jin Dynasty expanded its power to the Beijing plain. It captured Beijing from the Song Dynasty and renamed it Yanjing (the Yan Capital) in 1125. Twenty eight years later, Wanyan Liang, the emperor of the Jin Dynasty moved his capital from Shangjing to Yanjing and renamed it Zhongdu (the Central Capital) in 1153. For the first time in the history of China, the city of Beijing became a political capital of a major dynasty.

Zhongdu was now the primary capital of the Jin Dynasty rather than a secondary capital of the Liao Dynasty, and Wanyan Liang had to reconstruct Zhongdu on the basis of Liao's Nanjing. He named Lu Yanlun, who designed Shangjing, as the chief planner of Zhongdu and squandered eight hundred thousand men and four hundred thousand troops to build Zhongdu. Although the Jin Dynasty was a minority-governed dynasty, the city planners and the craftsmen who designed and built Zhongdu were Han people from the inner land of China. Even the construction materials for Zhongdu were mainly from the lands of the Song Dynasty for example the Genyue Stone from the Taihu Lake (in today's Jiangsu Province). Therefore the city layout and the building pattern of Zhongdu were in accordance with the ancient Chinese imperial city theory (Figure 4).

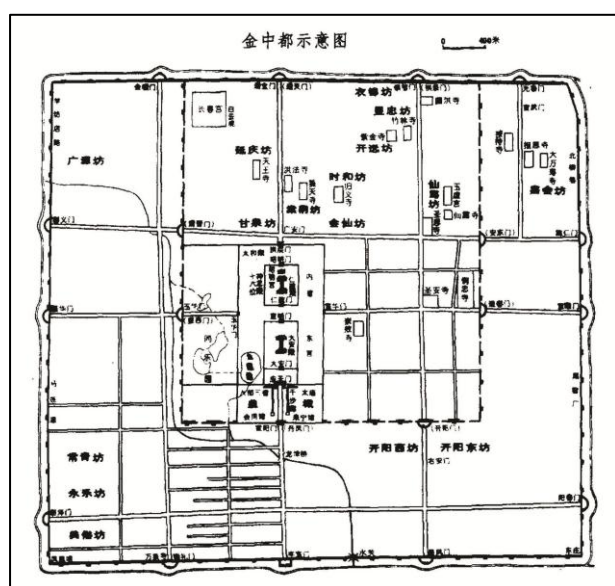


Figure 4: The layout of Jin's Zhongdu and Liao's Nanjing. Source: *Beijingcheng de qi yuan yu bianqian*. (Hou and Deng, 2001)

After its construction, Zhongdu was expanded to the west, east and south and its size was doubled from that of the Liao Nanjing. Zhongdu was a city based on three-concentric rectangles. The Royal Palace was in the middle of Zhongdu, and the second rectangle, which contained the Jin administrative agencies, was built around the Royal Palace. Most of the civilians lived in the third outer rectangle. According to ancient Chinese imperial city planning custom, the Ancestral Temple was placed in the center of Zhongdu in 1153. Many royal gardens and parks were built within Zhongdu and surrounding areas. The most famous one was the Tianning Palace, a detached palace for the royal family, and the affiliated Qionghua Island (today's Beihai Park) which were built in 1179. The Lugou Bridge which was built in 1189 over the Yongding River later became one of Yanjing's Eight Scenes<sup>3</sup>.

<sup>3</sup> The Eight Scenes of Yanjing are eight sites with beautiful landscape. It will be introduced in the section 3.7.2.

Jin Zhongdu was the capital of Jin Dynasty for 61 years, until the Jin Dynasty was defeated by the joint strike of the Song Dynasty and the rising Mongols from southern Siberia in 1214. Jin Xuan Zong, the last emperor of Jin Dynasty had moved to Kaifeng and Zhongdu was destroyed by the siege of invading Mongols in the summer of 1215.

### 1.2.3. Principal imperial city history of Beijing

#### 1.2.3.1. Beijing (Dadu) in the Yuan Dynasty (1267-1368)

Before Kublai Khan, the grandson of Genghis Khan, decided to move his capital from Shangdu (the Upper Capital, today's Siklingelei city of Inner Mongolia) to Beijing in 1267 to support the military campaign against the Song Dynasty better, he had visited Zhongdu in 1261. Since the palaces within Zhongdu lay in ruin, Kublai Khan appointed Liu Bingzhong to build a new capital close to the site of Zhongdu. In 1272 he also renamed Beijing as Dadu (the Grand Capital) of the Yuan Dynasty (1215-1368). When the Yuan Dynasty defeated the last defensive power of the Song Dynasty in 1279, the Yuan Dynasty unified China and Beijing became the imperial capital of China for the first time.

The construction of Dadu started in 1264 and lasted for more than two decades. The palace city of Dadu was constructed in 1274 and construction within the city was finished by 1285. The site of Dadu was to the northeast of Zhongdu and centered on Tianning Palace and Qionghua Island. This resulted in an important shift of water supply of Beijing from the Lotus Pond to the Gaoliang River and the north-south central axis of Dadu. This is the foundation of present Beijing's city layout.

Differing from the previous Ji City, Liao Nanjing and Jin Zhongdu in the pre-imperial history of Beijing, Yuan's Dadu was well designed and constructed in accordance with the ideal city model outlined in ancient Chinese books. Before the construction of the city, Liu Bingzhong made a detailed topographic survey and collected geographic information required for city planning. Then he developed a master plan of Yuan Dadu based on the ancient China imperial city planning theory and local geographic features. Hence Dadu essentially embodied the characteristics of an ideal imperial city set forth in Zhouli: Kaogongji (Book of Zhou rites: On craftsmanship)<sup>4</sup> (Picture 3). According to this book, an ideal imperial city should be a square with four walls; each side 4.5 kilometers long with three gates. Between each pair of symmetrical gates are thoroughfares. The whole imperial city is centered as the royal palace. The court and the market lie in front of and behind the royal palace respectively while the temples of ancestors, soil and grain are located at both sides of it.



Picture 3: The ideal imperial city in Kaogongji of Books of Rits. Source: Baidu Wenku

However, Dadu was not a simple copy of the ideal imperial city (Figure 5). Dadu was 6.6 kilometers in width and 7.4 kilometer in length. There were two gates in the north wall, whilst the other three sides had three gates. The court was located in the south part of the imperial city while the Royal Palace was located in the eastern center of the imperial city. The whole city was divided into 50 districts by nine thoroughfares and several avenues. Quadrangles were scattered within these districts.

<sup>4</sup> The Book of Rites is one of ancient Chinese classic books which are told to be written by Confucius. Kaogongji is the sixth chapter of this book and mainly concerned with craftsmen and agriculture.



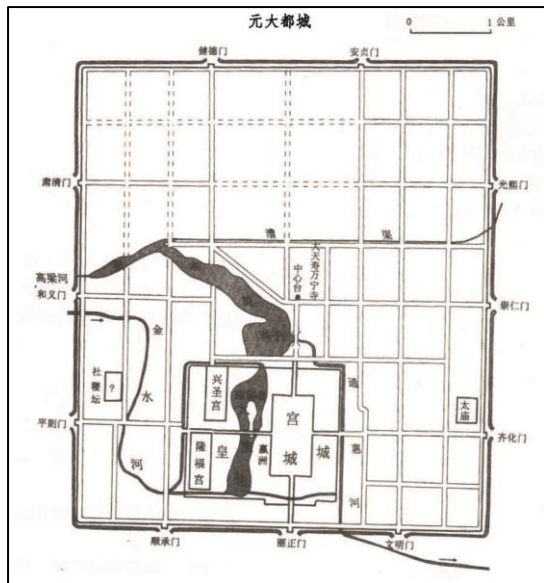


Figure 5: The city of Yuan's Dadu. Source: Beijingcheng de qi yuan yu bianqian. (Hou and Deng, 2001)

Another interesting point in the construction of Dadu is that the water supply and underground drainage system had been installed first before the construction of city buildings (Figure 6). Guo Shoujing, the most famous scientist in ancient China and the student of Liu Bingzhong, designed the watercourse for Yuan Dadu. He diverted the water from Changping, the northern area of Beijing, to Wengshanpo (today's Kunming Lake in the Summer Palace) and then directed it so that it flowed into Jishuitan, which was a large reservoir within Dadu, through the Gaoliang River. The part of Tonghui River within Dadu was dug to connect it to the Southern Grand Canal in order to improve transport links to Dadu. This then spurred the development of markets and business within the city. Subsequently he diverted the spring water from the Yuquan Hill to the Taiye Pond and brought water to the Royal Palace via the Golden Water River. He also designed the drainage system of Dadu. The waste water could flow through the open drainage ditches on both sides of the thoroughfares and be discharged outside of the city by culverts in the gates.

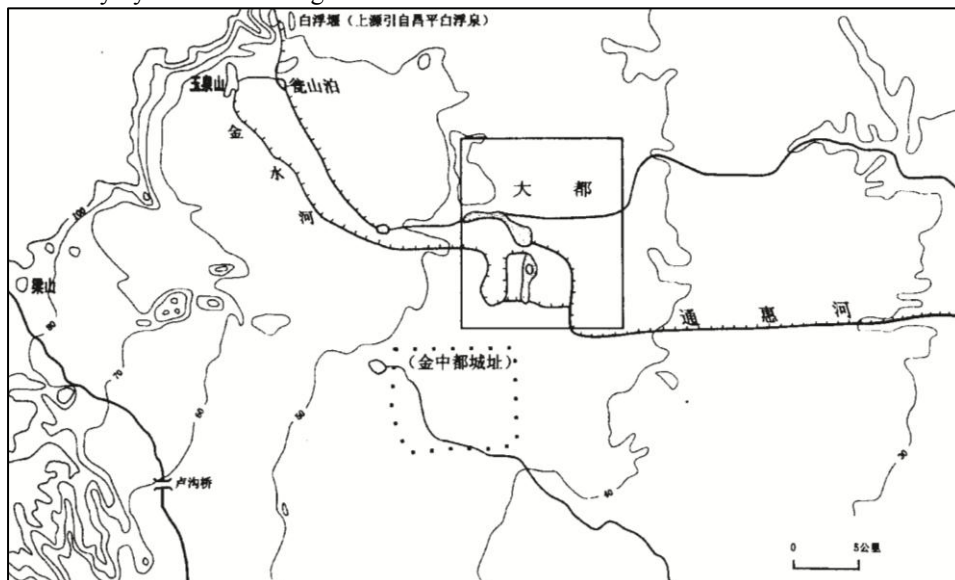


Figure 6: The water courses within and outside of Yuan's Dadu. Source: Beijingcheng de qi yuan yu bianqian. (Hou and Deng, 2001)

The emergence of the Yuan's Dadu represents the shift of Chinese imperial cities from Chang'an city on the Inner China Plain to Beijing on the China North Plain (Steinhardt, 1999). From then on, Beijing became the most important imperial capital of China until the founding of Republic of China in 1912.

### 1.2.3.2. Beijing in the Ming Dynasty (1421-1644)

The wave of peasant uprisings in the late Yuan Dynasty (1351-1367) undermined the reign of the Mongol-led Yuan Dynasty, and Zhu Yuanzhang proclaimed himself as the Emperor of the Ming Dynasty (1368-1644) after

his general Xu Da captured Dadu in 1368. Dadu's imperial palaces were razed and Zhu Yuanzhang declared Nanjing (present Nanjing city) as its capital. Zhu Yuanzhang made his fourth son, Zhu Di the ruler of Dadu in 1370.

Zhu Di became the third emperor of the Ming Dynasty, the Yongle Emperor in 1402 and renamed Dadu as Beijing (the Northern Capital). This is the first time that Beijing took on its modern name. From 1403, Zhu Di undertook many construction programs to prepare Beijing as its new capital. Some of present Beijing's most famous historical buildings, for example the Forbidden City and the Temple of Heaven, were built during that period. When the city construction was completed in 1421, Zhu Di moved his capital from Nanjing to Beijing, and this never changed until 1912.

The construction of the palaces started in 1436 and finished in 1439. Since the palaces of the Yuan royal family had been destroyed, new palaces were built on the eastern of Qionghua Island. A new moat was dug around the Forbidden City and the soil from the moat was heaped to create the Jing Hill. The northern part of Dadu was abandoned due to a fall in population and a new northern city wall was built 2.5 kilometers south of the old Dadu's northern wall. Hence the Jishuitan reservoir was left outside of the walls of the Ming city of Beijing. Meanwhile a new southern city wall was built 1 kilometer south of the southern city wall of Dadu. These two new city walls and the old eastern and western Dadu's city walls constituted the new city layout of Beijing in the Ming Dynasty.

The Tumu crisis in 1449 alerted the emperor of the Ming Dynasty to the weakness of defence of Beijing city. The Oirat Mongols from western Mongolia captured the emperor of the Ming Dynasty at Huailai to the north of Beijing and sieged Beijing. As a response and to aid monitoring of the northern frontier, the new emperor decided to strengthen and extend the Great Wall to the north of Beijing, including the famous Badaling Great Wall section of today. In the middle Ming Dynasty, the emperors decided to build an outer wall to protect the capital. This programme began with the southern city wall in 1553 but due to financial problems it had to be stopped before the other three sides of outer city wall were built. It did however change the rectangular city layout slightly (Figure 7).

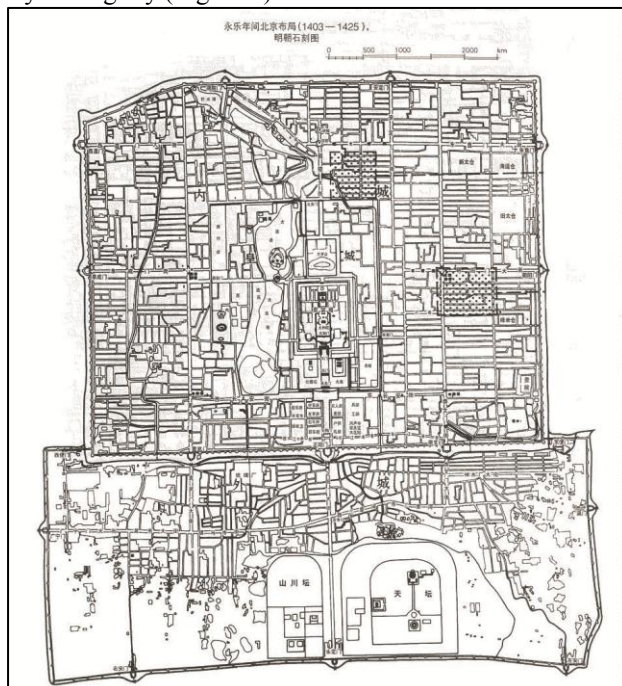


Figure 7: The city of Beijing in Ming Dynasty Source: The city record. (Wang, 2004)

### 1.2.3.3. Beijing in the Qing Dynasty (1644-1912)

In the beginning of 17th Century, the Manchus emerged from northeastern China and expanded their power towards the Chinese heartland. In 1644 the Manchus captured Beijing from Li Zicheng, the leader of the peasant revolt which ended the Ming Dynasty in same year, and then moved their capital from Shenyang to Beijing; this represents the beginning of Qing Dynasty (1644-1912).

The emperors of the Qing Dynasty did not make major changes to the city. Most of the old palaces, buildings,

and monuments of the Ming Dynasty were simply repaired and reused in the Qing Dynasty. The city remained at the same site and the Forbidden City was still used as the Royal Palace. The only change was that the Forbidden City was decorated with the Jurchen script and some of the gates were renamed. For example the Da Ming Gate was renamed as the Da Qing Gate.

When the new dynasty had, by the end of the 17th century, recovered from the economic effects of the changeover of dynasties, the emperors of Qing Dynasty began to construct many palatial gardens in and around Beijing (Figure 8). Most of these gardens were located in the northwestern part of Beijing. In 1684, the Kangxi Emperor of Qing Dynasty built the Changchun Garden at the site of Qinghua Garden of the Ming Dynasty (today's Beijing University) and died in this garden in 1722. Another famous palatial garden which was built by the Kangxi Emperor in 1707 was Yuanmingyuan Garden. It was decorated luxuriously with European Baroque-style buildings in the era of the Emperor Qianlong (1736-1796) and was praised as the Chinese Versailles. Another famous royal garden, Yiheyuan Garden (the Summer Palace), was built in 1750. These and the other royal gardens constituted the famous landscape of “three hills and five gardens” in Qing Beijing. Tragically most of them were destroyed by British invaders during the second Opium War in 1860 and the allied armies of eight nations in 1900. However the physical configuration of Beijing in the Qing Dynasty remains today and deeply influenced the planning and city development of modern Beijing.

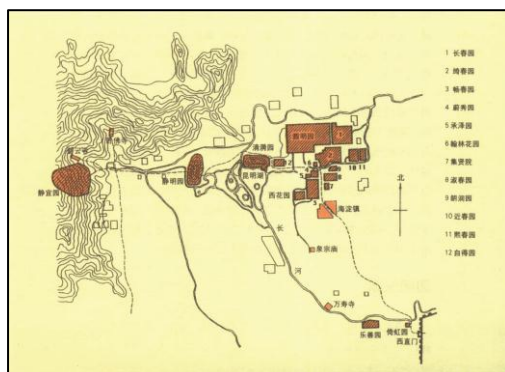


Figure 8: The Palatial gardens in the surroundings of Beijing during the Qing Dynasty. Source: The city record. (Wang, 2004)

## 2. Methodology

### 2.1. Aims

The past of any city is a key to the present and the future of that city (Zhu, 1993). Hence the history of Beijing's imperial city will shed light on many of the city's current issues and problems. The aim of this study is four-fold:

- To review the history of planning of Beijing's imperial city from the Yuan Dynasty to Qing Dynasty;
- To evaluate the sustainability of planning of Beijing's imperial city by inventory analysis with the framework PEBOSCA, addressing the seven resources which are included in this framework
- To analyze Beijing as an imperial city using an interdisciplinary approach;
- And finally, to extract implications for sustainable community development.

### 2.2. Methods

This study uses a case study approach and a sound comprehensive theoretical framework. The case study will focus the history of Beijing as an imperial city of China and will be presented via the PEBOSCA framework and an interdisciplinary approach.

The PEBOSCA framework which was proposed by Berg and Nycander (1997) is a theoretical, qualitative model for resource management in communities. It inherits from the UN HABITAT agenda a fundamental premise that sustainable habitation involves physical as well as biological, social, organizational, economic, cultural and aesthetic dimensions and it 'touches the living spaces for humans, the relevant spheres where we live our everyday life' (Berg, et al, 2010). The framework of PEBOSCA, in principle, can be applicable at any community scale – 'from small neighborhood area in urban or rural settings with 500 inhabitants to a whole town with 10000 residents or even a city inhabited by up to many millions of inhabitants' (Berg, et al, 2010). Material including maps of and literature relating to Beijing's imperial city will support the PEBOSCA inventory analysis.

Moreover, the city will be investigated at two organizational levels – the single building as a basic unit of the city, and the city as a whole – using an interdisciplinary approach. An interdisciplinary approach is widely used in the modern urban studies. In this study, the city will be analyzed within the intersection of disciplines of civil engineering, urban ecology, philosophy and landscape design etc.

### 2.3. Boundary

There are two important kinds of boundaries which should be defined in this study: the time boundary and the geographic boundaries. The city's history is divided into three phases: the pre-imperial city history from 1045 B.C. to 937 when Beijing was a regional city; the early imperial city history from 938 to 1266 when Beijing was a regional capital; the imperial city's history from 1267 to 1911 when Beijing was the imperial city of China. The last phase will be the focus of this study which included Yuan, Ming and Qing dynasties before the Republic of China was founded in 1912. The configuration of Beijing's imperial city was formed in the Yuan Dynasty and shaped in Ming and Qing dynasties and is still the core of the present Beijing municipality. Hence the geographic boundaries of this study refer to the region of Beijing city center within the 2nd Ring Road of modern Beijing. (Figure 9)

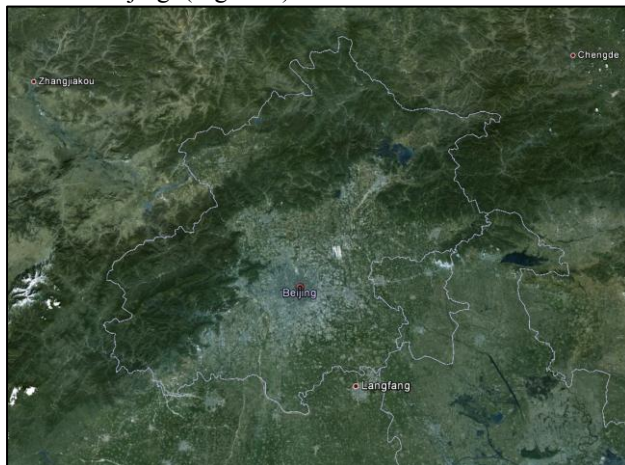


Figure 9: The geographic boundary of the study. Source: Google Earth



## 2.4. Limitations

The core task of this study is to evaluate the sustainability of Beijing's imperial city planning. Therefore, historical records and materials are essential. Chinese history was largely recorded by written texts and therefore lack of quantitative data is the primary limitation in this research.

### 3. Inventory analysis

In this section, information concerning the state of seven types of resources vital for sustainability of a community – including physical, economic, biological, organizational, social, cultural and aesthetic resources – in the imperial city history of Beijing will be collected and assessed within the PEBOSCA framework.

