Designing Bicycle Infrastructure in Nanjing, China

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ABSTRACT

China faces a very serious environmental situation as a result of severe environmental pollution in the country. Smog in eastern and northern China is a wake-up call for actions to be taken to improve the ecological environment. As a student in landscape architecture, my practicum topic focuses on a design that can reduce the problem of air pollution in China. A bicycle infrastructure design in Nanjing is proposed to encourage people to ride instead of drive. By creating a safe, functional, efficient, recreational and attractive bicycle system, more people will love cycling and realize the importance of “green travel”. At the same time, I would like to try to improve Chinese people’s awareness of environmental protection through a well-designed bicycle infrastructure.

Table of Contents.

Abstract *3*
Introduction *6*
one. Research Background *8*
Environmental Problems and Conditions in China *10*
Personal interest on this topic *12*
Design Trend of the Day *14*

two. Air Pollution & Solution in China *18*
Air Pollution in China *20*
Encourage people' low-carbon lifestyle through landscape design *24*

three. Bicycle Development in China *26*
The Background of Bicycle Development in China *28*
The Reason of Hard to Ride in China *30*

four. Case Studies & Design Principles *34*
The Bicycle System in Copenhagen *36*
The Bicycle System in Lyon *46*
Design Principles *60*

five. Site Selection and Design Intention *62*
Site Selection and Potentials *64*
Design Intention *70*

six. Bicycle Network & Mapping *72*

seven. Cycle Corridors Design *100*

eight. Branding Introducing + Components Design of Bicycle System *126*
Components of Bicycle System *128*
Introduce of Branding of Cycle System *130*
Design of Intersection *132*
Bollards Design *134*
Fence Design *136*
Sign Design *140*
Bicycle Location Map Design *142*
Traffic Light Design *144*
Bicycle Rack Design *146*
Proposed Design of Street *150*
Process of How to Rent A Bike *152*
Bicycle Design *154*
Bicycle Light Design *156*
Design of Electronic Shared Information *158*
Bicycle Rental Station Design *160*

nine. Site Analysis + Design *168*
Map of Plaza Location *170*
Site Analysis *172*
Design Process and Components *174*
Proposed Design to Improve People's Ecological Awareness *180*
Choices of Materials *182*
Choices of Vegetations *184*
Proposed Detail Drawing *186*
Proposed Perspectives *188*

ten. Conclusion *194*
Acknowledgments *197*
References *198*

INTRODUCTION

In modern society people abuse nature for economic improvement. Progress based on excessive exploitation of natural resources is unsustainable. After multiple warnings from nature, disasters caused by environmental exploitation and pollution from fast industrial development, some people have realized the importance of environmental conservation. Developed countries have particularly realized the importance of environmental protection, but the situation is still not optimistic in some developing countries. China faces a very serious environmental situation with severe pollution. Smog in eastern and northern China provides a wake-up call to take action for the ecological environment. More designers are trying to improve the environment through their efforts. Landscape architecture in China is not playing a positive role in protecting the environment. As a Chinese citizen studying landscape architecture in Canada, I am concerned about environmental issues and ecological design. I have focused my academic work on how to improve China's environmental situation through personal efforts.

This thesis describes an option for improving the increasingly terrible air pollution in China. Based on the research, motor vehicle use is the most significant contributor to smog in China. Landscape architecture may be employed to reduce the use of motor vehicles. Landscape design can promote people's environmental concern and encourage a low-carbon lifestyle. In many developed countries, people have higher awarenesses of environmental protection and realize the important role of green transport in urban green construction. Bike travel is both environmentally friendly and efficient. Considering the widespread acceptance of Chinese people for bicycles, it is feasible to establish a cycle network. In my opinion, since in the past few decades, Chinese peoples have demonstrated a preference for bicycle travel, but they gradually hide such preference due to many factors, such as the chaotic traffic condition and modern people's preference for private cars. I would like to design a convenient, safe and enjoyable cycling system, to help people rediscover the love for cycling and solve the increasingly serious air pollution and traffic jam in China.

To design a relatively complete green bicycle system, I set my research place in Nanjing, where I spent my five years of undergraduate life. Nanjing, as a famous historic and cultural city, is one of the four great ancient capitals in China and one of the six well-known historical capitals in China. Nanjing is also a newly emerging city full of vitality and going through rapid development. The fast economic development contributed to Nanjing's 242 smog days during 2013. This situation is closely related with the large amount of vehicles in the city. A bicycle infrastructure which could drastically reduce reliance on motor vehicles is urgent for Nanjing. The proposed construction of a public bicycle system will be divided into hardware construction and software construction. The hardware mainly includes bicycle routes, cycle corridors, parking spots, rental stations and other components, such as, intersection, bollard, fence, signs, bicycle location map, traffic light, rack and bicycle design. The software mainly includes a public bicycle business model and other management measures. The purpose of my practicum is to encourage people to ride instead of drive to reduce smog, by creating a functional, efficient, recreational and attractive bicycle system. I would also like to improve Chinese people's awareness of environmental protection through the design of cycle infrastructure.

one

Research Background

Environmental Problems and Conditions in China

Human society develops from primitive society, agricultural society to industrial society and today the modern society. In primitive society, human get most of the resources from nature, people respected and showed gratitude to nature at that time. In agricultural society, people learned to reclaim land and breed captive animals; they knew how to live in peace with nature. However, starting from industrial society, regardless of the harm to the natural environment, human tried their best to seek the development of economy. People abused the nature in the modern society; such economic progress based on excessive exploitation of natural resources is unsustainable.