#### 3.1. Physical resources

Physical resources “must be able to nourish the population to secure a sustainable life support (Berg, et al, 2010)”. Within the ancient city of Beijing, physical resources included water, food, energy and other materials. Additionally, the natural climate and geography of the area will be considered in this section.

##### 3.1.1. Geography

Beijing is situated at the meeting point of the Yanshan Mountains, Taihang Mountains and the Northern China Plain. It adjoins the Taihang Mountains and Shanxi Plateau to the west, the Yanshan Mountains and Inner Mongolia Plateau to the north and the Songliao Plain to the northeast. It is approximately 150 kilometers to the Bohai Sea Gulf to the southeast. (Figure 10)

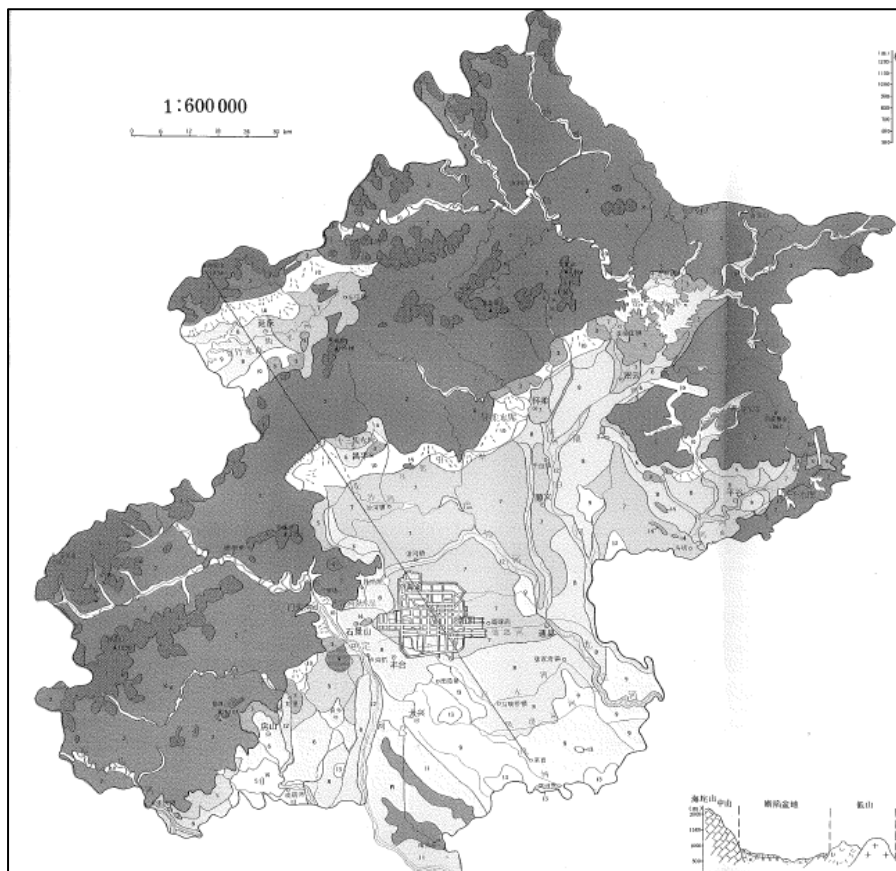


Figure 10: The geography of Beijing. Source: Beijing lishi dituji, Volume 2. (Hou, 1997)

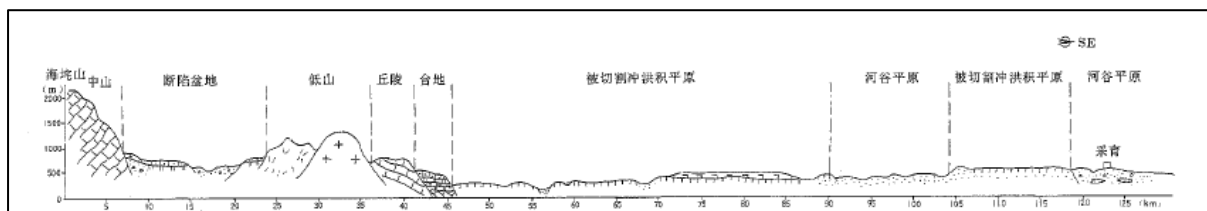


Figure 11: The topography of Beijing. Source: Beijing lishi dituji, Volume 2. (Hou, 1997)

Beijing is centered at 39°54'24" N and 116°25'29" E and located at the northwestern tip of the North China Plain. The Beijing municipality is 176 kilometers long from north to south and 160 kilometers wide from east to west. It has a total area of about 16410 square kilometers including the plain area of 6338 square kilometers which

accounts for 38.6% and the mountainous area of 10,072 square kilometers which accounts for 61.4% (Hou, 2009). Since Beijing is surrounded by mountains on three sides, the topography gradually decreases from west to east (Figure 11). The elevation in the plain the region and the mountainous region is about 20-60 meters and 1000-1500 meters respectively, and central Beijing's elevation is about 44 meters. The Dongling Mountains to the west of Beijing and on the border with Hebei Province are the highest point of this area with an elevation of 2303 meters while Caichangtun in eastern Beijing is the lowest point of this area with an elevation of 8 meters. This unique geographic landscape significantly influenced the origin and the development of Beijing.

### 3.1.2. Climate

Located in the warm temperate zone of East Asia, Beijing has a sub-humid continental monsoon climate featuring four distinct seasons. Spring is windy with sandstorms and winds from the Mongolian steppe. Summer is hot and humid. Autumn is sunny and clear but quite dry. Winter is generally cold, windy and dry. Spring and autumn are very short, lasting for two months and one and half months respectively; summer and winter are very long, lasting for three months and five months respectively (Hou, 2009). The annual average temperature is about 11-12 °C. The highest temperatures are about 35-40 °C, often in July and August, while the lowest temperatures are about -14 to -20 °C, always in January. There are 180-200 frost-free days per year in most areas but fewer in the western mountain area (Hou, 1997). (Figure 12)

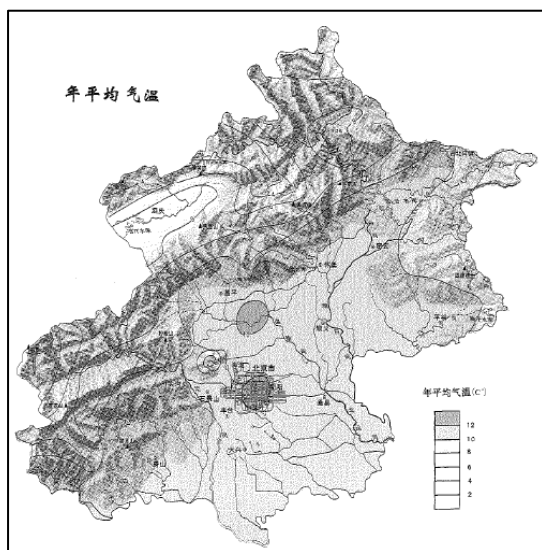


Figure 12: The climate situation in Beijing. Source: Beijing lishi dituji Volume 2. (Hou, 1997)

Annual sunshine hours in most parts of Beijing are about 2600-2750 hours. The average solar radiation in Beijing is at 132.9 kcal per square centimeter, maximum in autumn and minimum in winter. (Figure 13)

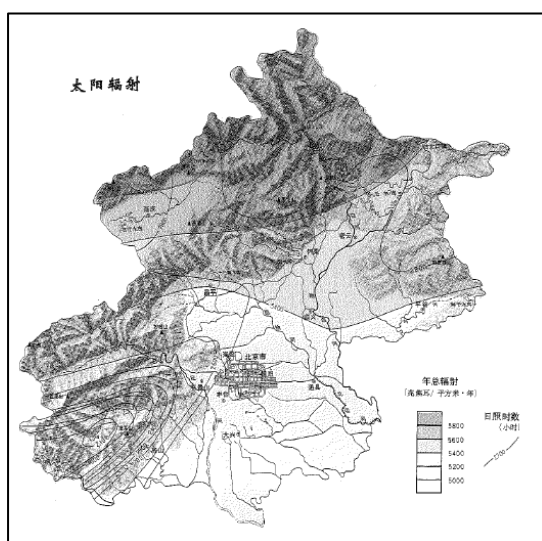


Figure 13: The solar radiation in Beijing. Source: Beijing lishi dituji Volume 2. (Hou, 1997)

Beijing has a monsoon climate. 60% of the precipitation is in July and August while the other seasons are quite dry. The average precipitation of Beijing is about 626 mm and it is one of the areas with the highest rainfall in Northern China (Hou, 1997). (Figure 14)

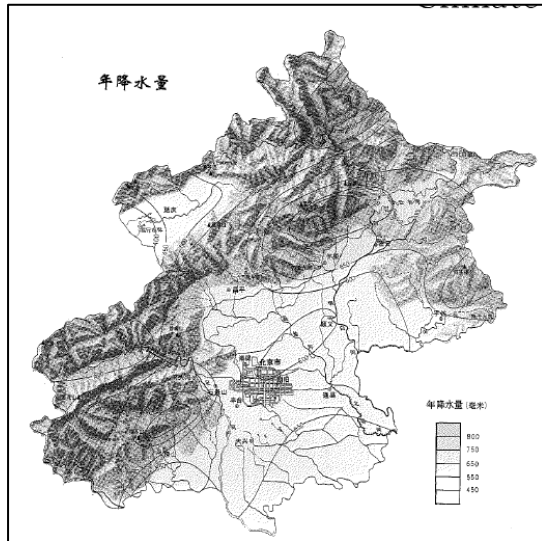


Figure 14: The precipitation in Beijing. Source: Beijing lishi dituji Volume 2. (Hou, 1997)

### 3.1.3. Hydrology

Beijing is located in the Hai River basin and more than 100 rivers flow through the city. The total length of these rivers is more than 2700 kilometers and the annual runoff reaches 2.599 billion cubic meters (Hou, 1997). There are five river systems of the Haihe River basin in Beijing. They are the Daqing River system, the Yongding River system, the North Grand Canal system, the Chaobai River system and the Ju River system from west to east. The North Grand Canal system originates within the region of Beijing while the other four river systems flow in from outside Beijing; all of them ultimately flow south and empty into the Bohai Sea (Figure 15).

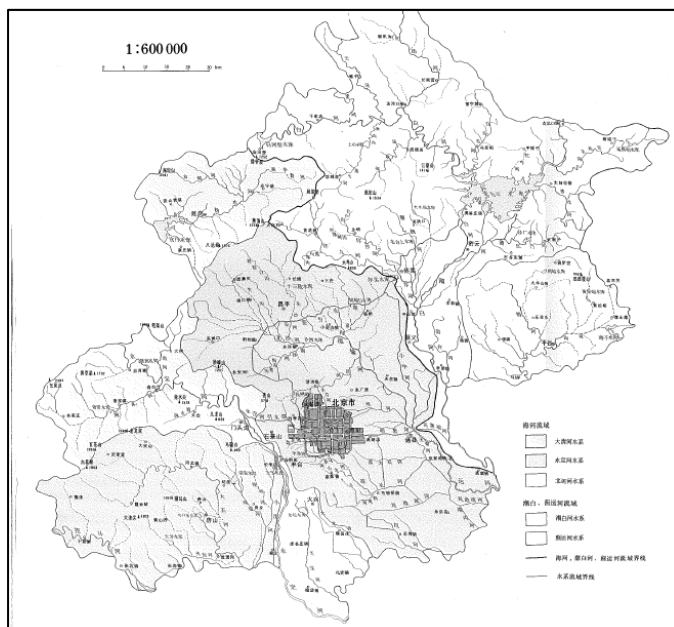


Figure 15: The hydrology of Beijing. Source: Beijing lishi dituji Volume 2. (Hou, 1997)

The Daqing River system flows from Hebei Province and the Juma River, Dashi River and Xiaoqing River are the three main branches of it. The Yongding River system flows from Shanxi Province and it is the largest river which provides the major water resources via the Guanting Reservoir to the city. The North Grand Canal system originates from the Changping district and is linked to the Grand Channel in Tianjin. It is the main drainage

river system of Beijing in its imperial city period. Chaobai River system rises from Hebei Province and is another important water source for the city. The Miyun Reservoir in its upper reaches has been the main source of water for Beijing since the Yuan Dynasty. The Ju River system flows from Hebei Province. Due to the uneven temporal distribution of precipitation, these rivers show variable flow within the year and inter-annual variability of run-off, especially the Yongding River. This variability is part of the reason why massive watercourse constructions were undertaken during construction of Dadu in the Yuan Dynasty.

### 3.1.4. Energy

Beijing consumed a lot of energy as the imperial city of China in the Yuan, Ming and Qing Dynasties. The firewood and charcoal from the forests in the surrounding areas of Beijing were the main energy sources before the coal in the western area of Beijing was massively exploited and utilized in the Yuan Dynasty. Although the residents of Beijing began to exploit and burn coal from the Liao and Jin Dynasties, coal was the main energy sources only for the imperial family and the handicrafts industry within the imperial city until the Yuan Dynasty. Until the mid-15th century, Beijing residents still heavily relied upon wood for heating and cooking (Sun, 2007). With the increase of population in the Yuan and Ming Dynasties, the need for the firewood from ordinary families increased rapidly accordingly. This resulted in the deforestation in the surroundings of Beijing and it also prompted a shift in energy supply from firewood and charcoal to coal in Qing Dynasty. Coal became the main energy source for the residents of Beijing after steam power was applied in mining coal and transportation at the end of Qing Dynasty.

## 3.2. Economic resources

The prudent management of economic resources is a fundamental part of sustainable community development (Berg, 2010). The growth of population and the Jinghang Grand Canal as economic resources will be discussed in this part due to its important influence to the local economy development of Beijing's imperial city.

### 3.2.1. The population growth of Beijing in different historical periods

Population is one of the fundamental elements of human society and one of the most important economic resources for economic development of Beijing in Yuan, Ming and Qing Dynasties. Based on Han Guanghui's research on Beijing's population history (1996), population growth in Beijing during different periods is summarized in Table 1.

**Table 1: The population of Beijing in its history. Source: The historical demology and geography of Beijing. (Han, 1996)**

<b>Dynasties</b>	<b>Year</b>	<b>Households</b>	<b>Population</b>
Early Western Han	(206 B.C.)	20740	70685
Early Eastern Han	(57 A.D.)	44550	280600
Eastern Wei	(534-550 A.D.)	4600	170000
Sui Dynasty	(609)	91658	458000
Early Tang Dynasty	(618)	21098	102079
Middle Tang Dynasty	(742)	67242	371312
Liao Dynasty	(938)	N/A	100000/22000*
Liao Dynasty	(1142)	N/A	583000/150000*
Jin Dynasty	(1215)	108000	100000*
Jin Dynasty	(1216)	N/A	285000/91000*
Song Dynasty	(1270)	N/A	418000*
Yuan Dynasty	(1327)	N/A	952000*
Yuan Dynasty	(1369)	N/A	95000*
Ming Dynasty	(1448)	N/A	960000*
End of Ming Dynasty	(1643)	N/A	200000*
Qing Dynasty	(1647)	N/A	539000*
Qing Dynasty	(1781)	N/A	776242*
Qing Dynasty	(1881)	N/A	776111*

Three features of population change in the history of Beijing's imperial city can be summarized:

- The increase or decrease of the population at a specific time in the history of Beijing's imperial city had a strong relationship with peace and warfare. When a dynasty replaced another, the population tended to decrease and while a dynasty was in peace the population often increased.

- Growth in population often accompanies economic development and as was partly proved by the urban economic development in Yuan, Ming and Qing Dynasties.
- Change of population was consistent with the imperial city planning of Beijing during the Yuan, Ming and Qing Dynasties.

### 3.2.2. The Grand Canal

The Grand Canal, also named as the Jinghang Grand Canal, is the longest artificial river in the world with a total length of 1795 kilometers (Shan, Ge and Sun, 1992). It links the North China Plain and the prosperous Yangtze River Delta in the south, flowing through the Hai River, Huang River, Huai River, Yangtze River and Qiantang River in eastern China. The oldest parts of the Grand Canal date back to the Spring and Autumn Period in the 5th century B.C. and the main parts of the canal were built in the Sui Dynasty (581–618 A.D.). Beijing is the northern terminus of the Grand Canal and the part of the canal within Beijing municipality is called the North Canal and links up with the Yongding River in Beijing. The Grand Canal is made up of several smaller canals: the Tonghui River, North Canal, South Canal, Lu Canal, Middle Canal, Li Canal and Yangtze Canal from north to south. (Figure 16)



Figure 16: The Grand Canal. Source: Baidu Baike. <http://baike.baidu.com/view/17593.htm>

The Jinghang Grand Canal consisted of Yongji Canal which was built in 608 linking Luoyang with Beijing, Tongji Canal which was built in 605 linking Luoyang with Huaian and the Jiangnan Canal which was built in 610 linking Hangzhou with Zhenjiang. The construction of the Jinghang Grand Channel was not finished within the Sui Dynasty and continued in the Tang Dynasty (618-907). Although the Grand Canal was designed to consolidate the rule of the central government over the whole country, it did promote the exchange of foods and goods between the North China Plain and the Yangtze River Delta. It allowed faster and easier trading and stimulated Beijing's urban economy, allowing import of greater volumes of grain to sustain a larger population.

### 3.2.3. The city markets in Beijing during Yuan, Ming and Qing Dynasties

The distribution of markets within the Beijing's imperial city demonstrates the economic development of Beijing during Yuan, Ming and Qing Dynasties. There were more than 30 specific markets scattered in the Yuan's Dadu but the three main markets were located in Dongsì, Xisi and the north shore of Jishuitan. The Drum Tower Market which was on the north shore of Jishuitan and close to the wharf of the Grand Canal was the biggest market. The Yangjiao Market in Xisi was for the exchange for livestock and the Jiao Market in Dongsì was the business center in the eastern part of Dadu. The Tonghui River became the main route of water transportation after the middle of the Yuan Dynasty and thus most of the warehouses became located in the eastern part of Beijing. (Figure 17)

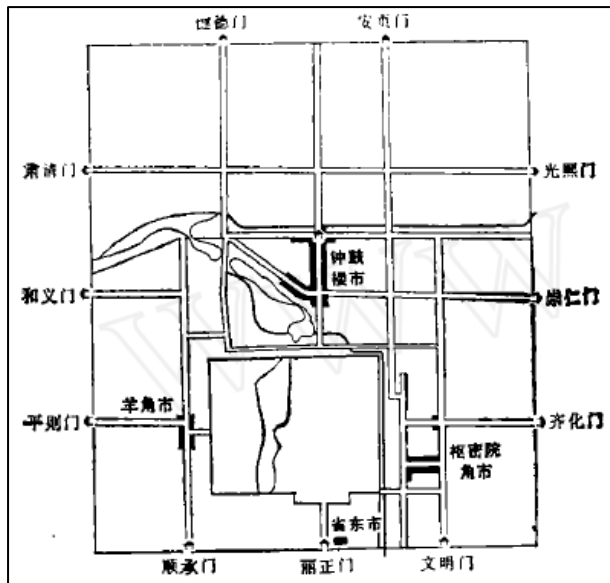


Figure 17: The distribution of markets in Yuan's Dadu. Source: On the historical change of markets and their locations in Beijing. (Gao, 1989)

Since the northern city wall moved south in the early years of Ming Dynasty, the Drum Tower Market reduced in importance and a new commercial center appeared at the Di'anmen to the south of the Drum Tower Market. In order to promote business prosperity, the government of the Ming Dynasty built many houses and stores at the four gates of the palace city; the Drum tower, Dongsi, and Xisi and the main commercial markets were distributed in these areas. (Figure 18)

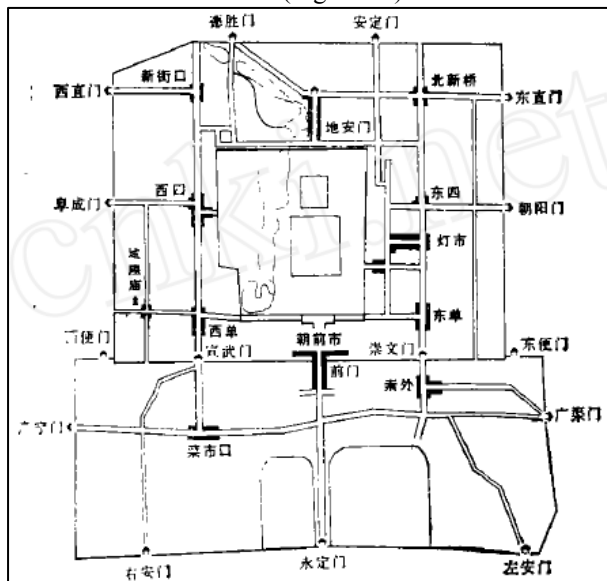


Figure 18: The distribution of markets in Ming's Beijing. Source: On the historical change of markets and their locations in Beijing. (Gao, 1989)

The expansion of Palace City walls in the middle of the Ming Dynasty occupied the part of the Tonghui River which resulted in the abolishment of water transportation. All the goods from the Grand Canal had to be unloaded at Tongzhou and then transported into the city from the Chaoyang Gate. Therefore most of warehouses were located in the eastern part of the inner city in the Ming Dynasty.

Beijing was divided into two parts after the outer city wall was built at the end of the Ming Dynasty. Many businessmen and craftsmen gathered in the outer city. The Chaoqian Market was the biggest one which located in the Zhengyang Gate while the other two markets located in the Daming Gate and the old site of Jin Zhongdu (Caishikou). In particular, the rise of the temples in the Ming Dynasty also promoted a new commercial fair, the temple fairs such as the Huguo Fair, which are like monthly bazaars held around temples.