After multiple warnings from nature, disasters caused by the excessive exploitation and pollution from fast industrial development, people realize the importance of environmental conservation. There are many environmental problems in China caused by years of rapid economic development and neglect of environmental protection. China faces a very serious environmental situation with severe environmental pollution. Streams and rivers cease to flow, forests and meadows decrease dramatically, the diversity of species decreases gradually, air is polluted in a large scale and desertification becomes more and more serious. The country also faces global warming, ozone depletion, ocean pollution, depletion and pollution of freshwater resources, serious water shortage in many cities, and other environmental problems. Smog in eastern and northern China in recent years provides a wake-up call for people to protect the country's ecological environment. The major reason for deterioration of China's ecological environment is probably connected with poor environmental education and awareness of Chinese. In 1969, Cuyahoga River in Ohio burst into fire, which is called America's wake-up call in history books. The strong environmental awareness had been firmly rooted in the minds of people until the 1970s (Zhengyao & Ling, 2006). Like the Americans at that time, the Chinese now begin to consider whether the environmental cost for industrialization is too high. The terrible smog and other environmental issues bring a lot of inconvenience for people and make the public anxious. Now environmental problems in China have caused the attention and discontent of many people.

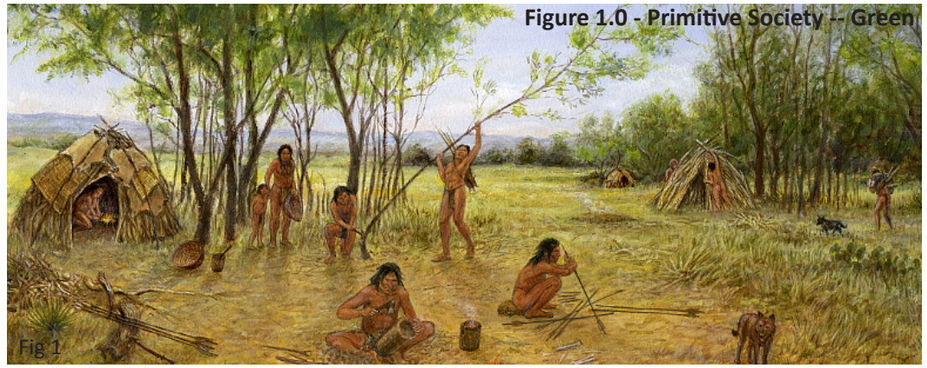


Figure 1.0 - Primitive Society -- Green

Figure 1.1 - Agricultural Society -- Yellow

Figure 1.2 - Industrial Society -- Black

Personal interest on this topic

I have become more concerned about environmental issues and ecological design since I start to learn architecture. Before I graduated from university, I had been living in China. The changes from blue sky, white clouds and green trees in my childhood to poor air quality and severe smog make me worried. I became a mother in 2014, and this change led me to think about creating a better environment for future generations. Future generations have the inalienable right of survival like people in contemporary times. Our generation is obliged to ensure that future generations have a suitable living environment and space. People should follow the principle of reasonable savings. The key point of contemporary people's responsibility for future generations is to leave enough survival resources for future generations and to provide them with at least the same and even more than they inherit from the previous generations so that they can create better development conditions for future generation during their own development. But the resources available for human benefit and development is limited on the earth, and ability of the earth to withstand environmental pollution and resource depletion is limited. Human activities must remain within the tolerance limitation of the earth, otherwise an overdraft and advance on the resources of future generations is required, which will inevitably harm the interests of future generations (Dehua, 2012, p53). The situation in today's China is overdraft and advance of the resources of future generations.I have been thinking about how to improve the situation through personal efforts.

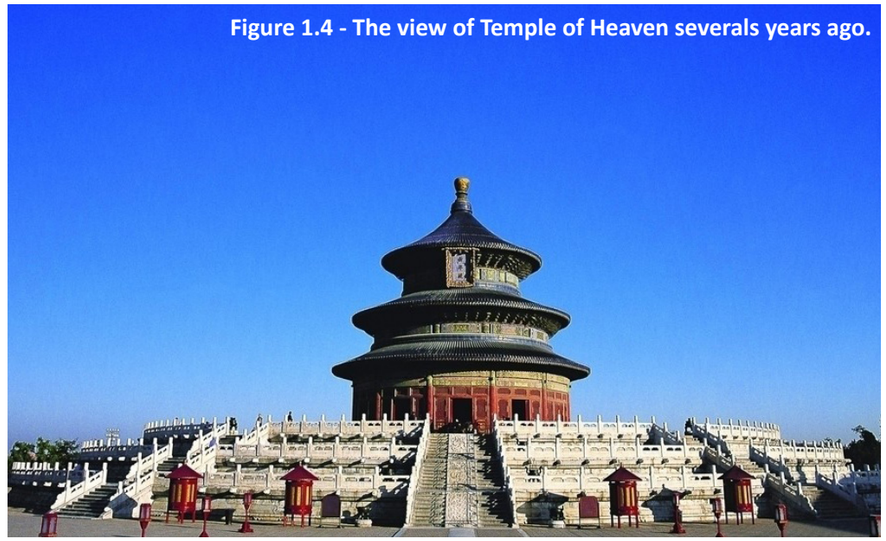


Figure 1.4 - The view of Temple of Heaven severals years ago.

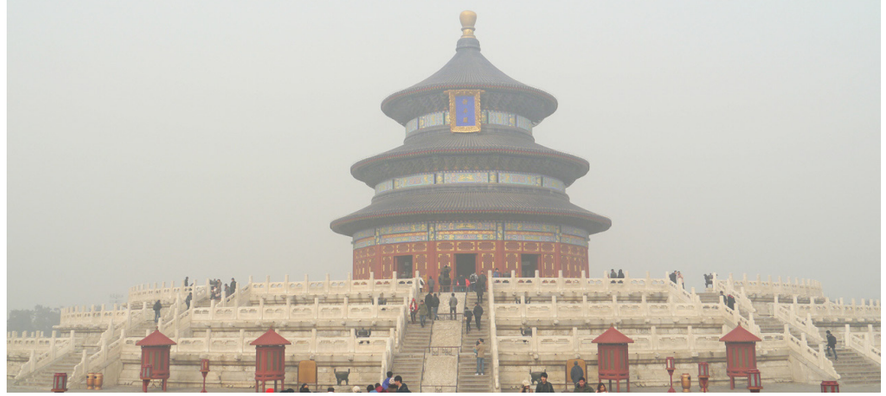


Figure 1.5 - The view of Temple of Heaven in recent years.

Design Trend of the Day

Nowadays, more and more designers are trying to improve the environment through their efforts. It is not only to satisfy consumers' needs, but it is also designers' own ideal. Many precedents of such designs can be found in developed countries, especially in the field of landscape architecture. The job of landscape architects is to help people maintain the harmony among buildings, communities, cities, human life and the earth. Landscape architecture is the ecological design of land and outdoor space. The goal of landscape design is to affect human ecosystems with a minimum design which maximizes the aid of forces of nature, and a regenerative design based on the organic self-regenerating ability of systems of nature. The goal is to change the input and output mode of existing linear logistics and energy flow and establish a circular process among the source, consumption enter and the channels. The landscape created by such a design is a sustainable landscape. Yu Kongjian points out that green landscape design should be local, protect and conserve natural capitals, allow natural action, revel nature and so on (Dehua, 2012, p125). Landscape design should not focus primarily on a form of beauty which presents the taste of the designer. Landscape designers should be people-oriented and consider the user's feelings fundamentally. On the basis of respecting and using nature, we should make the design humanized to a maximum extent so that people can understand the ecological beauty and generate the idea of environmental protection while feeling and experiencing the landscape. In 1969, the American landscape designer Lewis P. proposed a "4E" approach of landscape construction: educational, ecological, aesthetic and environmental. It has mentioned to take landscape habitat as the educational area. Development of personality is greatly related to the environment (Yichuan, Lifang, Liangming, & Lianfang, 2005). Meanwhile, human health is also closely linked with the environment. Good environment can ease the stress of urban life and inspire human potential. Overall, as the habitat of human, everybody will be in different environments and communicate with environment all the time. People's demand for quality of the environment is increasing, and landscape design is appealing for urban construction. The educational function of landscape design will help people obtain knowledge from the environment and improve people's moral qualities.

Therefore, people should place more emphasis on the educational function of landscape design.

During a few years when I studied in Canada, I was deeply attracted by the beautiful natural environment. I admire the awareness of environmental protection and harmonious society, which is lacked by Chinese people. Under the leadership of China's policy, if we can make everybody protect the environment every day, we will make great progress. As a student of landscape design, I always want to improve the environment through my own efforts, including not only small-scale environmental improvement from the design itself but also beautifying the environment ideologically in order to enhance social consciousness. I hope we can play a wider and more profound role in environmental protection through landscape design.

Current Landscape Designs in China

China's landscape design industry is developing quickly together with the rapid development of the national economy and improvement of people's living standards. The construction of garden cities, flower garden cities, and garden communities becomes popular so that the urban and rural environments in China change rapidly. The rapid development of landscape allows people to live in a beautiful and comfortable environment, which promotes public health. China's current landscape construction designs remain at the level of greening the landscape. The educational function of landscape design is often overlooked, which is one of the most important functions of modern landscape design. China's existing landscape design cannot play an active educational role to raise people's awareness of environmental protection. This inability is due to Chinese people's environmental awareness, the educational function of landscape in China, current problems of landscape in China and other problems. On the other hand, through the above studies, it is valuable and possible to raise Chinese people's awareness of environmental protection through landscape. Designers should pay attention to and study the design in this aspect.

Letting people make full use of landscape and learn from the design is a good way for developing landscape design. Based on the current condition of air pollution and landscape design in China, I think this is the most efficient, sustaining and inexpensive way to improve the environment. People can easily receive diverse information about the importance and benefits of protecting environment through TVs, broadcasts, books and schools. This information only makes people realize it is good and necessary to protect the environment, but most people do not know how to practically act to protect it. From my point of view, two efficient ways for people to recall their environmental consciousness are to feel and to experience. Making use of landscape design is a good way for people to feel and experience.

This paper showcases a way for people to put awareness for the need and benefit of protecting the environment into action, through the suggestion of a functional landscape design. This study also discusses whether landscape design could improve Chinese people's awareness of environmental protection.

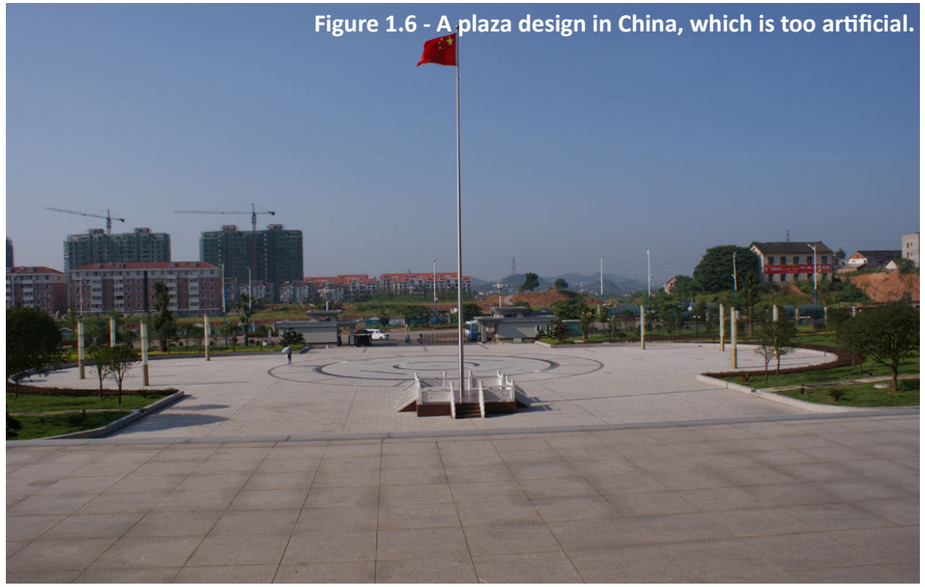


Figure 1.6 - A plaza design in China, which is too artificial.