The entry of Manchu troops into inner Beijing in the early Qing Dynasty made the city overcrowded and caused the decline of commercial markets within the inner city. With the decline of the separation system between Manchu and Han people, commerce began to increase again in the late of Qing Dynasty. New commercial centers appeared at the major intersections in Beijing and most of Beijing's oldest brands were founded in the Qing Dynasty. (Figure 19)

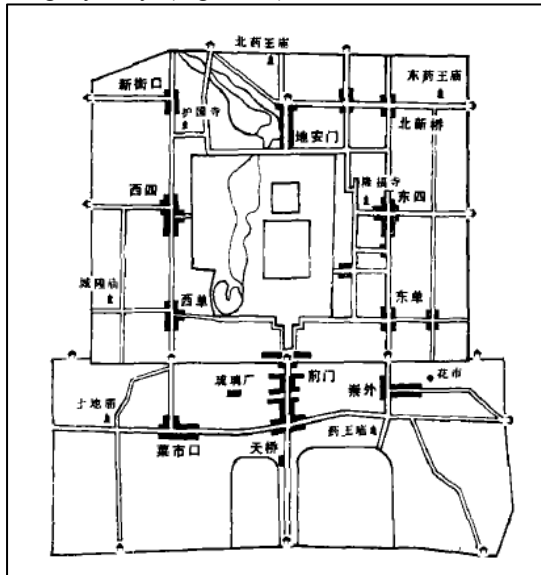


Figure 19: The distribution of markets in Qing Dynasty. Source: *Beijingcheng de qiyuan yu bianqian*. (Hou and Deng, 2001)

### 3.3. Biological resources

The ecosystem services offered by biological resources such as the ability of plants and algae to oxygenate the air through photosynthesis are a prerequisite for all higher life on earth (Berg, et al, 2010). The local soil and vegetation in ancient Beijing will be outlined in this section as well as the gardens subsequently created.

#### 3.3.1. Soil and Vegetation

The soil in Beijing can be categorized into seven types of soils: the alpine meadow soil distributed in the platform and gentle slope at the top of the hills with altitude above 1900 meters; the mountain brown soil distributed in the middle of the hills with the altitude of above 700-800 meters; the "cinnamon soil" is the most widespread kind and is distributed in the foothill plains and hilly areas with altitude between 40-700 meters; the moist soil is mainly located in the flood plains and mountain valleys; the meadow swamp soil and paddy soil found in the marshes and wetlands; the aeolian sandy soil is located on the both sides of the Yongding river, the Chaobai River and the other rivers. (Figure 20)

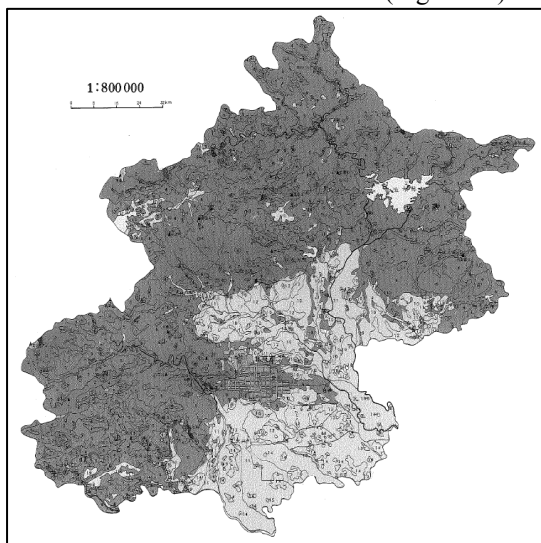


Figure 20: The soil types in Beijing. Source: *Beijing lishi dituji*, Volume 2. (Hou, 1997)



The diversity of topography, climate and soil in Beijing is in accordance with the rich types of vegetation and complexity of composition of species. The typical vegetation in Beijing is deciduous broad-leaved forest of the warm temperate zone and coniferous forest of the temperate zone. The vegetation in mountain areas consists of alpine meadows, with birch forests and pine birch forests, while the vegetation in the plains is cultivated vegetation. (Figure 21)

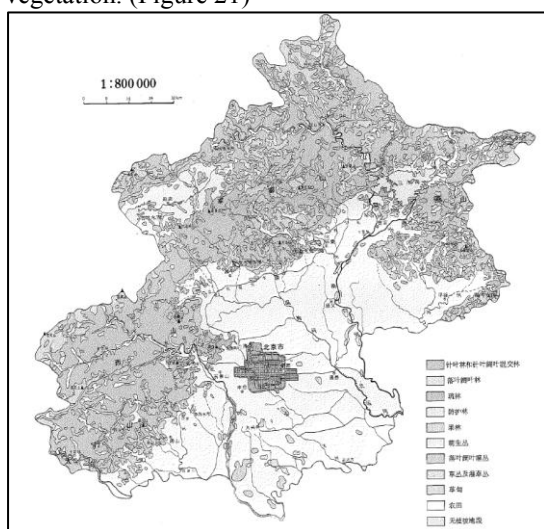


Figure 21: The vegetation in Beijing. Source: Beijing lishi ditu, Volume 2. (Hou, 1997)

### 3.3.2. The Chinese gardens in Beijing during Yuan, Ming and Qing Dynasties

Chinese gardens integrated the natural landscape into human habitation and created a more livable environment for the residents of Beijing's imperial city. The Royal Gardens in Yuan Dadu were centered at the Wansui Hill and the Taiye Pond. The Longfu Palace and the Xingsheng Palace lay in its west and the Dongling Garden lay in its east. The nobility also built gardens all over the city, for example the Shufang Pavilion, the Wanchun Garden, and the Tsinghua Pavilion. The entertainment gardens for the civilians were also further developed in the Yuan Dynasty.

The Chinese gardens expanded greatly when Yongle Di of the Ming Dynasty decided to move the capital to Beijing. He ordered the construction of several royal gardens within and outside the Imperial City. Alongside the Royal Garden in the Forbidden City, there was the East Garden, the West Garden outside of the palace city, while the South Garden and the Shanglin garden were built outside the Imperial City.

The construction of Chinese gardens during the Qing Dynasty was shifted to focus on the Summer Palaces in the outskirts of Beijing's imperial city. The Jingming Garden and the Changchun Garden were built in the western suburbs of Beijing. Another feature of the Chinese gardens under the Qing Dynasty was that the nobility was the main driver for their development. There were dozens of Chinese gardens constructed for the nobility which included the Chun Prince Garden, the Gong Prince Garden and the Zheng Prince Garden. They were influenced strongly by the magnificent and splendid features of the Royal Gardens (Figure 22). The Royal Gardens and the private gardens for the nobility constituted the unique green structures of Beijing's Imperial City.

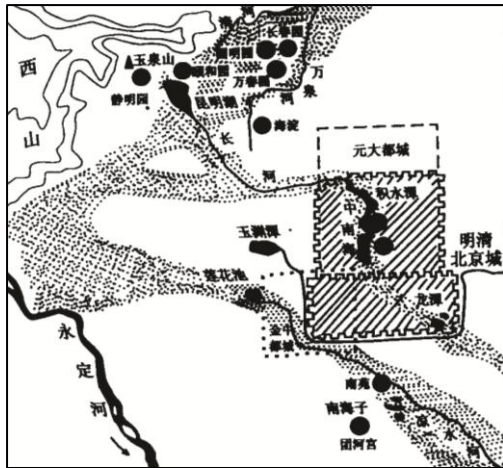


Figure 22: The Chinese Garden within and outside of Beijing. Source: *Beijingcheng de qi yuan yu bianqian*. (Hou, and Deng, 2001)

### 3.4. Organizational resources

A community can never be sustainable unless its houses and its immediate outdoor environments are well-built and planned and its local community area's functions are well organized (Berg, 2010). In order to assess the organizational resources on sustainability of Beijing's imperial city better, the city layout and the road system in Beijing's imperial city will be studied.

#### 3.4.1. The city layout

Beijing was the largest city of China during the Yuan, Ming and Qing dynasties. It represents a typical Chinese imperial city organizational system which can be seen from its layout during this period. In general, Beijing's imperial city was a multi-walled and rectangular city consisting of the Palace City, the Royal City and the Imperial City. The Forbidden City, which was an enclosed area for royal families, lay in the core of the Royal City and remained in keeping with the existing axial symmetry. The court lay in the front of the Royal City and the commercial markets lay behind, while the Temple of Ancestors and the Altar of Land and Grain were located on the east and west sides of the Royal City respectively. The Drum Tower, the Bell Tower, the Altars of the Sun, the Moon, the Heaven and the Earth scattered around the Imperial City. The thoroughfares linking between the opposite gates separated the city into several districts and made the city looked like a chessboard. Quadrangles, a typical building pattern in the Beijing area since Yuan Dynasty, were built next to one another along the streets and alleys.

##### 3.4.1.1 The city layout of Beijing in Yuan Dynasty

Yuan Dadu was a triple-walled city in a concentric pattern. The outer wall measured more than 28.6 kilometers in perimeter and had eleven gates, three on each three sides except the north side which had two. Four turrets were built at the corners of the city walls and it was surrounded by a moat. The outer city wall was built with earth and covered with the reeds to prevent erosion. The shape of the outer city wall was a trapezium which the width of the top and the bottom were 8 and 24 meters respectively and 16 meters high. The second outer wall was 9.35 kilometers in length and it was also built with the soil. The area enclosed by the second outer wall was the Royal City. The palace city was in the east of the Royal City and it was protected by the third city wall which was about 3.5 kilometers in length. The city layout of Yuan Dadu was not exactly symmetrical because of the natural watercourse in the west of the city center. The Taiye Pond and the Qionghua Island was the center of Dadu and the Palace City and the royal palaces were located in the west and east sides of them (Figure 23).



Figure 23: The city layout of Yuan's Dadu. Source: Beijing lishi dituji, Volume 1. (Hou, 1989)

The geographic center of the Dadu was a pavilion which lay in the present Drum Tower. The Ancestral Temple and the Altars of Soil and Grain were also on the east and west of the city respectively. The highest building in Dadu was the Royal Palace. The city was divided into 50 districts and quadrangles firstly appeared in Beijing since then. All of these shaped the unique layout of Beijing in the Yuan Dynasty.

### 3.4.1.2. The city layout of Beijing in Ming and Qing Dynasties

Although the palaces of the Ming Dynasty were built on the same site as the Yuan Dadu, the indentation of the north city wall and the expansion of the south city wall had changed the city layout of Beijing in Ming and Qing Dynasties greatly. Moreover, the construction of a south defensive wall in the middle of the Ming Dynasty added a new part to the previous imperial city. The newly added part was called the Outer City while the rebuilt Dadu was called the Inner City in Ming and Qing Dynasties. In addition the city wall was rebuilt with bricks instead of the earth of the Yuan Dynasty. These changes shaped the city layout of Beijing in the Ming Dynasty and the whole imperial city looked like a combination of two rectangles (Figure 24).

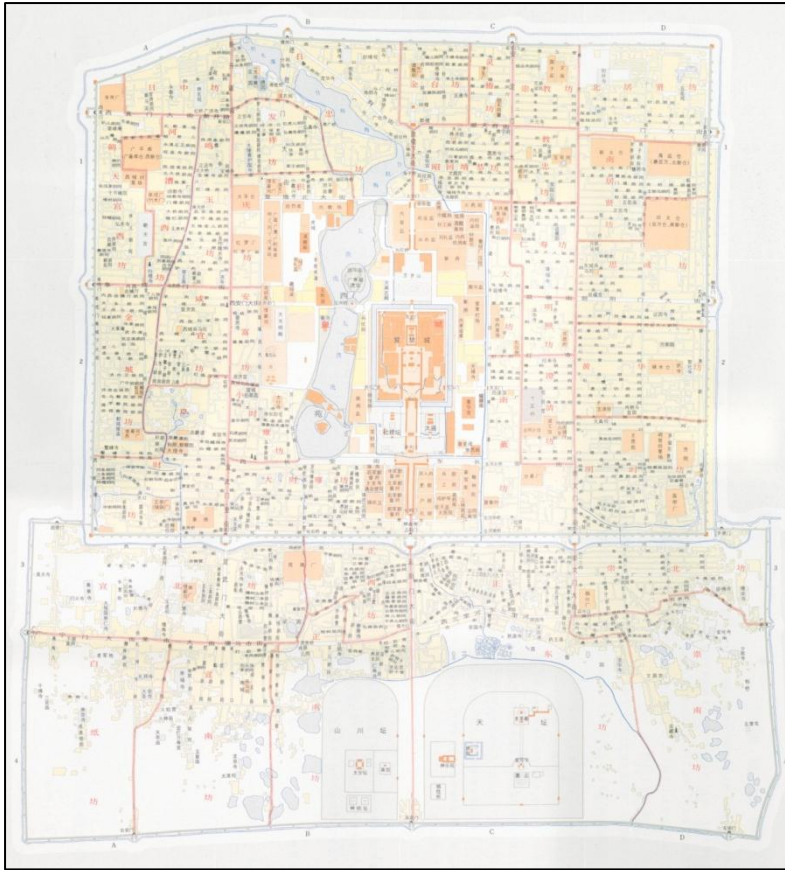


Figure 24: The city layout of Beijing in Ming Dynasty. Source: Beijing lishi dituji, Volume 1. (Hou, 1989)

The rebuilt Inner City wall measured 22 kilometers in perimeter and nine gates were positioned along the Inner City wall, three on the south side and two in each other three sides. The newly constructed Outer City wall was 14 kilometer long and seven gates were placed along it, two in north side, three in the south side and each one in east and west sides. The Royal City lay in the south center of the Inner City and its wall was 9 kilometers long. It had one gate in each side but triple gates in the south side which emphasized royal majesty. The moat was dug deeper in the Ming Dynasty and the soil from the digging of the moat was placed behind the Forbidden City. It was then called “Mei Shan” (Today’s Jing Hill in the north gate of the Forbidden City) which was the highest point of the whole of Beijing in the Ming Dynasty.

The city layout of Beijing in the Ming Dynasty was inherited by the following Qing Dynasty with the addition of a new temple and altars. The Royal City was a place only for residence of the royal families and remained unchanged until 1912. The south gate of the Forbidden City, the Tian’an Gate, was reserved for the emperors.

The symmetry and the coherence of the city layout of Beijing in Ming and Qing Dynasties were more obvious than under the dynasties before them. A uniform city axis was present (Figure 25) and the palaces and the other buildings were placed along this axis. Compared with the enormous spatial arrangement in the city layout of Yuan Dadu, the compact city spaces of Beijing in the Ming and Qing Dynasties posed more pressure on the arrangement and distribution of the Chinese courtyards. Although the courtyards were still grouped side by side into the districts, but the size of it became smaller while the direction and space allocation kept the same. This will be discussed more detailed in the next section.



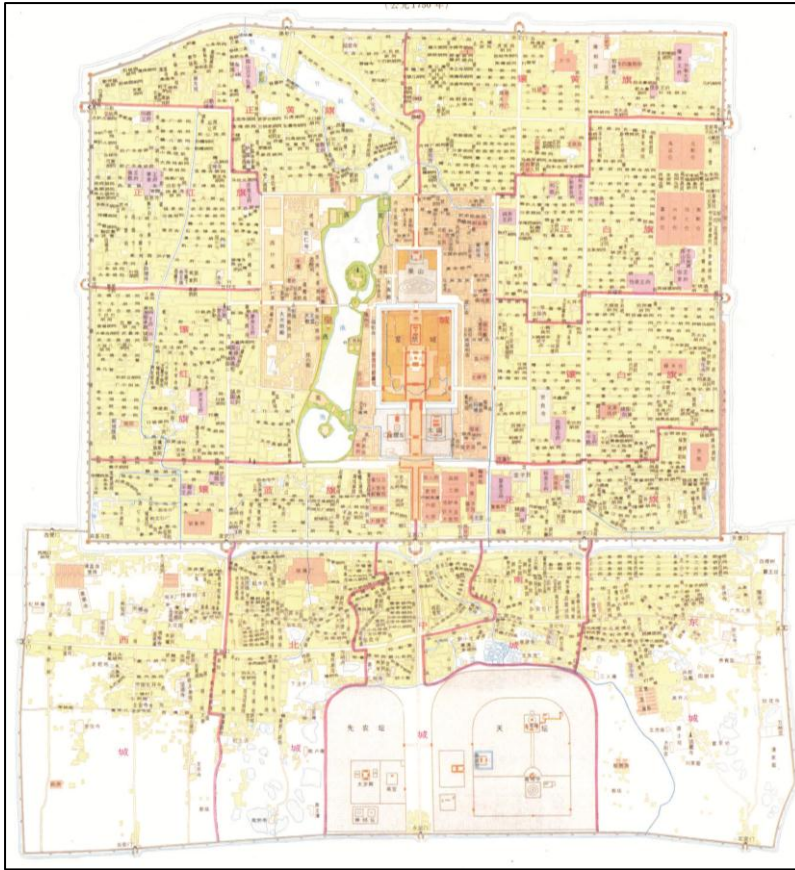


Figure 25: The city layout of Beijing in Qing Dynasty. Source: Beijing lishi dituji, Volume 1. (Hou, 1989)

### 3.4.2. The transportation system in Beijing imperial city

There were three types of roads within the imperial city: the thoroughfare, the street and the alley. (Figure 26)



Figure 26: The imagined image of road system in Beijing imperial city. Source: Zhang Wei

The thoroughfare was the main pattern of the road system in Beijing's imperial city which was about 24-30 meters in width. It linked every two opposite city gates and provided enough spaces for four carriages to run on its side by side. The street was the second pattern of the road system which was about 12-15 meters in width.

Two carriages could easily run on it and it linked the thoroughfares and divided the city into different districts with the thoroughfares. The third pattern of road system in Beijing was the alley which was the space between the different Chinese courtyards. The local dwellers called this alley “the Hutong” and it was 6-7 meters width. The residents could easily access the courtyards with the sedan chair, another typical transportation tool.

### 3.5. Social resources

Even if a community succeeds in creating a renewable life support system, affordable housing, access to valuable green spaces and well organized townscapes, it still cannot be sustainable with bad social relations among its members (Berg, et al, 2010). The social hierarchy system and the city block system as the social resources will be studied to obtain a clear picture on the sustainability of Beijing’s imperial city.

#### 3.5.1. The social system in Beijing imperial city

Chinese history from the Zhou Dynasty to the Qing Dynasty is defined as the feudal period by historians and the feudal system was the governing political and social system of Beijing’s imperial city from the Yuan Dynasty to Qing Dynasty.

The basis of feudalism in China is the ownership of land. All land belonged to the emperor and all the people were subject to the emperor at different levels. Since the unification of the Qin Dynasty in 221 B.C., the whole country was divided into several commanderies instead of the fiefs ruled by the vassals. The centralized administration system was established to take the responsibility for ruling the country on behalf of the emperor. The hereditary system was implemented for dealing with the succession of the throne in China. After the emperor died, the eldest son succeeded. The same order was copied in the inheritance of family property and family decision making. The society was constructed based on the closeness of the patriarchal and consanguine relationships.

The philosophy of the feudal system in China was Confucianism. Confucius emphasized the role of rites in the social structure and relationships and valued these as the fundamental order of the family, the society, the country, and even the universe. Within the framework of Confucian rites, loyalty and filial piety were the two basic principles of the five essential relationships of Confucian ethics and virtue between the emperor and the people, the father and the son, the husband and the wife, the brotherhood and the friends in Chinese society and families. These features of the feudal system influenced the social structure of Beijing and were deeply embedded in the architecture, city configuration and the common people’s daily life.

The impacts of the Chinese feudal hierarchy on the architecture and the configuration of cities were clear. According to the rites, the cities in the Chinese feudal society were categorized into three kinds of city with different sizes and layouts: the biggest one was the imperial city for the emperors, the medium one was the state capital for the nobles and the smallest one was the capital city for the officials (Xiang, 2009). Meanwhile, there were specific regulations on the format and the distribution of the ceremonial buildings. (Table 2).

*Table 2: The features of city layout of three types of cities in Chinese feudal hierarchy system. Source: Xiang, 2009*

	Height of city wall	Road width	Palaces	Gates each side
Imperial city	20-25 meters	12-16 meters	7	3
State capital	15-20 meters	10-12 meters	5	2
Capital city	12-15 meters	8-10 meters	3	1

There were also strict regulations in the single buildings for the officials at different levels which (Table 3).

*Table 3: The features of single building in Chinese feudal hierarchy system. Source: The ancient history of Chinese architectures. (Liu, 1984)*

Class	Rooms	Height of stylobate
Emperor	N/A	1.8-2 meters
Duke and marquis	19-21	1.5-1.8 meters
High level officials	14-15	1-1.2 meters
Medium level officials	12-14	0.6-0.8 meters
Low level officials	8-12	N/A

### 3.5.2. The city block system in Beijing

A city block is the basic unit of a residential area within a city (Liu, 2007). The typical block system in Beijing's imperial city is the Lifang system which originated from the well-field system in the Spring and Autumn Period and flourished in Sui and Tang Dynasties. The Chang'an city of Tang Dynasty and the Kaifeng city of Song Dynasty are two typical cases of the Lifang system before Yuan Dynasty. When designing Yuan Dadu, the Mongols took this system from Kaifeng, the conquered capital of the Song Dynasty.