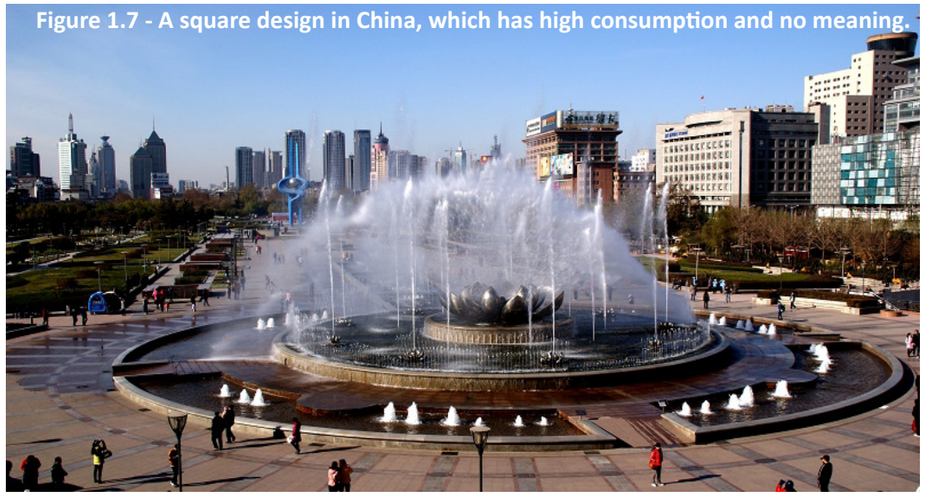


Figure 1.7 - A square design in China, which has high consumption and no meaning.

two

Air Pollution & Solution in China

Air Pollution in China

Since smog has been a severe concern in China these years, I focus on the air pollution in China. “IARC (International Agency for Research on Cancer) scientific publications no.161” made a statement: Recent estimates suggest that the disease burden due to air pollution is substantial. Exposure to ambient fine particles was recently estimated to have contributed 3.2 million premature deaths worldwide in 2010, due largely to cardiovascular disease, and 223 000 deaths from lung cancer. More than half of the lung cancer deaths attributable to ambient fine particles were projected to have been in China and other East Asian countries. (Federation of European Heating, Ventilation and Air Conditioning Associations, 2015)

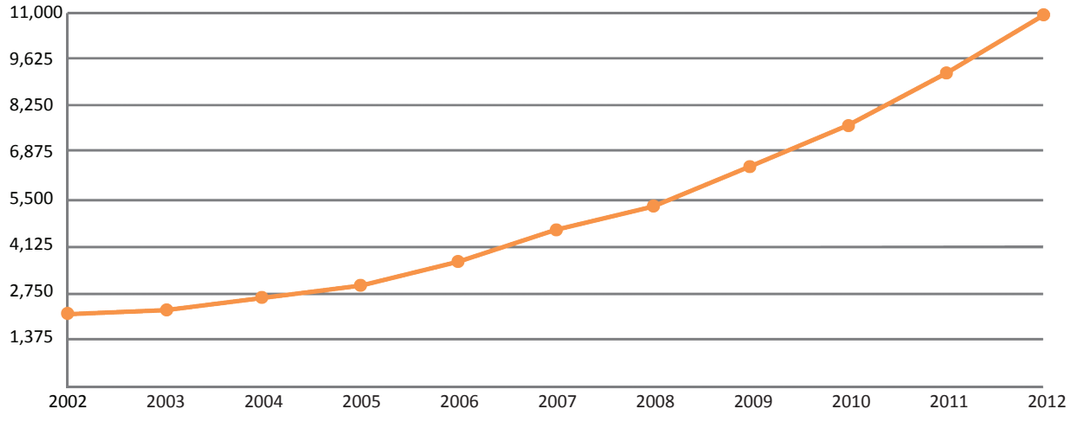
Some reports have shown that the connection between smog and mortality is growing. “Global Burden of Disease Study 2010” published in the authoritative medical journal The Lancet shows that outdoor air ranks the fourth among the killers that cause the death of Chinese. In the same year in China, outdoor air particulate pollution (mainly refers to PM2.5 - particulate matter) caused 1.2 million premature deaths, which is equal to the population in Xicheng District in Beijing. This pollution also resulted in the loss of over 25 million healthy life years, which means everyone will live seven days less than before if the figure is shared by 1.3 billion people. According to the data of Greenpeace, the contribution of 196 coal-fired power plants in Beijing to PM2.5 pollution in 2011 led to the premature deaths of nearly 2000 residents in Beijing (WeChat News, 2014). In 2012, Greenpeace volunteer Miss Zhong Yu did an experiment. She finished Beijing Marathon with “machinery lungs.” The machinery lungs could inhale 153 mcg PM2.5 contaminating particles per cubic meter machine at a speed of four liters per minute (which is the normal volume of air inhaled by people). After six hours and seven minutes, it inhaled 5605 mcg in total, which turned the white membrane sallow. “It makes me just want to die,” Ms. Zhong said on the verge of collapse, “You can imagine that your lungs turned in this colour on that day.” On October 28th, 2013, the heavy smog made at least 31 sections of roads paralyzed. Drivers cannot see objects clearly even at 200 meters. At 9:00 in the evening, a sad

Figure 2.0 - Smog situation in China.

driver called the studio of Beijing traffic radio station and said he was about to cry as he already had run four red lights due to the smog. The broadcaster comforted him: “Don’t worry. The smog is so serious that your license plate number will not be noticed clearly.” But the joke to adjust the tension was always interrupted by the continuous accident broadcast. Such a situation occurred at least 18 times in two hours. The congestion was eased until 21:00 (WeChat News, 2014). Such examples make people uneasy and anxious about environmental problems. Fortunately, the recent outbreak of a variety of environmental crises not only enhances Chinese people’s environmental awareness, but also makes their government take active measures to conduct environmental protection. In 2007, the Chinese government proposed the concept of ecological civilization, which aims to develop society in a sustainable and ecological way. In 2014, the new Chinese president Xi Jinping addressed an issue of increasing importance to many Chinese people: pollution. In response to smog affecting larger parts of China, he pointed out: “We will declare war against pollution and fight it with the same determination we battled poverty” (Xinhuanet, 2014). Therefore, because of increasing problems with smog, and the government of China’s willingness to ameliorate the situation, now is a good time to explore efficient means to increase ecological development in China. Environmental problems in China need to be solved urgently and may be improved with the collaboration of government policies.

To tackle the increasing environmental problems in China, I first look at the main sources of smog. A recent investigation by the Chinese Environmental Protection Agency showed that 31.1% of PM2.5 comes from motor vehicles, 22.4% comes from coal, 18.1% comes from industry, 14.3% comes from dust, and 14.1% comes from others (Jing, 2015). The investigation revealed that motor vehicles are the most significant cause of smog. According to the data recently released by the Traffic Management Bureau in China, there were a total of 264 million automobiles by late 2014, increased by 19.89% compared with 2013 (Chinabgao, 2015). Based on the above research, the emission of exhaust by motor vehicles in China is an increasingly terrible source of air pollution. A reduction in motor vehicle use will help decrease smog.

Figure 2.1 - THE DEVELOPMENT OF VEHICLES IN THE PAST 10 YEARS IN CHINA



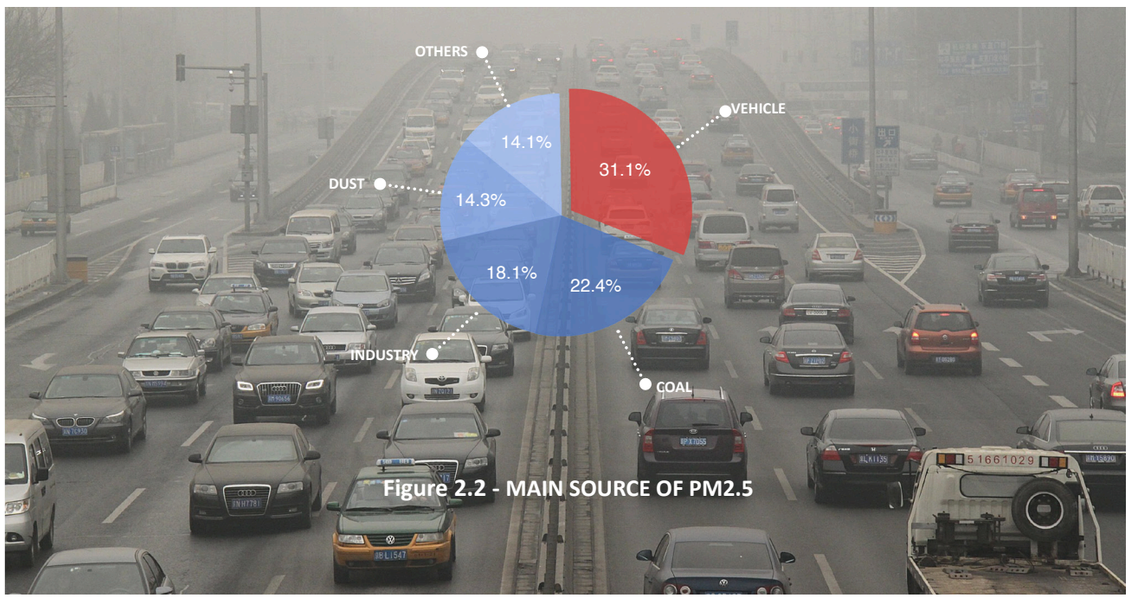


Figure 2.2 - MAIN SOURCE OF PM2.5

Encourage people' low-carbon lifestyle through landscape design

Landscape architecture can be used to help people reduce driving. Landscape design can provide people green places and help to promote people's environmental and low-carbon lifestyle. In many developed countries, people have higher awarenesses of environmental protection and they have realized the important role of green transport in urban green construction, such as the "CityBike" program in Copenhagen, "totally bike" in America and "calm traffic" action in Germany. Cycling can reduce vehicle emissions and carbon dioxide emissions and protect urban roads and buildings. There are many advantages of cycling: first is to reduce carbon dioxide emissions; second is to avoid pollution or traffic congestion and save time; third is to increase public health; fourth is convenience and low-cost; fifth is to ensure personal safety and avoid major accidents. In 1995, Copenhagen's municipal council launched the "CityBike" program to encourage people to use bicycles. It equipped the city with thousands of bicycles to meet people's demands for traveling in the "appropriate distance". The public bicycles provided by the government are free and users can put 20 Danish kroner (about six CAD) in a slot machine to ride the bike. Then they can return the bicycle to any public bicycle station and get their money back. "We aim to make 50% of citizens in Copenhagen ride a bicycle as a daily transport tool by 2015 so that we can reduce at least 80,000 tons of carbon dioxide emissions every year." Copenhagen Municipal Technology and Environment department Mr. Peter Mandelson says: "By then, more citizens in Copenhagen will regard bicycles as a safe and convenient daily transport tool (CYOLNET, 2008)." It is visible that traveling by bike is both environmentally friendly and efficient.