Literally, a Lifang is a square which each side is 1 li (0.5 kilometer) long with an enclosed wall, two or four gates and a decorated archway. A crisscross main road divides the Lifang into four parts and a smaller crisscross alley in each part separates it into 16 smaller areas. (Figure 27). The imperial city was made up of a lot of Lifangs with specific functions and looked something like a chessboard. It is important to note that a Lifang is not only a basic unit in city construction, but also a basic unit in the city's administrative system. A certain number of households were organized into a Lifang and each Lifang was designed for residential, commercial, security or administrative purposes. The enclosed wall and the ditch surrounding the Lifang isolated it with the others. The Lifang system was neat and easy to administer and was thus widely used in ancient Chinese city planning.

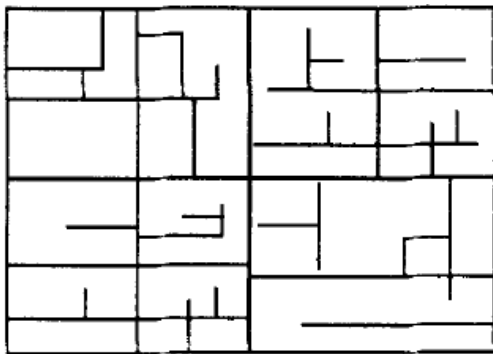


Figure 27: The layout of Lifang System. Source: Liu, 2007.

The Lifang system in Beijing's imperial city was different from that in Chang'an and Kaifeng. The Lifang in Beijing was more open. The Lifang wall, ditch and the gates were abandoned but the archway was reserved as a benchmark or symbol of the place (Picture 4). More groceries, restaurants and service facilities were built along the crisscross road within the Lifang and served its residents. The difference between the different Lifangs' functions blurred and the Lifang system had evolved into the street system in the Ming and Qing Dynasties.



Picture 4: The archway in Beijing. Source: <http://www.nipic.com/show/1/62/23bc0018df3d0ab7.html>

### 3.6. Cultural resources

A community may still not be fully sustainable if it has not been adapted to its local culture (Berg, 2010). All local communities have their characteristic nature, its typical population with its unique worldviews, traditions and individual resources – all ingredients of communities' exclusive culture (Bokalders & Block, 2010; Berg et al, 2010). The cultural resources in Beijing's imperial including the adaptability of the local culture and the inclusion of extraneous cultures, ceremonies, festivals, and recreational activities will be examined in this section.

### 3.6.1. The ceremonies in Beijing daily life

In Chinese perceptions, there are four important stages in one's life: the birth of new life, the marriage of a new couple, the longevity of the aged, and passing away. Accordingly four important ceremonies are carried out in the ordinary family of Beijing. The anniversary drawing is a specific ceremony which is held at the first birthday of an infant. Several items will be prepared for the choosing ("drawing") of an item by the child. The parents then infer implication from the grasped item about the child's future life and express the best wishes to the child. For example the Chinese brush prefigures the wealth of knowledge and the abacus indicates the good fortune (Picture 5). The drawing is followed by a lunch.



Picture 5: The Anniversary drawing in Beijing common family.

Source: [http://www.daenwang.cn/chuantong/minjianxisu/custorm\\_8702.html](http://www.daenwang.cn/chuantong/minjianxisu/custorm_8702.html)

The Chinese wedding ceremony is usually hosted in the quadrangles and a small stage is built for the announcement of the marriage. The wedding is the last step before two young people start their married life together. Before it, several formalities including proposal, matching, engagement, and dowry will be made carefully between the two families. Even on the day of the wedding, the formalities of the wedding do not stop and many decorations and rituals are designed to commemorate the wishes and blessing for the new couple. (Picture 6)



Picture 6: The traditional Chinese wedding in quadrangle. Source: China News Net.

The celebration of the aged's birthday is the manifestation of the principal of filial piety within the ordinary Chinese family. The scope of the aged's birthday celebration varies based on the wealth of the family but the basic parts of this ceremony include the reception, congratulation, donation, banquet and theatre. The aged family member is the focus of this ceremony and noodles are prepared as the symbol of longevity (Picture 7). This ceremony is perceived by Chinese people as an expression of showing respect to the elderly and filial piety.





Picture 7: The special noodles prepared for the aged in their birthday.

Source: <http://blog.msn.soufun.com/23684308/11230490/articleDetail.htm>

The last important ceremony is the funeral of a family member. In Chinese belief, death means the beginning of the new cycle of the life. Therefore the funeral is also called the “white happiness”. The process of the white happiness is complicated and usually lasts for several days. A banquet is also prepared to host the visitors and the relatives. This is a Chinese way to express grief and mourning. The above four important ceremonies and other smaller ceremonies illustrate the ethics and virtues in Chinese family relationships.

### 3.6.2. The festivals in the Chinese calendar

Before the Gregorian calendar was introduced in China in 1912, the Chinese calendar was used for astronomy and to manage the agricultural and daily activities of the Chinese. The Chinese calendar is a lunisolar calendar which incorporates elements of a lunar calendar with those of a solar calendar (Wikipedia: the Chinese Calendar, 2013). The major festivals marked in the Chinese calendar represent the value orientation and behavioral principles of Chinese social relationships which include the Spring Festival, the Lantern Festival, the Dragon Boat Festival, the Mid-Autumn Festival and the Double Ninth Festival, etc.

The Spring Festival, which is quite similar to Christmas in Western Countries, is the eve before the first day of a new year. On that day all family members gather together, enjoy a luxurious dinner which ends with dumplings and the lighting of fireworks to celebrate the harvest and honour the ancestors. Two weeks later is the Lantern Festival. After eating sweet dumplings, the children go out, with lanterns made of paper and bamboo in hand, and solve riddles in the lanterns. This also marks the end of the New Year Festival and the people will start another busy and prosperous year. The Dragon Boat Festival occurs on the 5<sup>th</sup> day of the 5<sup>th</sup> month of the year, which is also the longest day of the year. People eat rice dumplings, drink wine and race special boats with the shape of dragons. The Mid-Autumn Festival is another day for family and friends to gather together to celebrate the summer harvest. Mooncake is prepared for the full moon worship at night. The number 9 is the largest one in Chinese perceptions and hence the 9<sup>th</sup> day of the 9<sup>th</sup> month is the Double Ninth Festival in the Chinese calendar. People climb high mountains and drink chrysanthemum tea. It marks the arrival of autumn and that it is going to be colder day by day. (Picture 8)



Picture 8: The foods for different festivals in China (a. The sweet dumplings, left; b. The rice dumpling, middle; c. The moon cakes, right). Source: a: <http://tieba.baidu.com/p/1401474153>; b: <http://www.nipic.com/show/1/55/4620710ke2ba7308.html>; c: [http://www.xkb.com.au/html/life/meiweiaozhou/2010/0915/42707\\_4.html](http://www.xkb.com.au/html/life/meiweiaozhou/2010/0915/42707_4.html)

### 3.6.3. The recreational activities for the civics

Besides the typical ceremonies and festivals mentioned above, the recreational activities of the residents in Beijing's imperial city show the features of cultural resources such as adaptability and inclusion more clearly.

Teahouses were common in Beijing's imperial city and were important public spaces for recreational activities. The drama, the Teahouse, demonstrates the civic lives in a teahouse of Beijing in the Qing Dynasty. After walking the bird in the morning, the people gathered in the teahouse to discuss. Topics of discussion varied from the national policy to the domestic trivia. (Picture 9)



Picture 9: Walking the bird in the morning in Beijing. Source: <http://bbs.photofans.cn/thread-407559-1-1.html>

People also enjoyed local dramas. The Drum Song of Beijing and Chinese Story Telling are the two typical dramas originating in Beijing. They also enjoyed playing games, for example cricket fighting. Cross Talk is another recreational activity which arose during the Ming Dynasty. After several centuries' development, it gradually developed to be a style of comedic monologue. Beijing cuisine which is the local style of cooking also represents these features. Peking Roast Duck is perhaps the best known dish which is an exemplary mixture of local foods and dietary habits.

Meanwhile, Beijing was also the imperial city of China from the Yuan Dynasty to Qing Dynasty. Its recreational activities evolved with the inclusion of extraneous cultures. Beijing Opera is a traditional drama which originated from southern China. The introduction of this drama into Beijing's imperial city in the 18th century promoted its rapid development. It incorporated the original drama style with the local drama style and finally became popular in the Qing Dynasty. The most famous character in Beijing Opera is the Guanyu, who is conceived as the symbol of loyalty.

### 3.7. Aesthetic resources

We enjoy or detest our living environments through complex sensory input (Berg, 2010). A well-organized city layout, a pleasant appearance of the city, and living environments designing with the natural elements can provide a synaesthetic sensation with pleasure and happiness while a balanced inter-sensory feeling including the visual, olfactory, tactile and auditory senses also reflects the sustainability status of a community or a city. In this section the features of city layout and the famous eight scenes in imperial Beijing will be outlined.

#### 3.7.1. The beauty of harmony in the city configuration of Beijing imperial city

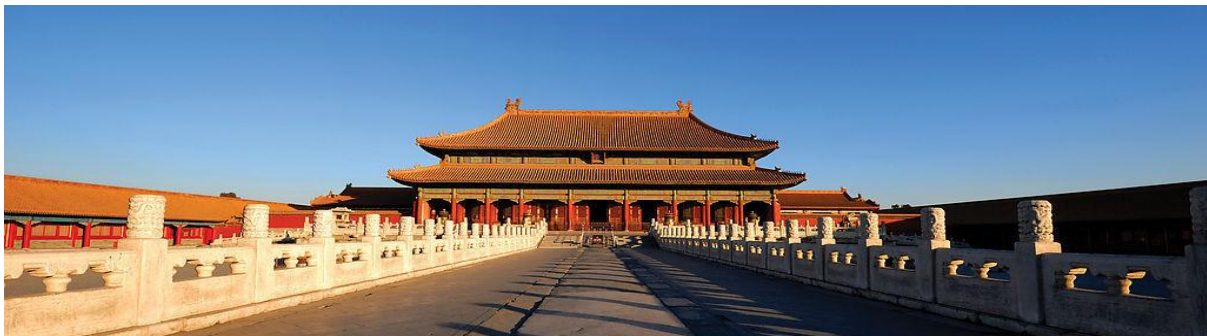
Although the imperial capital Beijing was designed and constructed for the emperors, its city configuration represents the philosophy of harmony between the heaven, the earth and the people in ancient Chinese Confucianism. It can be seen from the subjective city axis, the grading color regulation of buildings and the skyline representing the power of royalty.

The buildings in the imperial city of Beijing and the Forbidden City were organized symmetrically along an invisible city axis. Liang Sicheng, the foremost architect and scholar of ancient Chinese architecture, once praised that "the line define the city's vertical rhythm in a pattern resembling ocean waves in the north-south direction and divides the east and west part of the city symmetrically"(Liang, 1986) (Picture 10). The most important buildings representing the majesty of royalty were located along this line.



Picture 10: The city axis of Beijing. Source: <http://tszyk.bucea.edu.cn/gdwhlczyk2/ghyjp1/bjyz1/6467.htm>

The imperial Beijing was a city of hierarchy, expressed not only through the symmetrical city layout but also through the grading colors system of the buildings. The imperial buildings monopolized the use of many bright colors: bright yellow, green and cobalt blue tiles for the roofs, a velvety red for the walls and gates of the Forbidden City, and a gray brick for the city wall. (Picture 11)



Picture 11: The red walls and green tile in Beijing. Source: [http://pic1.nipic.com/2008-09-11/2008911213319528\\_2.jpg](http://pic1.nipic.com/2008-09-11/2008911213319528_2.jpg)

The colors of the imperial buildings were not to be imitated by commoners, and the height of imperial buildings was not to be surpassed. This creates the typical skyline, the highest in the center and decreasing to the surroundings (Figure 28 and 29).

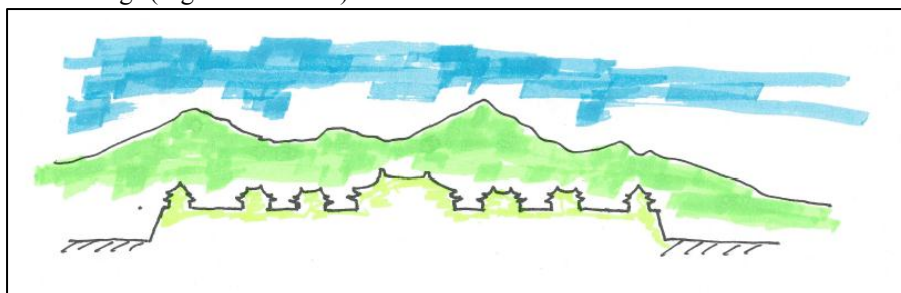


Figure 28: The imagined image of skyline of Beijing from south north. Source: Zhang Wei

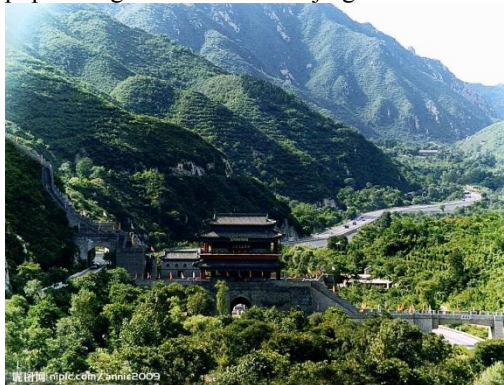


Figure 29: The imagined image of skyline of Beijing from west to east. Source: Zhang Wei



### 3.7.2. The Eight Scenes of Imperial Beijing

The Eight Scenes of Imperial Beijing are eight beautiful places within and around imperial Beijing. They are exemplary aesthetic resources which provide residents with sensory pleasure. They are: the Junyong Pass of the Great Wall surrounding with greenery in spring (Picture 12); the Lugou Bridge in moonlight in the dawn (Picture 13); the Taiye Pond in the windy autumn (Picture 14); the Qionghua Island in the summer; the city gate of Ji in the rain; the Western Hills covered by snow on a sunny winter's day; the Jade Spring and the Jade Hill in the summer (Picture 15); and the Golden Pavillion in the setting sun. The Eight Scenes of Imperial Beijing were and are created via unique mixture of artificial buildings and natural landscape, and remain some of the most popular sights in modern Beijing.



*Picture 12: The Junyong Pass of the Great Wall surrounding with the greenery in Spring (Upper left).*

Source: <http://www.nipic.com/show/1/75/0202713101f06143.html>

*Picture 13: The Lugou Bridge covered by the moon in the dawn (Upper right).*

Source: <http://gb.cri.cn/20864/2008/03/11/3105@1973558.htm>

*Picture 14: The Taiye Pond in the windy autumn (bottom left).*

Source: [http://news.xinhuanet.com/life/2010-08/20/c\\_12465967.htm](http://news.xinhuanet.com/life/2010-08/20/c_12465967.htm)

*Picture 15: The Jade Spring and the Jade Hill in the summer (bottom right).*

Source: <http://ljc999123.blog.163.com/blog/static/164229583201061973641260/>

## 4. Interdisciplinary analysis

A community can be perceived as a combination of buildings or the community itself. Originally, communities developed from settlements in the form of caves or wigwams. Over time such a settlement evolved into a residence in the form of single buildings, and then these residences were gathered together to form a community or a city. Thus, both the single building and the community itself are the focus for sustainable community development.

Based on this understanding, the quadrangle as a single building and Beijing's imperial city as the community itself will be analyzed with an interdisciplinary approach in this section to evaluate the implications for building a sustainable community.

### 4.1. Micro level: the quadrangle and the green building

The building is the basic unit of a community when planning or evaluating a sustainable community. To some extent, the sustainability of a single building is quite critical for the sustainable development of the community. The quadrangle was the most popular building pattern in China, and therefore it is important to use it as the fundamental level of organization investigated in this section.

#### 4.1.1. The origin of the quadrangle

The quadrangle is a typical and representative building pattern in Northern China and the whole country. Its history dates back to the Zhou Dynasty in the 1st century B.C., and a relic of an ancient courtyard built in that period was found at Shanxi Province (Han, 2008). A series of archaeological findings from later dates reflects the fact that courtyard buildings have been built and used as the popular residence by the Chinese people for hundreds of years (Jia, 2009). To some extent, the quadrangle is also "the outcome of the old socio-economic conditions, old culture and old style of life" (Wu, 1991).

The introduction of the quadrangle in the Beijing area started with the construction of Dadu in the Yuan Dynasty. Since Dadu was built at the new site rather than the old site of Zhongdu in the Jin Dynasty, there were vast areas of vacant land between the thoroughfares and avenues after the palace city and the royal city had been delimited. The Emperor enacted policies to attract the people to live in the new imperial city. The rectangular shape of the quadrangle was suitable to fit within the streets, and therefore many quadrangles were built by the gentry and the rich during the Yuan Dynasty. The prominent feature of the quadrangle in Yuan Beijing was the "H" shape of the principal house. However, the shrinking of the city walls in the Ming Dynasty and the rapid population increase in the Qing Dynasty changed this feature slightly. Since space and land were limited, the quadrangles in the Ming and Qing Dynasties were smaller than those in the Yuan Dynasty. The quadrangles built in later times adopted a simplified shape of the principal house instead of the H shape. Meanwhile the size of the yards within the quadrangle decreased accordingly. These changes resulted in the typical layout of the quadrangle which still can be seen in present day Beijing.

#### 4.1.2. The features and components of a quadrangle

A quadrangle is an enclosed area with a rectangular shape, also called Siheyuan in Chinese. The quadrangle is usually symmetrical and oriented on a north-south axis. In this sense, the Forbidden City is an example of the biggest quadrangle. The components within a typical Chinese quadrangle are as follows (Figure 30):

**The entrance gate** is the main entrance of the quadrangle and is often located in the southeastern corner. It is also a boundary of public space outside the quadrangle and private space within the quadrangle. There are several types of entrance gates which mainly are different in decoration and design and represent the position in the social hierarchy of the host of the quadrangle.

**The screen wall** has no practical residential function but obstructs the view of passersby while decorating the quadrangle. There are two potential places for the screen wall. It is usually located behind the entrance gate, but sometimes it is also placed in front of the entrance gate if there is enough space. The pattern symbolizing the happiness and fortunes in the screen wall represents the peaceful family and the aesthetic taste of the hosts.

**The decoration gate** is a very particular gate within the quadrangle since it is the only passageway which links the inner yard representing privacy and the outer yard representing semi-privacy. Its importance is secondary to the entrance gate so it is often called the secondary gate. The female family members were not allowed to meet visitors outside of this gate in the ancient times.

There are several types of houses within a quadrangle and each has its own name due to different orientation and locations. The house on the north and the highest one is the **principal house**. Those houses on the east and west sides are **wing houses**. The house on the south side is called the **reversely-set house** because they are in the opposite directions from the principal house. The house to the north of the principal house is the **rear house**. The houses in different directions were allotted to different family members. The parents often lived in the principal house while the east and west wing houses are allocated to the son's family. The maiden daughter often lived in the rear house. The servants lived in the reversely-set house. The quadrangle was divided into two parts by the decoration gate. The yard to the south of the decoration gate is called **the outer yard** and the yard in the north of the decoration gate is **the inner yard**. The outer yard is mainly used for the transition between public and private spaces while the inner yard is essentially a private garden with plants and flowers.

**The circular corridor:** the houses within the inner yard are usually strung together by a cross corridor which shelters the inhabitants' movement within the yard from sunshine and rain in summer and wind and snow in winter.

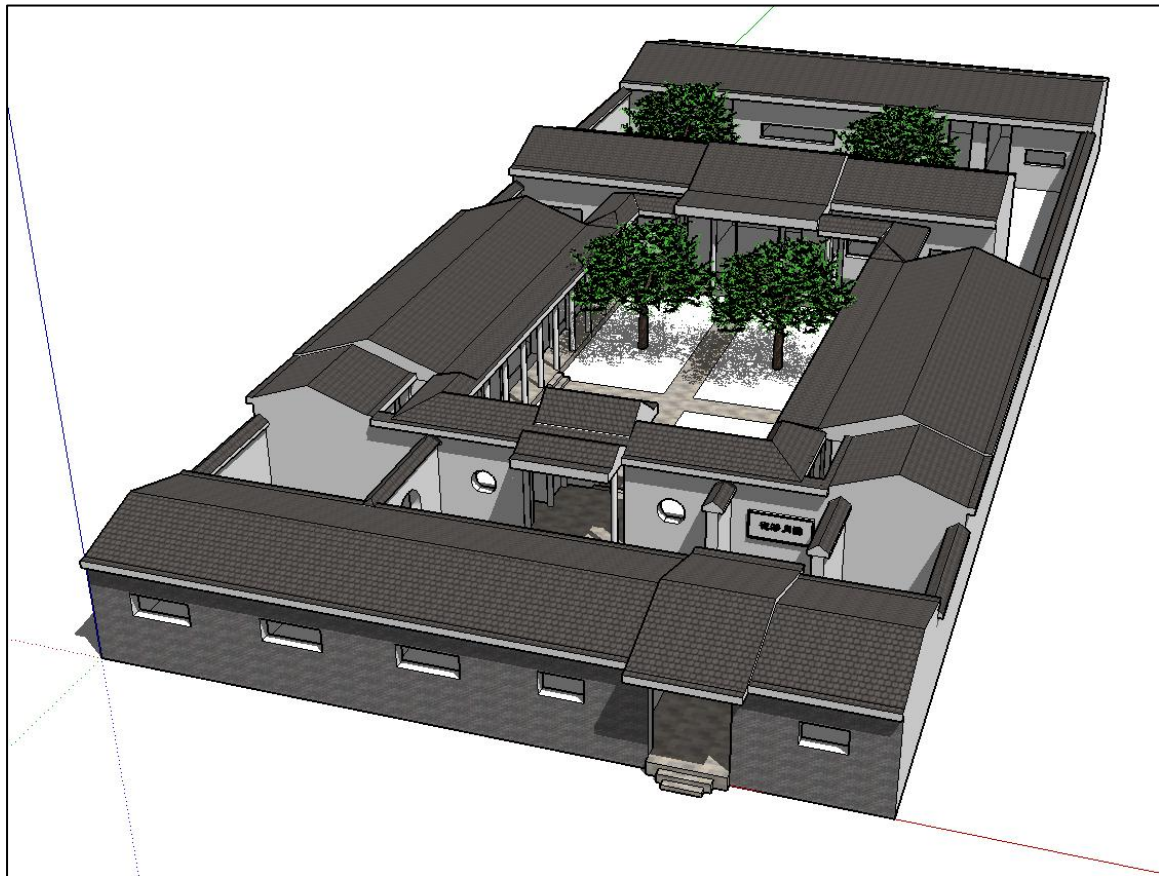


Figure 30: The parts of the quadrangle. Source: Author

Since the components of the quadrangle are easy to align in vertical or horizontal directions, there are a number of different quadrangle layouts.