In China, bike has been the main travel tool since 1970s. Once upon a time, China was known as the kingdom of bicycles. There was a flood of bicycles in Beijing Tiananmen Square as a symbol of China. The proportion of bikes in big cities was generally about 35% to 45%, which is far less than the proportion in small and medium cities with more than 60% generally (Shan, 2011). However, with economic development, more and more people purchase cars. Research has shown that the carbon emission varies between different traffic modes. Walking and cycling almost have no carbon emission while the public traffic system takes second place. The carbon emission of private cars is the highest (Shan, 2011). Many experts have proposed ecologically sustainable modes of travel, although most people still consider owning a private car as a goal (Shan, 2011).

In Boston in the United States, there is a big project called "Big Dig" which costs nearly $ 20 billion. It buries the fast lanes through the city underground to restore the green corridor, walking and cycling space on the ground. China can build green corridors like Boston's without such a great cost. There is a Appalachian Trail in Eastern United States, and every American is proud of finishing the casual way of the Appalachian Mountains, which takes one summer holiday to finish. There is a green bicycle lane in Canada across the entire country smoothly (Kongjian, 2014). In China, we can build such a green bike lane so that Chinese people can be proud of traveling the entire length of the lane rather than look down upon cyclists. Thus, I think landscape design and planning can solve the shortage of bike lanes and people's bias against cycling in China. First of all, we can design bike lanes through landscape design to provide people with a safe, green and healthy travel environment. The parking spots and infrastructure of transfer points should be considered in order to complement bike lanes. Second, the green lane established through landscape design can encourage people to travel ecologically, allowing people to actively enjoy the process of cycling. Meanwhile, they can enjoy the beauty of nature in cycling and contribute to protecting nature and reducing carbon dioxide emissions in order to effectively improve people's awareness of environmental protection.

Considering the widespread acceptance of Chinese people for bicycles, it is feasible to establish a cycle network. In my opinion, since the past few decades, Chinese people always have a deep preference for bicycle, but they gradually hide such preference due to many factors, such as the chaotic traffic condition and modern people's preference for private cars. I would like to design a convenient, safe and ecological cycle system, so as to help people rediscover the love for cycling and solve the increasingly serious air pollution and traffic jam in China.

three

Bicycle Development in China

The background of bicycle development in China

Bicycles have played an important role in Chinese people's travel since the first several bicycles were shipped from Europe to Shanghai in 1868. In the late 19th century, China began to import bicycles from the United Kingdom and ran a Tongchang Bicycle Shop for selling bicycles and the parts. In the early 20th century, there were approximately 20 bicycle stores in Shanghai. After World War I, bicycles became vehicles of postmen with the development of posts and telecommunications. There was a drastic increase in demands for bicycles, so another new group of bicycle stores were opened within the city. In 1940, the Shanghai bicycle plants were founded, so that China had its own branded bicycle manufacturers. In 1949, only about 15, 000 bicycles were produced in China. In 1958, 267 small factories were merged into the No. 3 Shanghai Bicycle Factory, namely the predecessor of the Phoenix Bicycle Factory. Several years later, Phoenix became a brand of bicycles well known to every household, and was suddenly in short supply. However, there were still many people who cannot afford bicycles. In the 1960s and 1970s, bicycles played important roles in people's lives. Sewers, watches and bicycles were regarded as three major objects that symbolized if a family was wealthy or not. The elder generations told me that a bicycle was the foremost material condition for girls to get married in that period and a dignified dowry for girls to be married. A person would attract a crowd of people to stop and envy him if he rode a bike. By late 1980s, there had been a total number of 0.5 billion bicycles in China. It was the first time that Chinese people changed their own place with bicycles (Myhenan, 2011).

The bicycle was a vivid reflection of an older image of China, a symbol of Chinese manufacturing and image of China in the eyes of foreigners. In the 1980s, China was called a kingdom of "bicycles". George Bush, the former president of America, received two bicycles as gifts in Beijing. During economic reform of China, Deng Xiaoping defined prosperity as the possession of a bicycle in every family. Bicycles have enforced the development of the world's most populous country. They carry people and materials, becoming load carriers full of Chinese characters independently developed in China. In the early 1990s, mountain bikes became

popular in Beijing. People's expectations for bicycles were not for their hardness and durability, but for higher speed and more joyful riding experience (Myhenan, 2011). In the late 1990s, 180 bicycles were owned by every hundred households in cities (Ying, 2010). In 1994, the first "Industrial Policies for Automobiles" were released by the State Council, which publicly reported that "individuals were encouraged to buy cars". Thereafter, a watershed moment occurred was achieved in the idea that China was a forbidden area of private cars. By the mid- and later periods of the 1990s, individuals' purchase of cars had appeared like an onrush of water that could not be stopped. From that period bicycles gradually became less popular for people's lives in large cities of China (Myhenan, 2011).

Figure 3.0 - Riding bike is a proud thing in China, 30 years ago.

Figure 3.1 - Chinese people love riding in 1980s.

Figure 3.2 - Now roads are dominated by cars in China.

With economic development, more and more people purchase cars. The possession of a private car became a symbol of improved economic status for Chinese people. Data recently released by China's Traffic Management Bureau and the Ministry of Public Security indicate there were 264 million automobiles and 0.3 billion drivers of automobiles by late 2014. There were 117 million small passenger cars. Among these passenger cars, there were 0.105 billion private cars, which accounted for 90.16% and increased by 19.89% compared with 2013. On average, 25 private cars were owned by every hundred households in China. In Beijing, 63 private cars were possessed by every hundred households, while more than 40 out of 100 families possessed private cars in large cities such as Guangzhou and Nanjing (Chinabgao, 2015).