**The quadrangle with one yard:** it has only one yard since there is no decoration gate. This is the minimum quadrangle which is suitable for a single family.

**The quadrangle with two yards:** there are two yards in this quadrangle and it is the basic quadrangle. A decoration gate separates the yards into an outer yard and an inner yard. The inner yard is also the main living place.

**The quadrangle with three or more yards:** Besides the outer yard and inner yard, there still has a backyard within a quadrangle which is the standard quadrangle.

**The compound quadrangle:** sometimes the yard cannot be added in the vertical direction of the quadrangle due to the limited length, and then a yard or a garden may be added in the horizontal direction of the standard one.

#### 4.1.3. The software modeling

In order to better analyze the sustainability of the quadrangle, a model has been built with the software Sketchup (Version 8.0.16846) and analyzed with Google Earth (Version 7.0.3.8542). Sketchup is a 3D modeling program which is widely used in architecture designing and landscape design. Google Earth is a virtual geographical information program which provides the local geographical data for this analysis.

A quadrangle with three yards is built for the analysis. The data of this quadrangle is from the book “The atlas of architecture components of quadrangles” (The standardization office of Beijing institute of Architecture Design, 2006) and the book “Beijing quadrangle” (Jia, 2009).

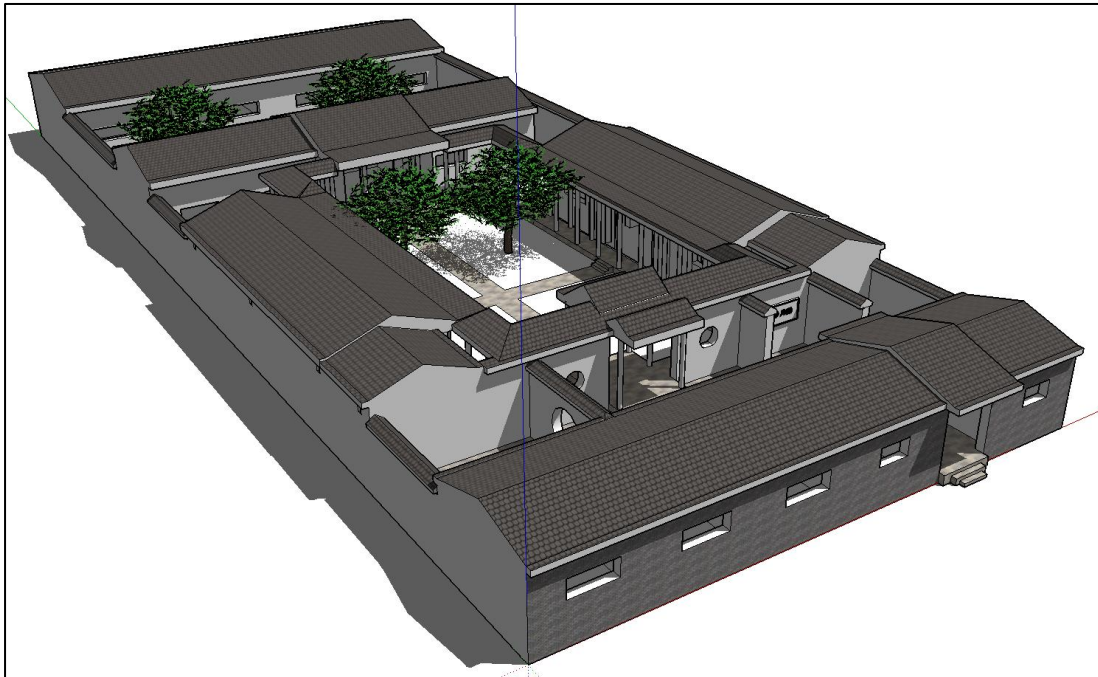


Figure 31: The bird's eye of a quadrangle



Figure 32: The front face of a quadrangle



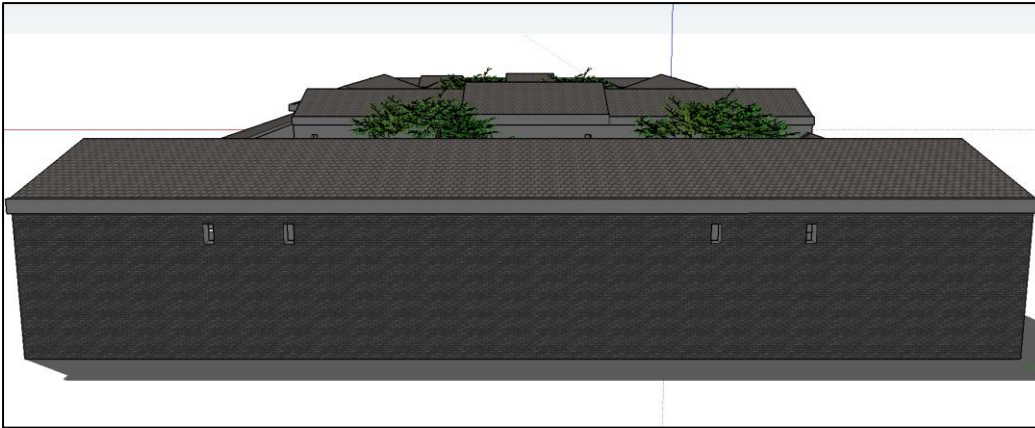


Figure 33: The rear face of a quadrangle

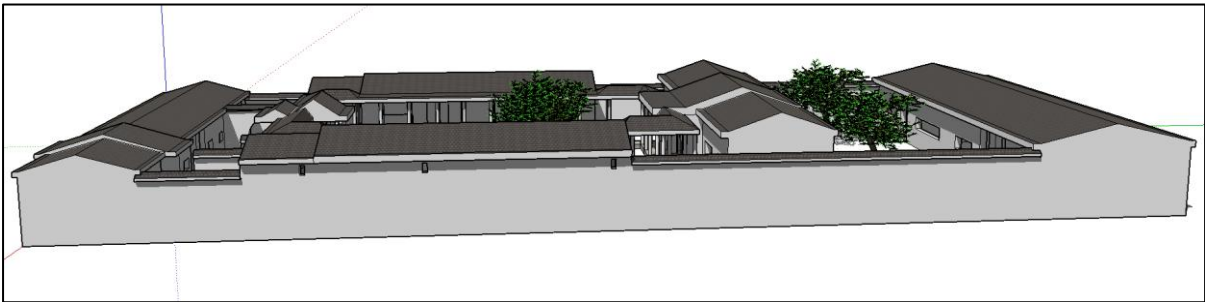


Figure 34: The side of a quadrangle

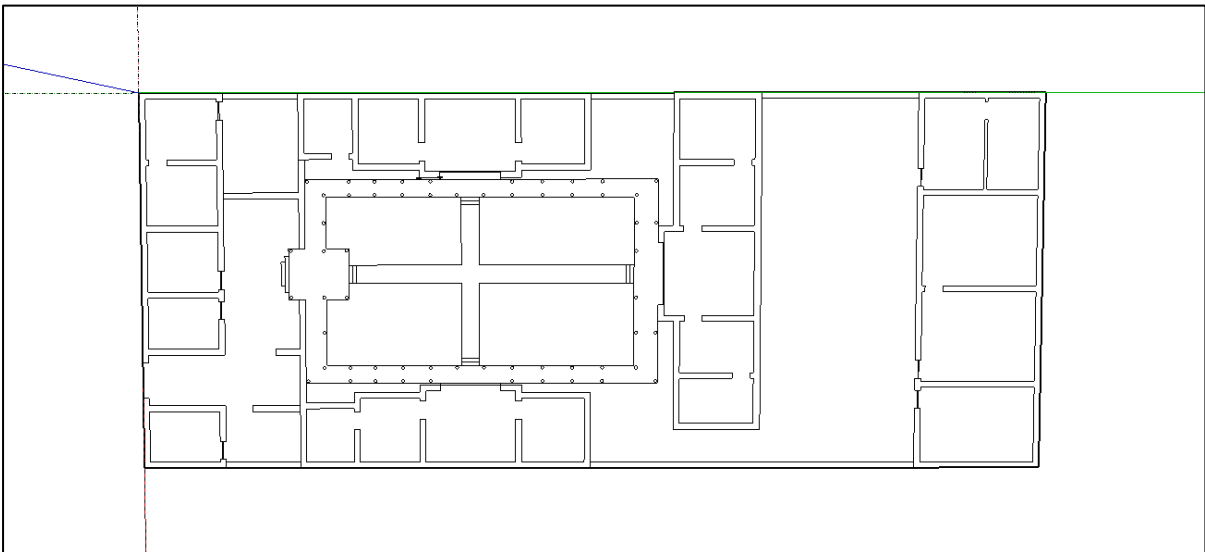


Figure 35: The layout of a quadrangle



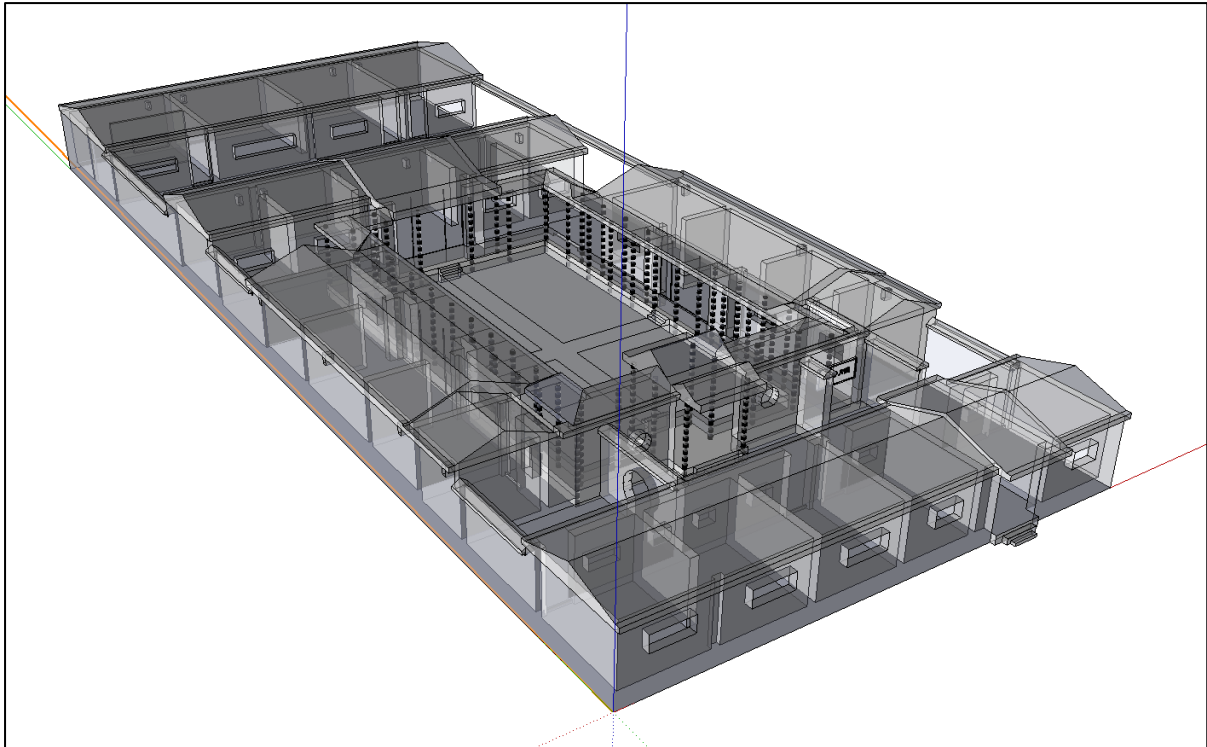
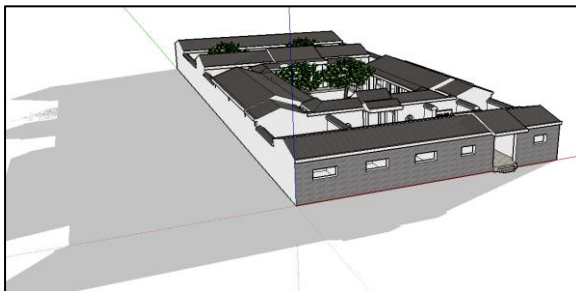


Figure 36: the perspective view of a quadrangle

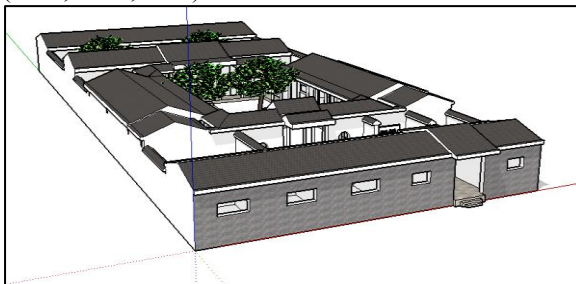
The results of daylight analysis within Sketchup and Google earth:



(6 am, 22nd, June)



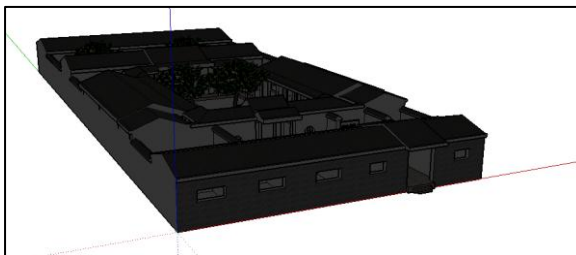
(10 am, 22nd, June)



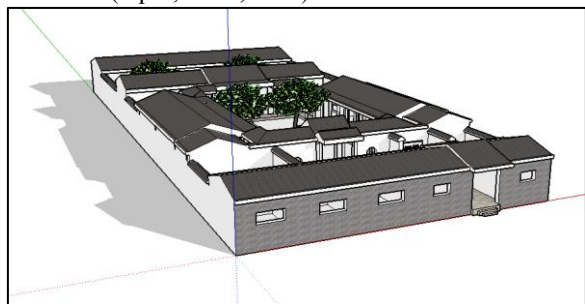
(2 pm, 22nd, June)



(6 pm, 22nd, June)



(6 am, 22nd, December)



(10 am, 22nd, December)

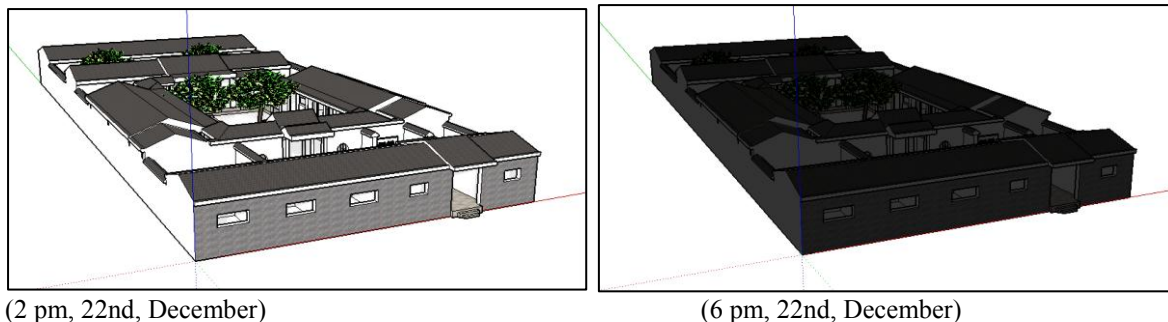


Figure 37: Analysis results of daylight of a quadrangle

#### 4.1.4. Analysis and discussion

There are several assessment frameworks for sustainable building or green building since sustainable development has become an important issue in architecture and landscape design. The China Ministry of Housing and Urban-Rural Development issued a national standard on green building evaluation in 2006 (MOHURD, 2006) which was proposed by the China Academy of Building Research. Meanwhile the Leadership in Energy and Environmental Design (LEED) is a series of rating systems which are widely used in green building assessment and proposed by the U.S. Green Building Council (U.S.GBC, 2008). Moreover, Bokalders and Block (2010) proposed an approach to design healthy, efficient and sustainable buildings which included four main aspects of green building. See the appendix for details. The major indicators for green building assessment are listed in Table 4.

Table 4: The main criteria of the applied assessment standards in this study.

China National assessment standard for Green Building	LEED for homes Ranking System
1. Land utilization and built environment 2. Energy utilization and efficiency 3. Water utilization and efficiency 4. Material utilization and efficiency 5. Indoor environmental quality 6. Operation management	1. Innovation and design process 2. Location and linkages 3. Sustainable sites 4. Water Efficiency 5. Energy and atmosphere 6. Materials and resources 7. Indoor environmental quality 8. Awareness and education

A tentative assessment is made according to the China National Standard on assessment of green building and the LEED for homes ranking system<sup>5</sup>, the results are below:

Table 5: Result of tentative assessment with Green Building Standard of China<sup>6</sup>

	Yes	No	N/A
Controlling index	8	1	13
General index	13	1	19
Optimization index	2	1	4
Total	23	3	36
Percentage	37%	5%	58%

<sup>5</sup> The checklists of these two systems can be found in the appendix.

<sup>6</sup> The detail result can be found in the Appendix 4.

Table 6: The result of tentative assessment with LEED for Homes

	Project points	Max points Available	Percentage
1. Innovation and Design process (ID)	6	11	55%
2. Location and Linkages (LL)	8	10	80%
3. Sustainable Sites (SS)	15	22	68%
4. Water Efficiency (WE)	4	15	27%
5. Energy and atmosphere	9	38	24%
6. Materials and resources	12	16	75%
7. Indoor environmental quality	5	21	24%
8. Awareness and education	0	3	0%
Total	59	136	43%

The results of tentative assessment with two standards provide a brief overview of the sustainability of the quadrangle but the scores do not reflect the real situation. The main reason for this is that there are several indices which are not suitable for the quadrangle since these two standards are mainly focused on modern architecture and there is a lack of detailed information on the building and operation process of a quadrangle. Considering this, the implications of the quadrangle for construction of a green building are discussed by addressing the structure of the houses and the quadrangles.

The houses in a quadrangle are mainly gable houses with a flat roof and their composition principles are almost the same with little difference on the height, width, and orientation of the house. This is also evidence of the buildings' adaptation to the local semi-arid climate. Most of the ancient Chinese houses have a similar layout with rectangular shape and the number of rooms is always odd. There is no exception to the houses in a quadrangle, but with a slight difference in the number of rooms, size, the height of the stylobate and the orientation. According to the rule recorded in the ancient Chinese architecture books, a house can be divided into three parts: the stylobate, the roof and the body of the building between them. This is the case with the houses in a quadrangle.

The houses in the quadrangle are always built on a stylobate of which basis and the solid part are built by the rammed earth and surrounded by the stones or bricks. The stylobate is 50-60 centimeters high and a stair of three or five steps is placed with it (Figure 38). Above the stylobate is the main part of the house which was made of wood in most of traditional quadrangles. The main part of the house can be divided into two parts, the carpentry and the joinery. The carpentry part is the overall structure of the house, for example the pillars, the roof beams and the roof timbers while the joinery part is the encirclements, partitions and the decorations for example the windows, ceilings and the divisions. A simple but effective structure was used in construction of the carpentry part of the traditional quadrangle which was called the post and lintel or trabeated method (Figure 39). By the occlusion of the pillars, beams, columns and rafters at horizontal and vertical direction, a more stable structure was formed to support the whole building. The different components of the carpentry part are connected in a simple but very strong method, the tenon and mortise method, which has been used in China for several hundred years (Wikipedia: mortise and tenon, 2013). The tenons and the mortises are engaged in an exact way with no need for nails or glue to form the solid and resilient structure of the ceiling. (Figure 40)

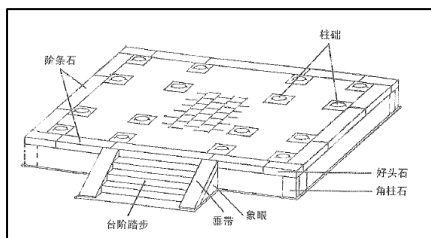


Figure 38: The stylobate of a house in a quadrangle. Source: Beijing Quadrangle. (Jia, 2010)

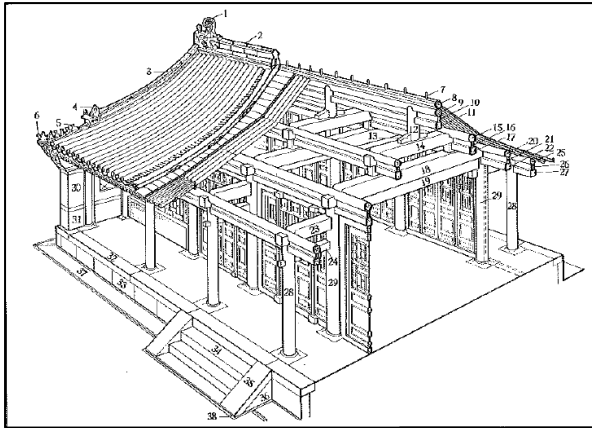


Figure 39: The post and lintel system in a quadrangle. Source: Beijing Quadrangle. (Jia, 2010)

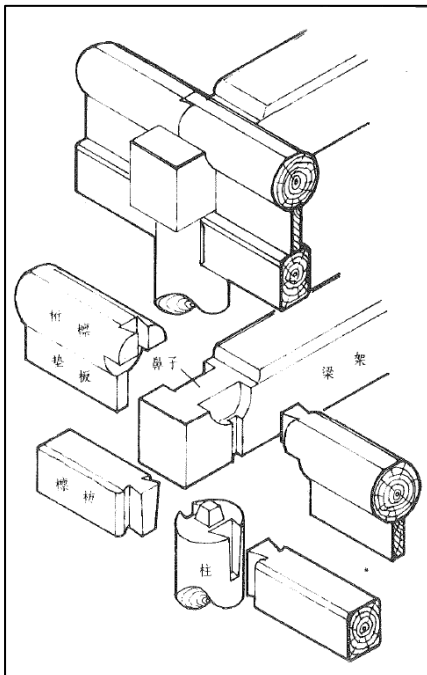


Figure 40: The tenon and mortise technology used in the quadrangle. Source: Beijing Quadrangle. (Jia, 2010)

Besides the carpentry and joinery parts, the rest of the main body of the house is the walls. The walls in the houses of a quadrangle can be categorized into three types: the gable wall, the threshold wall and the rear wall. The gable wall refers to the wall at the both sides of the house which are most thick but not load bearing. The main function of the gable walls is to encircle the building and keep the house warm. It also can prevent the spread of fire. The threshold wall is the part of walls under the window which is 0.8-0.9 meters high and mainly for decorative purposes. The rear wall refers to the wall behind the building and with only a small window in the upper part of the wall or no window in it. The doors and the windows of the house in the courtyard are often covered with a portiere of gauze or cotton to prevent insect entering in summer or keep in warmth in winter whilst ensuring that there is enough daylight and ventilation, thus reducing the energy needed for heating and lighting in daytime.

The roof of the house in a quadrangle refers to the part on the ceiling and it is covered by two layers. The inner layer is earth mixed with cellulose fiber and the outer layer is tiles. The occlusion of the tiles is very important to divert the rain water to the groove in the eaves and thence into the soil or a corresponding intake of an underground drainage system. The eaves of the roof project beyond the main body of the house and the stylobate in order to protect the foundation of the building from erosion caused by rain water.

The ground within the house and the yard is covered with bricks. The bricks for the ground and the tiles for the roof are baked from clay. The brick for the ground is a typical brick which is called five flayer brick and is made by polishing in its two opposite surfaces (Figure41). The special shape of the brick facilitates their production and means that less material is needed to create them.

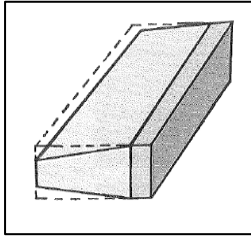


Figure 41: The typical bricks used in the quadrangle. Source: Beijing Quadrangle. (Jia, 2010)

The quadrangle also makes sense in terms of land utilization and micro-ecological environment within the courtyard. The rectangular shape of the quadrangle maintains a good balance between living and green areas. A comparison study of courtyard building and detached building has been made by previous researchers and the conclusion was reached that the land utilization of the courtyard building is efficient in terms of maximizing living area and green areas (Jia, 2009). (Figure: 42)

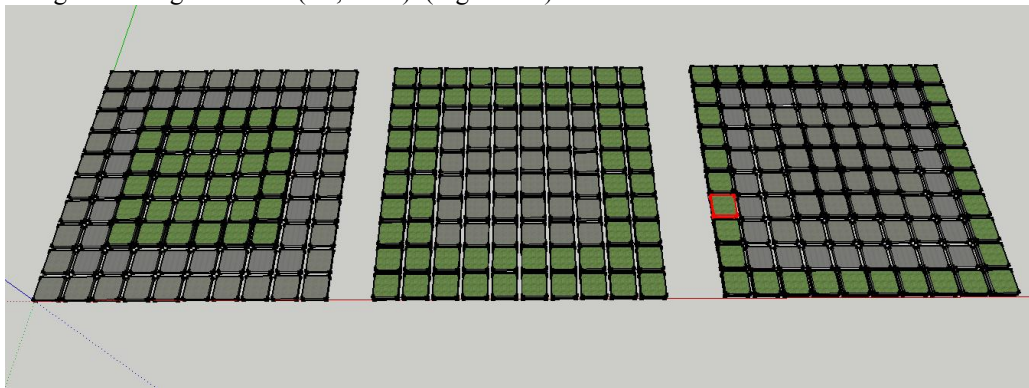


Figure 42: The comparison of land utilization of quadrangles and other building modes. Source: the author

The enclosed layout of the quadrangle also provides a comfortable and livable environment. The enclosure within the sides of the central open area is very helpful in creating a good microclimate within the courtyard, reducing the adverse effects of external climate (Hou, 1997). (Figure 43)

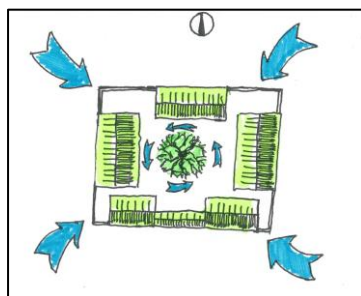


Figure 43: The micro-climate in the quadrangle. Source: Zhang Wei

## 4.2. Macro level: the Beijing imperial city planning and the sustainable city

A city is a relatively large and permanent settlement (Goodall, 1981; Kuper and Kuper, 1996). Although there still remains no completely agreed upon definition of what a sustainable city is or what it should be composed of, the city has already been studied as an independent system or unit within urban ecology. In this section, the Beijing's imperial city as a single unit will be studied.

### 4.2.1. The Fengshui theory in ancient Chinese city planning

It is no doubt that the Beijing's imperial city is the outcome of the ancient Chinese city planning ideal and theories. Besides the ideal imperial city which was recorded in the Books of Writs on Craftsmen, the Chinese ancient geomancy, or Fengshui Theory, also played a very important role in the planning history of Beijing's

imperial city. Therefore when we are seeking ways to ensure future sustainable cities of China, Chinese ancient geomancy theory must not be ignored.

The Fengshui Theory, also known as the Chinese Geomancy or Kanyu in Chinese, is derived from the long-term careful observation of nature and practical life experience based on the ancient Chinese philosophy of the nature and the universe, and thus has both empirical and mysterious aspects. Practically however, it is a comprehensive assessment method of environmental factors for building a settlement, whether a city or a single building. It is an ancient Chinese interdisciplinary approach which relates to geophysics, hydrogeology, cosmology, meteorology, natural landscape, architecture, ecology and anthropology (Ma, 2011). In general, the approach taken by Fengshui Theory is to look for a place with specific environmental advantages which meet the physical and psychological needs of the inhabitants. A brief summary table is presented with an overview of Fengshui Theory. (Table 7)

Table 7: The basic elements, methods and principles in Fengshui Theory. Source: Author collected

Basic Elements	Processes	Principles
Dragon: (龙 in Mandarin) refers to the mountain	1. Seek the dragon(寻龙 in Mandarin): Assessment of connectivity, arrangement, and shape mountainous range in regional scale	1. face the water with hills behind (背山面水 in Mandarin) 2. possess the wind and the water (藏风得水 in Mandarin) 3. Facing south (坐北朝南 in Mandarin)
Sha: (砂 in Mandarin) refers to the hills around the preferable site	2. Watch the hills(观砂 in Mandarin): assessment of topographical or geographical feature in local or village scale	
Shui: (水 in Mandarin) Refers to water body, rivers, streams and lakes etc.	3. Watch the water(察水 in Mandarin): assessment of stream connectivity and shape, networking with mountain to village for watershed, rice paddy	
Xue: (穴 in Mandarin) Refers to the preferable site	4. Define the site(点穴 in Mandarin):assessment of suitable location	
Direction: (向 in Mandarin) Refers to the orientation	5. Direct the orientation (立向 in Mandarin):arrangement for direction	
Form: (形 in mandarin) refers to the surrounding environment	6. Watch the form(观形 in Mandarin): assessment of the pattern, aspect and appearance of total landscape	

#### 4.2.2. The ecological effect of Fengshui Theory in Beijing imperial city planning

The approach of Fengshui Theory is to create a favorable human living environment by observing, understanding and utilizing the natural advantages of the local environment. This approach can be demonstrated when looking at the history of Beijing imperial city planning.

The origins of the design of Beijing, both of the Ji City and Yan City, are bound up with its location on the Beijing Plain which was surrounded with mountains of three sides: west, north and northeast. It was only open to the vast North China Plain in the south. Dating back to about 3000-4000 years ago, the area to the southeast of Beijing was dotted with lakes and swamps. This area provided enough water to the irrigation of the local agriculture along with the Yongding River and made Beijing known as “the Beijing Bay” (Figure 44). The surrounding mountains and plain to the south created a clement local climate since they blocked the cold air from Siberia and sand storms from Mongolia as well as aiding convergence of the warm air laden with water vapor from the Pacific in the area. The location thus reflects the principles of “face the water with hills behind” and “possess the wind and water” in Fengshui Theory.



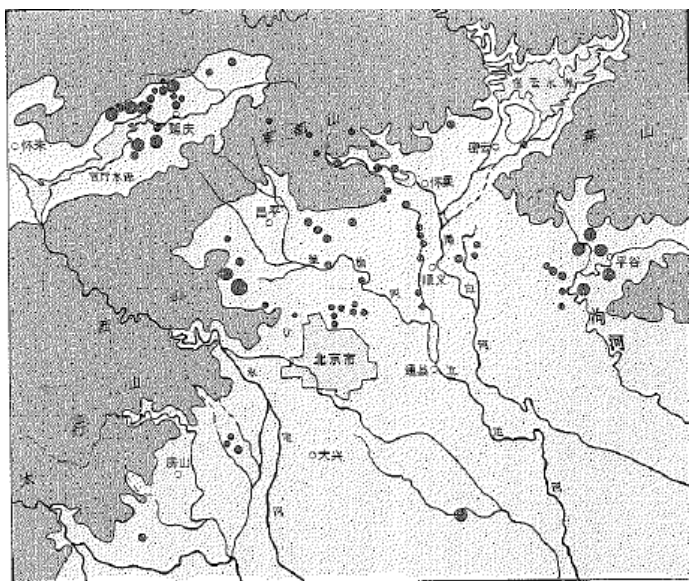


Figure 44: Ancient Beijing geography. Source: Beijing lishi dituji, Volume 2. (Hou, 1997)

Until the Ming Dynasty, the Forbidden City was built to the east of Taiye Pond while the earth dug from the moat was piled up in the north of the Forbidden City to form the Mei Hill which provided the perfect backdrop to the Forbidden City. The Golden River flowed through the imperial city in front of the Forbidden City and the palaces within it were built to face the south in accordance with the city axis. The whole Forbidden City was symmetrical. This symmetrical design formed a typical ideal Fengshui pattern for the Forbidden City and played a very important role in creation of a microclimate for the Forbidden City.

The relationship between Fengshui Theory and its ecological effect seems reasonable. A study made by Cheng, et al (2007) may provide some support for this. In this study, the local ecological environment in an ideal village based on Fengshui Theory was analyzed through the software simulation and the quantitative results of this study demonstrated that there existed significant correlations between the local environment and Fengshui methods. Another study made by a Korean landscape architect Hong, et al (2007) also demonstrated a compatible relationship between landscape ecology and Fengshui Theory. Moreover, Wang (1992) illustrated the positive ecological effect of Fengshui Theory in his book Research on the Fengshui Theory. (Figure 45)

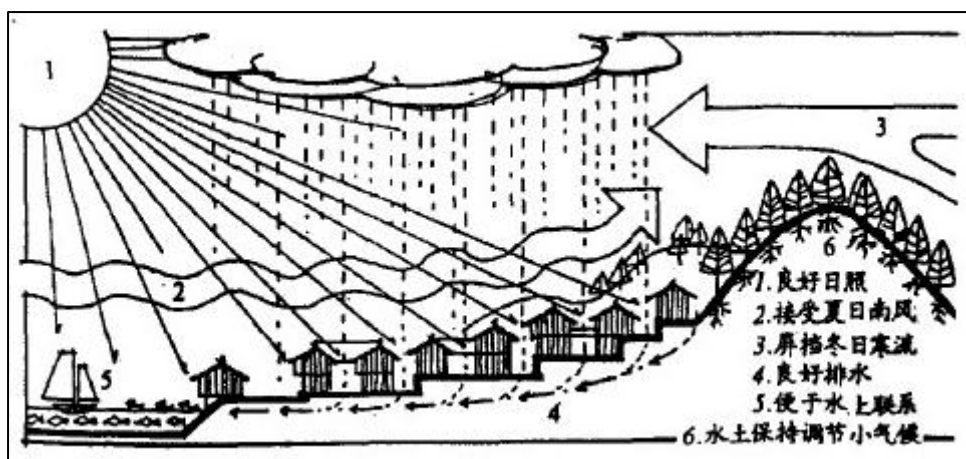


Figure 45: The good ecological effect of Fengshui Theory. Source: China Fengshui

The relationships between Fengshui Theory in Beijing's imperial city planning and the local environment are summarized (Table 8)



Table 8: The interrelations between Fengshui Theory and Environmental effects. Source: Author

Principles of Fengshui Theory	Environmental Impact
1. face the water with hills behind (背山面水 in Mandarin) 2. possess the wind and the water (藏风得水 in Mandarin) 3. Facing south (坐北朝南 in Mandarin)	1. Macro-climate within the quadrangles 2. Micro vegetation and landscape 3. Good Sunshine and daylight 4. Enough moisture 5. Cold air in summer and keep warm in winter 6. Well drained 7. Water and soil conservation

### 4.2.3. The implication of Beijing imperial city planning for building a sustainable city

Fengshui Theory is the outcome of the wisdom of the Chinese classical philosophy of “the harmony between men and nature” and the natural thoughts of “imitation of nature” reflected in the field of urban planning. Although Fengshui Theory is built on the basis of empirical analysis and ancient mysticism, it does have aspects in common with urban ecology, environmentalism, geography, and psychology. Hence it can serve as an inspiration for current practices in landscape design and sustainable community development.

Fengshui Theory is an ancient Chinese urban planning theory which addresses the city siting, the utilization of urban ecological infrastructure and the city layout through the assessment of the special geographic conditions and the trade-off between the advantages and disadvantages of the surrounding landscape resources. The history of planning of Beijing’s imperial city is the perfect example of this theory put into practice. Based on the previous analysis and discussion, the applications for sustainable community planning are mainly focused on the following three aspects:

#### 4.2.3.1. Implication for city siting

In the long history of Chinese ancient city planning, the selection of the city site is the first prerequisite when considering building a town or a capital city. Fengshui Theory’s guidelines on this topic are to choose a specific location with a suitable ecological environment to build the city. The rationale behind city siting found in Fengshui Theory is the belief of harmonious interrelationships between natural phenomena mountains, wind, and water in order to ensure auspicious human existence. This approach is reflected by the principles of “facing the water with the hills behind” and “possession of wind and water”.

#### 4.2.3.2. Implication for ecological infrastructure

A city is an independent organic system which heavily relies on the local ecological infrastructure from its surrounding environment (Yu, 2000). In this sense, the Fengshui Theory can still be applied in the building and utilization of local ecological infrastructure. The city cannot survive if it is separated from its surrounding environment. The city extracts the energy, water, biomass, and other resource from the surrounding environment while discharging the solid waste, waste water and air back to it. A sustainable city keeps an appropriate ratio between its input and output which does not undermine the metabolic capacity from its surroundings. The principle in the Fengshui Theory is just the interpretation of this rule. Moreover, Fengshui Theory also provides a more positive solution to modifying the inappropriate part in the local environment to adapt or improve the capacity of local ecological infrastructure under the premise of remaining an overall harmonious environment. This makes it more applicable than simple city siting for the current urbanization process in China.

#### 4.2.3.3. Implication for the built environment

The Fengshui Theory specifically addresses the importance of the microclimate creation and also the utilization of natural resources in the built environment. Assessment is undertaken by the evaluation and balancing of the features of the local climate, geography, soil, hydrology, and landscape with city layout. All of these resources and processes are incorporated to form an overall framework in the Fengshui Theory. This integration of process within an overall framework of the Fengshui Theory will provide great inspiration and help today in addressing the all too obvious mistakes of overdevelopment or ignorance of the local built environment prevalent in the ongoing urbanization process of China.

## 5. Conclusions

In this thesis, the history of planning of Beijing's Imperial City is reviewed and assessed within the sustainable community evaluation framework, PEBOSCA. Seven kinds of resources are documented and assessed to demonstrate the sustainability of planning of Beijing's imperial city which started in the Yuan Dynasty and ended in Qing Dynasty.

The quadrangle or the Chinese courtyard, as a typical and representative single building pattern in Beijing, is restructured and analyzed via the software Sketchup and Google Earth. Thereafter it is tentatively evaluated using two green building assessment standards, one is the China national standard and another is a business-oriented ranking system, in a qualitative way. The result highlights the sustainability features of the quadrangles and their adaptation to the local environment, but it also demonstrates that the quadrangle is not a perfect model for green construction. However, it does imply that there is an easy way to improve the sustainability performance of the conventional quadrangles if they can be upgraded with modern technologies in the future.

An ancient Chinese urban planning theory, the Fengshui Theory, is also studied. This theory played a very important role in the planning of Beijing's imperial city. By a new interpretation of the Fengshui Theory in the language and framework of urban ecology, the implications of the Fengshui Theory on city siting, local ecological infrastructure and built environment are summarized.

Finally, the following conclusion is reached. Sustainable development is becoming a global issue of importance while the key to the challenges that we are facing originate at the local level. By reviewing the history of planning of Beijing's imperial city, we can find more inspiration in solving the problems ahead. Moreover, as a sustainability assessment framework, the PEBOSCA framework can play a positive and important role in sustainable community development since it integrates all resources important for achieving urban sustainability within a single united approach.

## 6. Acknowledgement

Firstly, I would like to express my sincere gratitude to my supervisor, Professor Per G. Berg, whose careful guidance and constant support of the study has been invaluable from the initial stage to the final review process over the last two and half years. This thesis would not have been able to be completed without his careful instruction, encouragement, patience and immense knowledge.

It is also a pleasure to thank Eva Friman, the evaluator of this thesis, and Elisabeth Almgren, the course coordinator. I am appreciative of their kindly support in the critical review process and in creation of the study plan, in particular their impressive efficiency a short timeframe. I am also grateful to Brita Svensson, the head of the Masters in Sustainable Development (MSD) Programme, for giving me such a valuable an opportunity to spend two years studying sustainable development in Sweden, a land now dear to my heart. Moreover, I thank Sara Westin, PhD and researcher in urban planning at Uppsala University, for her inspiring and generous help.

I also want to thank Mr. Wang Ke, the best artist of Chinese architecture I have ever known, and Mrs. Sun Lingyun, Wang's lovely wife and career partner, both of whom offered many useful suggestions and guidance during their meetings with me.

Thanks are also due to my classmates from around the world. Many tactful conversations, discussions and a feeling of common responsibility for future sustainable development among the students of the MSD programme encourage me to devote time to researching sustainable development in China after finishing my study in Sweden.

Special thanks are also due to all my best friends, especially Jin Shaobo, Li Yuan, Roland Sookias, Zhang Wei, Zhang Yue, Zhou Qinshen, Xu Yiran, Yang Yi and many others whose names are not listed here (apologies for my bad memory!). Jin and Roland's suggestions on the wording and grammar make the thesis easier to understand but all the mistakes shall be my faults. Zhang Wei's illustrations make the ideas discussed in this thesis more vivid and Xu and Yue's professional suggestions also inspired me greatly.

Lastly, I thank my wife, Hily, and my son, Momo, who was born during the studying process for their tolerance of the effects my thesis work had on my care for the family. They deserve with all of my love for the rest of my life.