Obstacles to Bike Riding

I remember when my father told me that he rode a bike with my mother on the street when he just married my mother and they were envied by passersby. It just has been over two decades, we have own two cars in the family.. The era of bicycles is about to turn a new page in China. In recent years, cycling has become increasingly difficult in China. With the increasing number of motor vehicles, the congestion of urban roads is intensified, and vehicle emissions have become the main source of pollution. People began to miss the bicycle era and advocate "green travel". The vocalization of a desire to allow more bicycles to return to the cities is louder and louder. However, when people actually ride a bike on the streets, it is difficult for them to travel by bike. This problem is mainly reflected by two issues: the failure to guarantee riders' right-of-way, and the difficulty to park bicycles. :

1. Failure to Guarantee Riders' Right-of-way

Some newly constructed roads have no special lanes for bicycles , and the lanes that exist for bicycles are too narrow in constructed roads. Bicycle lanes are often occupied by automobiles and bus stops are even set up in lanes for bicycles in some roads. These obstacles impact normal riding and cause traffic hazards. At present, bicycle transport is usually considered to be less important in designs. For instance, bike riders traveling straight forward shall yield to automobiles turning

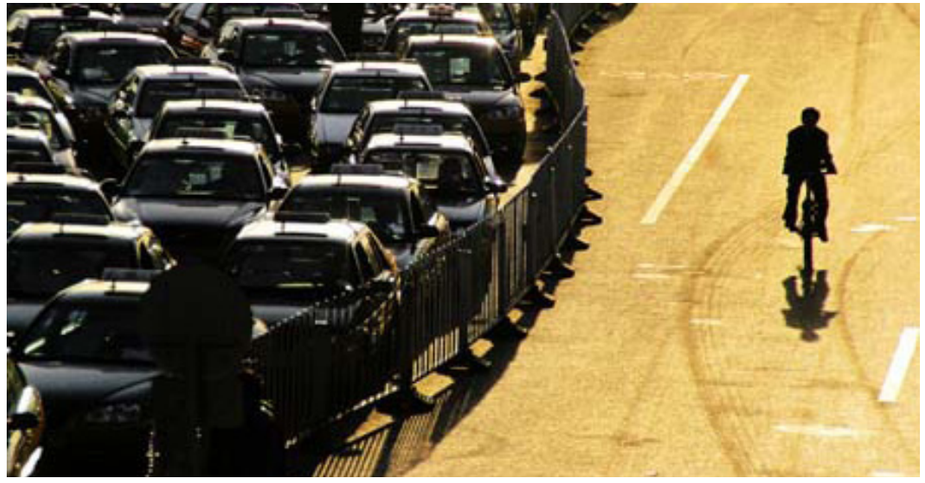


Figure 3.3 - The comparison of people riding and driving over the past 30 years.

right at intersections. It is unsafe to ride bikes and it is usually impossible to cross the road during the time of a traffic hour.

2. Difficult to Park Bicycles

Over the past few years, departments concerned with traffic planning usually have only attached importance to trips and parking of automobiles in solving traffic problems. This focus is due to the recent drastic increase in the amount of automobiles in all cities. These departments have also relaxed their uniform proper management of bicycle transportation. As a consequence, some original areas for parking bicycles have been transformed into parking lots for automobiles. Meanwhile, underground parking lots are only open to automobiles in many newly constructed public buildings. These restrictions make it more difficult to park bicycles. In recent years, urban rail transit such as subways and light rail have been successively constructed in some large and medium-sized cities to facilitate the construction of urban public transport systems and solve the problem of traffic jams. In planning construction, inadequate attention has been paid to bicycle transport as well, which has directly led to disorderly parking of bicycles which impacts the image of cities and loses of bicycles.

In summary, the lack of dedicated bicycle lanes, good connections, a well established bike route network and bicycle parking areas make it unsafe and inconvenient to ride in China. Besides, the trend makes travel tools become the symbol of social status. Cyclists are often looked down upon, which makes more and more people reject the opportunity to ride bikes. To achieve “green travel” the traveling environment can be improved and work can be done to reduce or eradicate the prejudice against cycling . They may functionally satisfy people’s need to travel and are also advantageous for health, amusement and environmental protection. Consequently, people once again start to enjoy ride a bike. I propose to design a functional, convenient, safe, interesting and enjoyable bicycle system to solve the existing problems and make people start to love cycling again.

Figure 3.4 - The comparison of bicycle parking places over the past 30 years.

four

Case Studies & Design Principles

The bicycle systems in Copenhagen, Denmark and Lyon, France were analyzed to provide examples of how landscape architecture can be used to ameliorate China's bicycling infrastructure. In the study of Copenhagen's bicycle system , I focused on the relationship between bicycle and people, how the government constructs and promotes the system, and the effect and contribution of the bicycle system. For the Lyon study, I looked at the components, construction and information feature of their bicycle rental system, as well as how the government promote and improve the bicycle system. Moreover, I did research on the influence of the bicycle system on people's travel modes.

1. The Bicycle System in Copenhagen

Background

Copenhagen is a well-known bicycle city because it has maintained a tradition of using bikes for a long time. In the city, bicycle planning is an indispensable part of urban road planning. Early in the 1960s and 1970s, a partial bicycle network was formed. Although many citizens possessed cars, they still use bikes that have become a transportation vehicle that is widely accepted in society as well as an important part in urban transportation. One-third of citizens commute to work by bike. Governmental ministers and the mayor are also known to ride bicycles to work (Wei, 2012).