## 7. References

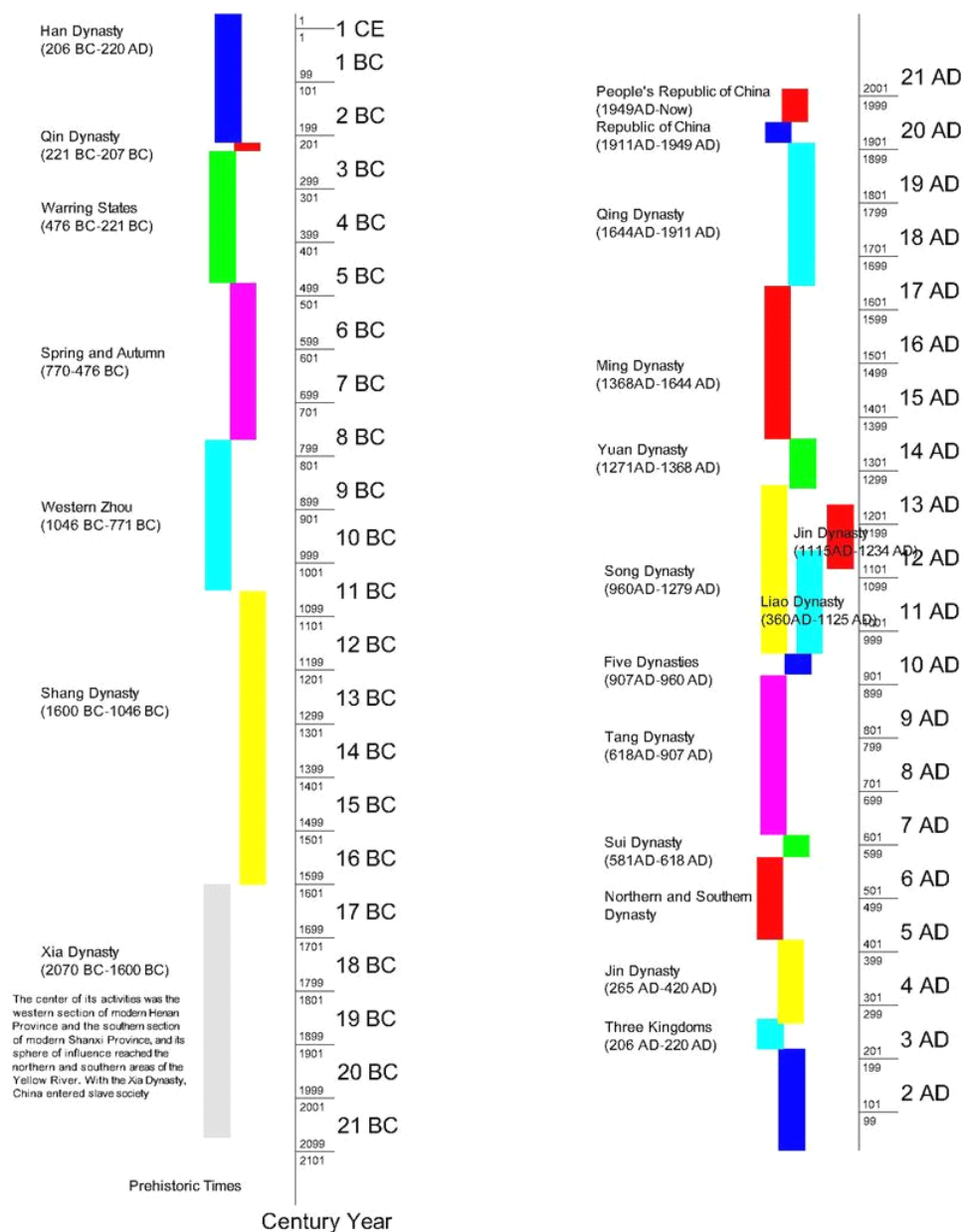
- Berg, P. G., & Nycander, G. 1997: Sustainable neighbourhoods—a qualitative model for resource management in communities. *Landscape and urban planning*, 39(2), 117-135.
- Berg, P. G. et al, 2010: Timeless Cityland – An interdisciplinary approach to building the sustainable human habitat. SLU Uppsala.
- Bokalders, V., & Block, M. 2010: *The whole building handbook: how to design healthy, efficient and sustainable buildings*. Routledge, London.
- Cheng, Jianjun, Gao, Yunfei & Wang, Zhenwu, 2007: The computer analysis of ecological physical environment of an ideal village. *Architecture Science*, 23(6).
- Gao, Songfan, 1989: On the historical change of markets and their location in Beijing. *Acta Geographica Sinica*, 2, 000.
- Goodall, Brian, 1987: *The Penguin Dictionary of Human Geography*. Penguin Press, London.
- Han, Guanghui, 1996: *The historical demology and geography of Beijing*. Beijing University Press, Beijing
- Han, Guangqu, 2008: *Illustrated history of the Chinese Courtyard*. China Water Power Press. Beijing.
- Hong, S. K., Song, I. J., & Wu, J. 2007: Fengshui theory in urban landscape planning. *Urban Ecosystems*, 10(3), 221-237.
- Hou, Renzhi, 1989: *Beijing Lishi Dituji, Volume 1 (The historical maps of Beijing)*. Beijing Publishing Press, Beijing
- Hou, Renzhi, 1997: *Beijing Lishi Dituji, Volume 2 (The historical maps of Beijing)*. Beijing Publishing Press, Beijing
- Hou, Renzhi, and Deng, Hui, 2001: *Beijingcheng de qi yuan yu bianqian (The origin and development of Beijing city)*. Zhongguo Bookstore Press, Beijing
- Hou, Renzhi, 2009: *The living memory of Beijing City*. Sanlian Bookstore Press, Beijing.
- Hou, Youbin, 1997: *The aesthetic of Chinese architecture*, Heilongjiang Science and Technology Press, Ha'erbin.
- Jia, Jun, 2010: *Beijing Quadrangle*. The Tsinghua University Press, Beijing.
- Kuper, A. and Kuper, J., 1996: *The Social Science Encyclopedia*. (2<sup>nd</sup> edition). Routledge, London.
- Liang, Sicheng, 1986: Beijing: A peerless masterpiece of urban planning, from The Collected Papers of Liang Sicheng, Vol.4, China Architecture & Building Press, Beijing.
- Liu, Dunzhen, 1984: The ancient history of Chinese architectures. China Architecture & Building Press, Beijing.
- Liu, Ji, Zhou, Bo, & Chen, Lan, 2007: Analysis on the Chinese ancient urban form in Lifang System – a case study on Chang'an in Tang Dynasty. *Sichuan Building Science*. 6, 043.
- Ma, Yong, 2011: Geomancy, ancient Chinese urban planning principles inspire contemporary cities, Master thesis, Urban and Regional Planning, Ball State University.
- McKinsey Global Institute, 2009: *Preparing for China's urban billion*. 2009.
- MOHURD, 2006: *GBT50378-2006: The evaluation standard for green building*. Beijing.

- National Bureau of Statistics of China, 2012: *China Statistics Yearbook of Statistics 2013*. China Statistics Press, Beijing.
- Rasmussen, Steen Eiler, 1951: *Towns and Buildings Described on Drawings and Works*. Harvard University Press, Cambridge.
- Shan, Shumo, Ge, Minqing, and Sun, Wenchang, (1992). *The Encyclopedia of Mountains and Rivers in China*, Shandong Education Press
- Steinhardt, Nancy Shatzman, 1999: *Chinese imperial city planning*. University of Hawaii Press, Hawaii.
- Sun, Donghu, 2007: The energy supply and its ecological impact of Beijing in Yuan, Ming and Qing Dynasties. *The series on Chinese historical geography*, 22(1), 134-144.
- Sun, Hui, & Liang, Jiang, 2003: Analysis on the internal structure of Lifang units of Chang'an in Tang. *City Planning Review*, 10, 015.
- The standardization office of Beijing institute of Architecture Design, 2006: *The atlas of architecture components*. Beijing, 2006
- UNESCO, The Peking Man World Heritage Site at Zhoukoudian:  
<http://www.unesco.org/ext/field/beijing/whc/pkm-site.htm>. Data visited 10 May 2013.
- U.S. Green Building Council. 2008: LEED for homes Rating System.  
<http://www.usgbc.org/redirect.php?DocumentID=3638>
- Wang, Jun, 2004: *The city record*. Beijing Sanlian Bookstore Press, Beijing
- Wang, Qiheng, 1992: *The research of Fengshui Theory*. Tianjin University Press, Tianjin.
- Wikipedia: The Chinese calendar, 2013: [http://en.wikipedia.org/wiki/Chinese\\_calendar](http://en.wikipedia.org/wiki/Chinese_calendar). Data visited 10 May 2013.
- Wikipedia: Mortise and Tenon, 2013: [http://en.wikipedia.org/wiki/Mortise\\_and\\_tenon](http://en.wikipedia.org/wiki/Mortise_and_tenon). Data visited 10 May 2013.
- Wu, Liangyong, 1991: Rehabilitation in Beijing. *Habitat International*, 15(3), 51-66.
- Yu, Kongjian & Li, Dihua, 2003: *The Road of Urban Landscape: the conversations with the mayors*. China Architecture & Building Press, Beijing.
- Xiang, Yansong, 2009: On effects of ritual on Chinese old architecture. *Shanxi Architecture*. 35(11), 35-36.
- Zhu, Wenyi, 1993: *Space, symbol, city*. China Architecture & Building Press, Beijing.

## Appendix

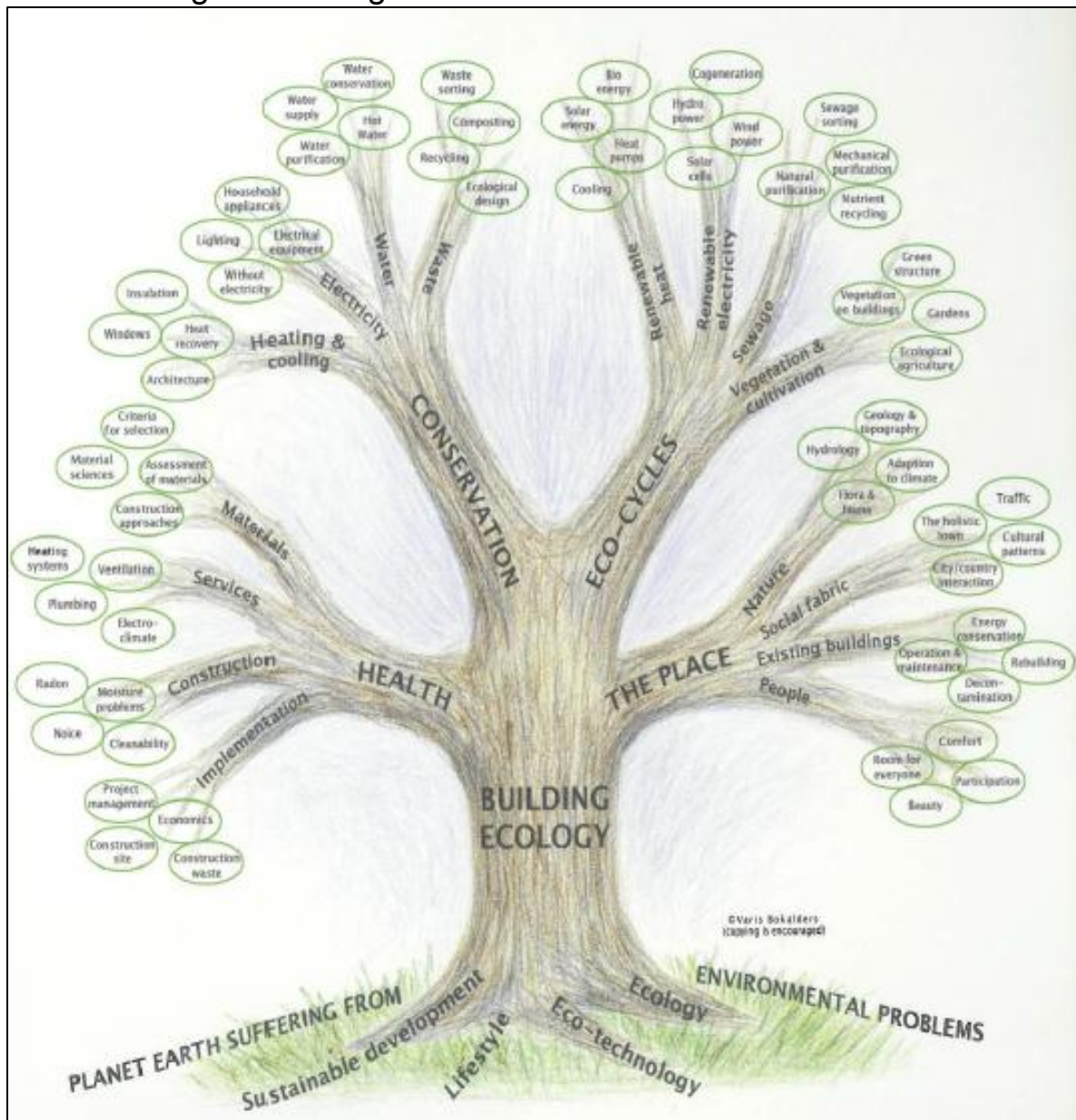
### 1. The chronology of Chinese history

For most of non-Chinese readers, it is difficult to understand the time line in this study hence a chronology of China's history is placed here to help understand the history of Beijing's imperia city better.



(Source: Ma, 2009)

## 2. The ecological building tree



Source:



### 3. LEED for Homes Checklist (Source: USGBC, 2008)



#### LEED for Homes Checklist

Builder Name:
Project Team Leader (if different):
Home Address (Street/City/State):

#### Project Description:

Building Type:

# of Bedrooms: 0

Project type:

Floor Area: 0.0

#### Adjusted Certification Thresholds

Certified: 45.0

Gold: 75.0

Silver: 60.0

Platinum: 90.0

Project Point Total: 0	ID: 0	SS: 0	EA: 0	EQ: 0
Certification Level: Not Certified	LL: 0	WE: 0	MR: 0	AE: 0

#### Notes:

- Detailed information on measures below are provided in the LEED for Homes Rating System
- # Indicates measures that must be documented using the Accountability Form

Notes:

1. Detailed information on measures that are provided in the LEED for Homes Rating System

2. # Indicates measures that must be documented using the Accountability Form

		Max Points Available		Project Points	
		Y / Pts	No	Maybe	
Innovation and Design Process (ID) (No Minimum Points Required)					
1. Integrated Project Planning	1.1	Preliminary Rating	Prerequisite		
	1.2	Integrated Project Team	1		
	1.3	Professional Credentialed with Respect to LEED for Homes	1		
	1.4	Design Charrette	1		
	1.5	Building Orientation for Solar Design	1		
2. Durability Management Process	2.1	Durability Planning	Prerequisite		
	2.2	Durability Management	Prerequisite		
	2.3	Third-Party Durability Management Verification	3		
3. Innovative or Regional Design	# 3.1	Innovation #1	1		
	# 3.2	Innovation #2	1		
	# 3.3	Innovation #3	1		
	# 3.4	Innovation #4	1		
Sub-Total for ID Category:		11	0		
Location and Linkages (LL) (No Minimum Points Required)					
		OR		Y / Pts No Maybe	
1. LEED ND	1	LEED for Neighborhood Development	LL 2-6	10	
2. Site Selection	# 2	Site Selection		2	
3. Preferred Locations	3.1	Edge Development		1	
	3.2	Infill	LL 3.1	2	
	3.3	Previously Developed		1	
4. Infrastructure	4	Existing Infrastructure		1	
5. Community Resources	5.1	Basic Community Resources		1	
	5.2	Extensive Community Resources	LL 5.1, 5.3	2	
	5.3	Outstanding Community Resources	LL 5.1, 5.2	3	
6. Access to Open Space	6	Access to Open Space		1	
Sub-Total for LL Category:		10	0		
Sustainable Sites (SS) (Minimum of 5 SS Points Required)					
		OR		Y / Pts No Maybe	
1. Site Stewardship	1.1	Erosion	Prerequisite		
	1.2	Minimize Disturbed Area of Site	1		
2. Landscaping	# 2.1	No Invasive Plants	Prerequisite		
	# 2.2	Basic Landscape Design	SS 2.5	2	
	# 2.3	Limit Conventional Turf	SS 2.5	3	
	# 2.4	Drought Tolerant Plants	SS 2.5	2	
	# 2.5	Reduce Overall Irrigation Demand by at Least 20%		6	
3. Local Heat Island Effects	# 3	Reduce Local Heat Island Effects		1	
4. Surface Water Management	# 4.1	Permeable Lot		4	
	4.2	Permanent Erosion Controls		1	
	4.3	Management of Run-off from Roof		2	
5. Nontoxic Pest Control	5	Pest Control Alternatives		2	
6. Compact Development	6.1	Moderate Density		2	
	6.2	High Density	SS 6.1, 6.3	3	
	6.3	Very High Density	SS 6.1, 6.2	4	
Sub-Total for SS Category:		22	0		

LEED for Homes Rating System

xi



# LEED for Homes Project Checklist (continued)

				Max Points Available	Project Points		
					Y / Pts	No	Maybe
<b>Water Efficiency (WE)</b> (Minimum of 3 WE Points Required)				OR			
1. Water Reuse	1.1	Rainwater Harvesting System	WE 1.3	4			
	1.2	Graywater Reuse System	WE 1.3	1			
	1.3	Use of Municipal Recycled Water System		3			
2. Irrigation System	2.1	High Efficiency Irrigation System	WE 2.3	3			
	2.2	Third Party Inspection	WE 2.3	1			
	2.3	Reduce Overall Irrigation Demand by at Least 45%		4			
3. Indoor Water Use	3.1	High-Efficiency Fixtures and Fittings		3			
	3.2	Very High Efficiency Fixtures and Fittings		6			
Sub-Total for WE Category:				15		0	
<b>Energy and Atmosphere (EA)</b> (Minimum of 0 EA Points Required)				OR			
1. Optimize Energy Performance	1.1	Performance of ENERGY STAR for Homes	Prerequisite				
	1.2	Exceptional Energy Performance		34			
7. Water Heating	7.1	Efficient Hot Water Distribution		2			
	7.2	Pipe Insulation		1			
11. Residential Refrigerant Management	11.1	Refrigerant Charge Test	Prerequisite				
	11.2	Appropriate HVAC Refrigerants		1			
Sub-Total for EA Category:				38		0	
<b>Materials and Resources (MR)</b> (Minimum of 2 MR Points Required)				OR			
1. Material-Efficient Framing	1.1	Framing Order Waste Factor Limit	Prerequisite				
	1.2	Detailed Framing Documents	MR 1.5	1			
	1.3	Detailed Cut List and Lumber Order	MR 1.5	1			
	1.4	Framing Efficiencies	MR 1.5	3			
	1.5	Off-site Fabrication		4			
2. Environmentally Preferable Products	2.1	FSC Certified Tropical Wood	Prerequisite				
	2.2	Environmentally Preferable Products		8			
3. Waste Management	3.1	Construction Waste Management Planning	Prerequisite				
	3.2	Construction Waste Reduction		3			
Sub-Total for MR Category:				16		0	
<b>Indoor Environmental Quality (EQ)</b> (Minimum of 6 EQ Points Required)				OR			
1. ENERGY STAR with IAP	1	ENERGY STAR with Indoor Air Package		13			
2. Combustion Venting	2.1	Basic Combustion Venting Measures	Prerequisite				
	2.2	Enhanced Combustion Venting Measures	EQ 1	2			
3. Moisture Control	3	Moisture Load Control	EQ 1	1			
4. Outdoor Air Ventilation	4.1	Basic Outdoor Air Ventilation	Prerequisite				
	4.2	Enhanced Outdoor Air Ventilation		2			
	4.3	Third-Party Performance Testing	EQ 1	1			
5. Local Exhaust	5.1	Basic Local Exhaust	Prerequisite				
	5.2	Enhanced Local Exhaust		1			
	5.3	Third-Party Performance Testing		1			
6. Distribution of Space Heating and Cooling	6.1	Room-by-Room Load Calculations	Prerequisite				
	6.2	Return Air Flow / Room by Room Controls	EQ 1	1			
	6.3	Third-Party Performance Test / Multiple Zones	EQ 1	2			
7. Air Filtering	7.1	Good Filters	Prerequisite				
	7.2	Better Filters		1			
	7.3	Best Filters	EQ 7.2	2			
8. Contaminant Control	8.1	Indoor Contaminant Control during Construction	EQ 1	1			
	8.2	Indoor Contaminant Control		2			
	8.3	Preoccupancy Flush	EQ 1	1			
9. Radon Protection	9.1	Radon-Resistant Construction in High-Risk Areas	Prerequisite				
	9.2	Radon-Resistant Construction in Moderate-Risk Areas	EQ 1	1			
10. Garage Pollutant Protection	10.1	No HVAC in Garage	Prerequisite				
	10.2	Minimize Pollutants from Garage	EQ 1	2			
	10.3	Exhaust Fan in Garage	EQ 1	1			
	10.4	Detached Garage or No Garage	EQ 1, 10.2, 10.3	3			
Sub-Total for EQ Category:				21		0	
<b>Awareness and Education (AE)</b> (Minimum of 0 AE Points Required)							
1. Education of the Homeowner or Tenant	1.1	Basic Operations Training	Prerequisite				
	1.2	Enhanced Training		1			
	1.3	Public Awareness		1			
2. Education of Building Manager	2	Education of Building Manager		1			
Sub-Total for AE Category:				3		0	
LEED for Homes Point Totals:				136		0	
(Certification level)						Not Certified	

LEED for Homes Rating System



## Project Checklist, Addendum A Prescriptive Approach for Energy and Atmosphere (EA) Credits

Points cannot be earned in both the Prescriptive (below) and the Performance Approach (pg 2) of the EA section

Points cannot be earned in both the Prescriptive (below) and the Performance Approach (pg 2) of the EA section				Max Points Available	Project Points		
Energy and Atmosphere (EA) (No Minimum Points Required)				OR	Y / Pts	No	Maybe
2. Insulation	2.1	Basic Insulation	EA 3.2	Prerequisite 2			
	2.2	Enhanced Insulation					
3. Air Infiltration	3.1	Reduced Envelope Leakage	EA 3.2	Prerequisite 2			
	3.2	Greatly Reduced Envelope Leakage		3			
	3.3	Minimal Envelope Leakage					
4. Windows	4.1	Good Windows	EA 4.2	Prerequisite 2			
	4.2	Enhanced Windows		3			
	4.3	Exceptional Windows					
5. Heating and Cooling Distribution System	5.1	Reduced Distribution Losses	EA 5.2	Prerequisite 2			
	5.2	Greatly Reduced Distribution Losses		3			
	5.3	Minimal Distribution Losses					
6. Space Heating and Cooling Equipment	6.1	Good HVAC Design and Installation	EA 6.2	Prerequisite 2			
	6.2	High-Efficiency HVAC		4			
	6.3	Very High Efficiency HVAC					
7. Water Heating	7.1	Efficient Hot Water Distribution	EA 8.2	2			
	7.2	Pipe Insulation		1			
	7.3	Efficient Domestic Hot Water Equipment		3			
8. Lighting	8.1	ENERGY STAR Lights	EA 8.2	Prerequisite 2			
	8.2	Improved Lighting		3			
	8.3	Advanced Lighting Package					
9. Appliances	9.1	High-Efficiency Appliances	EA 10.2	2			
	9.2	Water-Efficient Clothes Washer		1			
10. Renewable Energy	10	Renewable Energy System	EA 10.2	10			
11. Residential Refrigerant Management	11.1	Refrigerant Charge Test	EA 11.2	Prerequisite 1			
	11.2	Appropriate HVAC Refrigerants					
Sub-Total for EA Category:				38		0	

By affixing my signature below, the undersigned does hereby declare and affirm to the USGBC that the LEED for Homes requirements, as specified in the LEED for Homes Rating System, have been met for the indicated credits and will, if audited, provide the necessary supporting documents.

Project Team Leader \_\_\_\_\_ Company \_\_\_\_\_  
Signature \_\_\_\_\_ Date \_\_\_\_\_

By affixing my signature below, the undersigned does hereby declare and affirm to the USGBC that the required inspections and performance testing for the LEED for Homes requirements, as specified in the LEED for Homes Rating System, have been completed, and will provide the project documentation file, if requested.

Rater's Name \_\_\_\_\_ Company \_\_\_\_\_  
Signature \_\_\_\_\_ Date \_\_\_\_\_

By affixing my signature below, the undersigned does hereby declare and affirm to the USGBC that the required inspections and performance testing for the LEED for Homes requirements, as specified in the LEED for Homes Rating System, have been completed, and will provide the project documentation file, if requested.

Provider's Name \_\_\_\_\_ Company \_\_\_\_\_  
Signature \_\_\_\_\_ Date \_\_\_\_\_

LEED for Homes Rating System

xiii

#### 4. The Checklist for Green Building Assessment of China (Source: MOHURD, 2008)

绿色建筑（运行使用阶段）评价要求补充说明（住宅建筑）								
指标名称	类别	编号	标准条文	纸质材料要求	现场审核要求			Score
					现场审核内容	执行方式	执行者	
节地与室外环境	控制项	4.1.3	人均居住用地指标：低层不高于 43 m²、多层不高于 28 m²、中高层不高于 24 m²、高层不高于 15 m²。	1.项目审批文件 2.小区规划设计图纸、说明等	建筑套型	现场核实	评价小组	N/A
		4.1.5	种植适应当地气候和土壤条件的乡土植物，选用少维护、耐候性强、病虫害少、对人体无害的植物。	1.室外景观(或园林绿化) 主要竣工资料 2.种植竣工图 3.苗木表	植被类型	现场核实	评价小组	yes
		4.1.6	住区的绿地率不低于 30%，人均公共绿地面积不低于 1 m²。	小区规划设计与景观(或园林绿化) 主要竣工资料	绿地率、人均公共绿地指标	现场核实	评价小组	yes
		4.1.7	住区内部无排放超标的污染源。	1. 小区规划设计图纸、环评报告 2.或运行后的现场检测报告	分步落实：1）区域内有无污染源；2）如有污染源，环保措施落实情况 & 措施有效性	现场核实	评价小组	N/A
节地与室外环境	控制项	4.1.8	施工过程中制定并实施保护环境的具体措施，控制由于施工引起的大气污染、土壤污染、噪声影响、水污染、光污染以及对场地周边区域的影响。	1.施工组织设计资料（控制扬尘及大气污染、土壤侵蚀和污染、污水、噪声、照明、现场围挡设置等）+施工单位出具的严格照此施工的声明 2.或实施记录文件（包括实地照片、实时连续录像等） 3.或提供评审过相关内容的省部级以上奖项的相关证明材料（如詹天佑奖、鲁班奖、省级工程质量奖、绿色施工奖、安全文明工地奖等材料中涉及本项评价的证明）				N/A
	一般项	4.1.11	住区环境噪声符合现行国家标准《城市区域环境噪声标准》GB 3096 的规定。	1.环评报告 2.噪声相关设计分析文件 3.运行后的现场测试报告或现场措施落实情况说明				yes
		4.1.12	住区室外日平均热岛强度不高于 1.5℃。	热岛分析计算报告及措施	控制热岛措施落实情况	现场核实	评价小组	yes
节地与室外环境	一般项	4.1.13	住区风环境有利于冬季室外行走舒适及过渡季、夏季的自然通风。	1.小区总平面图 2.风环境模拟预测分析报告及措施				yes
		4.1.14	根据当地的气候条件和植物自然分布特点，栽种多种类型植物，乔、灌、草结合构成多层次的植物群落，每 100 m²绿地上不少于 3 株乔木。	1.室外景观(或园林绿化) 主要竣工资料 2.种植竣工图 3.苗木表	植被情况	现场核实	评价小组	yes

	优选项	4.1.17	合理开发利用地下空间。					No
节能与能源利用	控制项	4.2.1	住宅建筑热工设计和暖通空调设计符合国家和地方居住建筑节能标准的规定。	1.建筑竣工图设计说明 2.节能计算报告（以管理部门批复后的复印件为准） 3.检验记录：1）建设监理单位的进场验收/复验记录，2）分项工程和检验批的质量验收记录，3）相关管理部门的检查记录	围护结构按图施工情况、破损、改造情况及效果等，必要时可要求提供现场实测报告	现场核实	专家	N/A
		4.2.2	当采用集中空调系统时，所选用的冷水机组或单元式空调机组的性能系数、能效比符合现行国家标准《公共建筑节能设计标准》GB 50189 中的有关规定值。	1.集中空调系统竣工图 2.相关设备的型式检验报告或证明符合能效要求的检验报告 3.建设监理单位的进场验收记录				N/A
	一般项	4.2.4	利用场地自然条件，合理设计建筑体形、朝向、楼距和窗墙面积比，使住宅获得良好的日照、通风和采光，并根据需要设遮阳设施。	1.建筑竣工图设计说明 2.日照、自然通风、自然采光效果优化模拟计算报告	是否按设计落实	现场核实	评价小组	Yes
		4.2.7	公共场所和部位的照明采用高效光源、高效灯具和低损耗镇流器等附件，并采取其他节能控制措施，在有自然采光的区域设定时或光电控制。	1.照明竣工图设计说明 2.各层照明平面图 3.照明控制系统图 4.照明产品清单	公共场所照明节能情况	现场核实	评价小组	N/A
	节能与能源利用	4.2.8	采用集中采暖或集中空调系统的住宅，设置能量回收系统（装置）。	1.能量回收系统设计说明及竣工图 2.节能效益分析 3.相关产品说明及第三方检测机构型式检验报告 4.竣工验收资料（风量、热交换效率的检验记录） 5.风量、温度运行记录	能量回收系统运行情况（新风、排风风路是否通畅、过滤器是否定期维护等）	现场核实	专家	N/A
		4.2.9	根据当地气候和自然资源条件，充分利用太阳能、地热能等可再生能源。可再生能源的使用量占建筑总能耗的比例大于 5%。	1.可再生能源（风能、太阳能、水能、生物质能、地热能、海洋能等等）系统主要竣工资料（包含可再生能源利用率计算） 2.运行记录或测试报告	可再生能源利用情况	现场核实	评价小组	Yes
		4.2.10	采暖或空调能耗不高于国家批准或备案的建筑节能标准规定值的 80%。	节能计算报告				N/A
		4.2.11	可再生能源的使用量占建筑总能耗的比例大于 10%。	1.可再生能源（风能、太阳能、水能、生物质能、地热能、海洋能等等）系统主要竣工资料（包含可再生能源利用率计算） 2.运行记录或测试报告	可再生能源利用情况	现场核实	评价小组	Yes

节水与水资源利用	控制项	4.3.1	在方案、规划阶段制定水系统规划方案，统筹、综合利用各种水资源。	1.给排水系统主要竣工资料 2.水系统规划方案（含水平衡图或表） 3.运行情况说明（与设计是否存在差异，说明原因）	水系统规划方案落实情况	现场核实	专家	Yes
		4.3.2	采取有效措施避免管网漏 损。	1.给排水系统主要竣工资料 2.相关产品说明 3.水表设置的平面示意图 4.全年用水量计量情况报告	水系统设备、材料应用情况（管材、管件、阀门、设备和水表的安装使用情况）	现场核实	评价小组	N/A
		4.3.3	采用节水器具和设备，节水率不低于8%。	1.给排水系统主要竣工资料 2.产品说明书、产品检测报告	全部使用节水器具	现场核实	评价小组	N/A
		4.3.4	景观用水不采用市政供水和自备地下水井供水。	景观主要竣工资料	景观用水形式	现场核实	评价小组	N/A
		4.3.5	使用非传统水源时，采取用水安全保障措施，且不对人体健康与周围环境产生不良影响。	1.非传统水源系统主要竣工资料 2.非传统水源水质检验报告（包括日常自检和第三方检测机构出具的送检报告）	非传统水源水质保障措施落实情况（水质处理措施、储存及输配系统控制措施（倒流措施、独立管网、管道标识）等	现场核实	评价小组	N/A
节水与水资源利用	一般项	4.3.6	合理规划地表与屋面雨水径流途径，降低地表径流，采用多种渗透措施增加雨水渗透量。	1.给排水系统主要竣工资料（包括场地雨水总平面图、雨水入渗措施的详图、设计施工说明等） 2.景观主要竣工资料 3.相关产品说明书 4.开发前后场地综合径流系数和雨水外排量计算比较	地表与屋面雨水径流途径，渗透措施（雨水口、埋管做法等）	现场核实	专家	Yes
		4.3.7	绿化用水、洗车用水等非饮用水采用再生水、雨水等非传统水源。	1.非传统水源系统主要竣工资料 2.全年非传统水源用水量计量结果和自来水补水计量结果	非传统水源使用情况（非传统水源水表及自来水补水水表的设置与计量情况）	现场核实	评价小组	N/A
		4.3.8	绿化灌溉采用喷灌、微灌等高效节水灌溉方式。	1.给排水系统主要竣工资料 2.景观主要竣工资料 3.相关产品说明书 4.水表计量结果	绿化灌溉方式	现场核实	评价小组	N/A
		4.3.9	非饮用水采用再生水时，优先利用附近集中再生水厂的再生水；附近没有集中再生水厂时，通过技术经济比较，合理选择其他再生水水源和处理技术。	1.当地市政主管部门对项目使用市政再生水或自建中水设施的相关规定 2.项目使用市政再生水的许可文件 3.全年非传统水源用水量计量结果和自来水补水计量结果	水表计量结果	现场核实	评价小组	N/A
节水与水资源利用	一般项	4.3.10	降雨量大的缺水地区，通过技术经济比较，合理确定雨水集蓄及利用方案。	1.雨水系统设计说明、设计计算书（包含水量平衡分析、系统容量计算等技术经济分析内容） 2.雨水系统主要竣工资料	雨水利用的水表计量情况	现场核实	评价小组	Yes

				3.运行数据报告（全年逐月雨水用水量记录报告）				
		4.3.11	非传统水源利用率不低于 10%。	1.给排水系统主要竣工资料，非传统水源系统主要竣工资料 2.非传统水源利用率计算书 3.运行数据报告（全年逐月用水量记录报告）	非传统水源使用的水表计量情况	现场核实	专家	N/A
	优选项	4.3.12	非传统水源利用率不低于 30%。	1.给排水系统主要竣工资料，非传统水源系统主要竣工资料 2.非传统水源利用率计算书 3.运行数据报告（全年逐月用水量记录报告）	非传统水源使用的水表计量情况	现场核实	专家	N/A
节材与材料资源利用	控制项	4.4.1	建筑材料中有害物质含量符合现行国家标准 GB 18580~18588 和《建筑材料放射性核素限量》GB 6566 的要求。	1.建材产品检验报告 2.工程决算材料清单(标明生产厂家) 3.检验记录：1) 建设监理单位的进场验收/复验记录，2) 分项工程和检验批的质量验收记录，3) 相关管理部门的检查记录				Yes
		4.4.2	建筑造型要素简约，无大量装饰性构件。	1.建筑、结构竣工图 2.全部疑似装饰性构件及其功能一览表（设计单位提供） 3.土建工程决算书 4.装饰性构件造价占工程总造价比例计算书 5.双层外墙面积占外墙总面积比例的计算书	装饰性构件、女儿墙高度与竣工图和计算书的一致性	现场核实	专家	No
	一般项	4.4.3	施工现场 500km 以内生产的建筑材料重量占建筑材料总重量的 70%以上。	1.工程决算材料清单（包含材料生产厂家的名称、地址，材料用量） 2.主要材料采购合同 3.比例计算书				Yes
		4.4.4	现浇混凝土采用预拌混凝土。	1.施工单位提供的混凝土用量清单 2.预拌混凝土的采购合同、供货单				N/A
	一般项	4.4.5	建筑结构材料合理采用高性能混凝土、高强度钢。	1.结构竣工图 2.工程决算材料清单 3.混凝土检验报告（含耐久性指标） 4.高性能混凝土、高强度钢比例计算书 5.关于所采用混凝土、钢材合理性的论证材料（可选项）				N/A
		4.4.6	将建筑施工、旧建筑拆除和场地清理时产生的固体废弃物分类处理，并将	1.建筑施工废弃物管理规划 2.施工现场废弃物回收利用记录				Yes



			其中可再利用材料、可再循环材料回收和再利用。	3.可再利用、可再循环材料回收利用率计算书				
		4.4.7	在建筑设计选材时考虑使用材料的可再循环使用性能。在保证安全和不污染环境的情况下，可再循环材料使用重量占所用建筑材料总重量的 10%以上。	工程决算材料清单中的可再循环材料使用重量占所有建筑材料总重量的比例计算书				N/A
节材与材料资源利用	一般项	4.4.8	土建与装修工程一体化设计施工，不破坏和拆除已有的建筑构件及设施。	1.土建竣工图 2.装修竣工图	土建与装修工程一体化施工情况	现场核实	专家	N/A
		4.4.9	在保证性能的前提下，使用以废弃物为原料生产的建筑材料，其用量占同类建筑材料的比例不低于 30%。	1.工程决算材料清单 2.有关材料的使用数量、废弃物掺量的说明 3.废弃物为原料的建材占同类建材的比例计算书				N/A
	优选项	4.4.10	采用资源消耗和环境影响小的建筑结构体系。					Yes
		4.4.11	可再利用建筑材料的使用率大于 5%。	1.工程决算材料清单 2.可再利用建材用量比例计算书				Yes
室内环境质量	控制项	4.5.1	每套住宅至少有 1 个居住空间满足日照标准的要求。当有 4 个及 4 个以上居住空间时，至少有 2 个居住空间满足日照标准的要求。	1.建筑竣工图 2.日照模拟分析报告				Yes
		4.5.2	卧室、起居室（厅）、书房、厨房设置外窗，房间的采光系数不低于现行国家标准《建筑采光设计标准》GB/T 50033 的规定。	1.建筑竣工图（包含门窗表） 2.窗地面积比计算书 3.采光分析计算报告				Yes
		4.5.3	对建筑围护结构采取有效的隔声、减噪措施。卧室、起居室的允许噪声级在关窗状态下白天不大于 45 dB（A），夜间不大于 35 dB（A）。楼板和分户墙的空气声计权隔声量不小于 45dB，楼板的计权标准化撞击声声压级不大于 70 dB。户门的空气声计权隔声量不小于 30 dB；外窗的空气声计权隔声量不小于 25 dB，沿街时不小于 30 dB。	1.建筑竣工图设计说明、围护结构做法详图 2.或检测报告（其中允许噪声级为现场检测，其余可为实验室检测）				Yes
室内环境质量	控制项	4.5.4	居住空间能自然通风，通风开口面积在夏热冬暖和夏热冬冷地区不小于该房间地板面积的 8%，在其他地区不小于 5%。	1.建筑竣工图纸（包含门窗表） 2.开口窗地面积比计算说明书	居住房间通风可开启开口面积	现场核实	评价小组	Yes

		4.5.5	室内游离甲醛、苯、氨、氡和 TVOC 等空气污染物浓度符合现行国家标准《民用建筑室内环境污染控制规范》GB 50325 的规定。	由第三方检测机构出具的室内空气污染物浓度检测报告				N/A
	一般项	4.5.6	居住空间开窗具有良好的视野，且避免户间居住空间的视线干扰。当 1 套住宅设有 2 个及 2 个以上卫生间时，至少有 1 个卫生间设有外窗。	建筑竣工图	两幢住宅楼居住空间的水平视线最小距离，卫生间是否设有外窗	现场核实	评价小组	No
		4.5.7	屋面、地面、外墙和外窗的内表面在室内温、湿度设计条件下无结露现象。	建筑围护结构的热工计算书（包含防结露措施的详细说明及构造做法详图）	热桥附近有否结露、发霉现象	现场核实	评价小组	N/A
		4.5.9	设采暖或空调系统（设备）的住宅，运行时用户可根据需要对室温进行调控。	暖通竣工图设计说明	采暖或空调住宅室温可否自主调控	现场核实	评价小组	N/A
		4.5.10	采用可调节外遮阳装置，防止夏季太阳辐射透过窗户玻璃直接进入室内。	1.建筑竣工图 2.遮阳系统设计说明 3.遮阳装置竣工图	可调节外遮阳情况	现场核实	评价小组	Yes
		4.5.11	设置通风换气装置或室内空气质量监测装置。	暖通竣工图设计说明	是否设置通风换气装置或室内空气质量监测装置	现场核实	评价小组	N/A
室内环境质量	优选项	4.5.12	卧室、起居室（厅）使用蓄能、调湿或改善室内空气质量的功能材料。	1.建筑和暖通竣工图纸及设计说明 2.相关技术设计说明或检测报告	蓄能、调湿或改善室内空气质量的功能材料使用情况	现场核实	专家	N/A
运营管理	控制项	4.6.1	制定并实施节能、节水、节材与绿化管理制度。	1.节能管理模式、收费模式等节能管理制度 2.梯级用水原则和节水方案等节水管理制度 3.建筑、设备、系统的维护制度和耗材管理制度 4.绿化用水的使用及计量、各种杀虫剂、除草剂、化肥、农药等化学药品的规范使用等绿化管理制度 5.日常管理记录	物业的资源节约与绿化管理情况	现场核实	评价小组	N/A
		4.6.3	制定垃圾管理制度，对垃圾物流进行有效控制，对废品进行分类收集，防止垃圾无序倾倒和二次污染。	1.垃圾处理系统主要竣工资料 2.物业的垃圾管理制度	分类收集和处理废弃物	现场核实	评价小组	N/A
		4.6.4	设置密闭的垃圾容器，并有严格的保洁清洗措施，生活垃圾袋装化存放。		垃圾容器设置及使用维护	现场核实	评价小组	N/A

	一般项	4.6.5	垃圾站(间)设冲洗和排水设施，存放垃圾及时清运，不污染环境、不散发臭味。	垃圾站(间)主要竣工资料	垃圾站卫生处理情况	现场核实	评价小组	N/A
		4.6.6	智能化系统定位正确，采用的技术先进、实用、可靠，达到安全防范子系统、管理与设备监控子系统与信息网络子系统的基本配置要求。	1.建筑智能化系统主要竣工资料（包括验收报告） 2.运行记录	智能化系统是否功能完善，运行是否安全可靠	现场核实	专家	N/A
运营管理	一般项	4.6.7	采用无公害病虫害防治技术，规范杀虫剂、除草剂、化肥、农药等化学药品的使用，有效避免对土壤和地下水环境的损害。	1.物业管理相关条例 2.化学药品的进货清单与使用记录				Yes
		4.6.8	栽种和移植的树木成活率大于 90%，植物生长状态良好。	物业管理相关条例	植物生长及维护状况	现场核实	评价小组	Yes
		4.6.9	物业管理部门通过 ISO14001 环境管理体系认证。	物业管理公司的资质证书				N/A
		4.6.10	垃圾分类收集率（实行垃圾分类收集的住户占总住户数的比例）达 90%以上。	物业管理相关条例	垃圾分类收集情况	现场核实	评价小组	N/A
		4.6.11	设备、管道的设置便于维修、改造和更换。	各专业主要竣工资料	公共设施（管井、公共设备及管道等）设置在公共部位	现场核实	评价小组	N/A
	优选项	4.6.12	对可生物降解垃圾进行单独收集或设置可生物降解垃圾处理房。垃圾收集或垃圾处理房设有风道或排风、冲洗和排水设施，处理过程无二次污染。	垃圾处理间主要竣工资料	可生物降解垃圾处理措施	现场核实	评价小组	N/A