Development of bicycle system

In Copenhagen, bicycle transportation, motor transportation and pedestrianism are regarded as independent transportation systems. Bicycle networks are allocated in the central area of the city. The bicycle road is 30km length in total in the city. In recent years, the percentage of bicycle transportation in Copenhagen has been increasing, which is mainly attributed to the fact that the municipal government spares no efforts to improve the transportation environment and services for bicycles. In 2002, the total investment into the construction of urban road reached 60 million DKK, one third of which was used to improve the bicycle's transportation environment (Wei, 2012). The goal of Copenhagen's bicycle transportation policy is to increase the percentage of people who use bicycles to commute, enhance

bicyclers' safety, and accelerate bicycling. Since 2000, Copenhagen's municipal government has formulated and passed a series of regulations about urban bicycle transportation and clarified the goals. First, in the urban public transportation, the usage bicycles should increase from 34% to 40%; second, the injuries and deaths of bicyclists should be reduced by 50%; third, the percentage of those who think it is safe to ride bikes should increase from 57% to 80%; fourth, bicycle traveling speed should increase from 5km/h to 10km/h; fifth, the number of roads that bicyclists are not satisfied with and that have a low quality should be controlled with 5% of the total number (Wei, 2012). Bicycle transportation policy can be evaluated based on the formulation of qualitative and quantitative goals, such as those outlined by Copenhagen's municipal government. In order to reach the above goals, the government decided to focuses on nine issues: first, increase the number of bicycle tracks and routes; second, set up green bicycle route; third, improve the bicycle use conditions in the central urban area; fourth, connect the bicycles and public transportation; fifth, improve bicycle parking facilities; sixth, improve signal crossings; seventh, repair and maintain bicycle tracks; eighth, clean bicycle tracks; ninth, publicize and provide information (Wei, 2012).

Figure 4.0 - People cycling in Copenhagen.

People and bicycles

1. Bicycles' roles in Copenhagen transit

Unlike many European cities, Copenhagen has a long biking tradition. Bikes are widely accepted in society. The percentage of bicycle transportation takes up about one fifth of the total transportation. From the perspective of education, bicycle users are the most highly-educated. Among them, senior riders keep increasing. Bicycles are mostly used for working, accounting for 34% of all commuters. In particular, one half of the users choose bicycles because of speed and convenience (Wei, 2012). Almost all people choose bicycle as a workout method. Many people think that biking is the most economical tool, as well.

2. Planning framework

Bicycle transportation in Copenhagen makes huge contributions to the environment. It is also one of the urban development goals of Copenhagen's municipal government that bicycle transportation should play the central role in urban transit. To achieve this goal, the municipal government have pledged to continue to increase the percentage of bicycle transportation in urban transit, accelerate bicycle travel, and improve the safety and comfort of bicyclists. In addition, bicycle parking site set up at the rail stations and the first and final bus stops will provide convenience for transferring from bikes to another transportation method and vice versa. It regulates that the expansion of road infrastructures should take the development of bicycle tracks into consideration. At the same time, the overall goal proposed in "Transportation and Environmental Planning" in 1997 is: Do not increase motor transportation level any more (Wei, 2012). The transportation network in Copenhagen will be mainly dominated by public transportation and bicycle transportation. In addition, some regulations beneficial to bicycle transportation development were issued. It was also raised that the major deaths and injuries when using bicycles would reduce by 40%. Bicycle transportation safety receives great concerns (Wei, 2012). Bicycle transportation has been integrated into urban planning at different levels. The purpose is to ensure that bicycle transportation will play a central role in the urban transportation in the future.

3. How to increase the number of bicycle users

In Copenhagen, bicycle users are usually considered to have best treat. In fact, many people only use bikes when the city takes a supporting attitude. It is beneficial to maintain the scale of bicyclers and stimulate more people to ride bikes to work by enhancing awareness of safety and improving bicycle travelling speed. The annual "I Ride to Work" and other activities provide an opportunity for people to try and know riding to work.

Among the bicycle users in Copenhagen, four fifths people are satisfied with the environment for bicycle use in the city. Two thirds of the people who use cars say that they may give up cars and choose bikes if the bicycle use conditions improve greatly (Wei, 2012). Therefore, it is necessary to set up sound bicycle keeping facilities at the terminal stop in the city as well as those in suburbs that ensure that bicycles will not be lost at night. In addition, people can easily ride bikes to the working places after getting off buses.

Figure 4.1 - People cycling in Copenhagen.

Main measures to promote cycling

1. Increase bicycle tracks and bicycle lines

A long time ago, the bicycle tracks built along the road were the main facilities for bicycle transportation in Copenhagen. By the end of 2001, the bicycle track had reached 307km and the bicycle line had reached 9km. According to “Priority Plan of Bicycle Track from 2001 to 2016,” in the next 15 years, 16.4 million dollars will be invested to construct an additional 51km of bicycle track and lines. The construction order is as follows: First, in any area where this are no designated spaces to ride bicycles, set the bicycle lines that accelerates bicycling; second, construct as many bicycle tracks as possible in the places with spatial restrictions which are prohibitive to bicycling; third, construct connection lines and bicycle networks in the places that lack bicycle tracks; fourth, under the same conditions, choose priority areas for bicycle transportation (Wei, 2012).

2. Construct bicycle green routes

In Copenhagen, for bicycle users, bicycle green routes are a new transportation facility, especially for long-distance users. The route has a large scale, not only providing broad tracks, but also providing pavements. In terms of route selection, make use of green separation zones to reduce casualties and limit intersections between bicycle routes and other motor tracks to reduce delays.

3. Improve the conditions for bicycle use in the central area

“Report of Tranquility of Transportation in Downtown Area” proposed the long-term plan of improving bicycle use in the central area. The first step in the improvement of the urban center was the demonstration project in 1999; i.e., bicycle routes were painted on six main roads. The project was successfully completed. Besides, administration approved of continued upgrading and renovating. One part was upgraded to be bicycle tracks. The other project was transforming the one-way route in the historical block to be two-way tracks. In addition, within the historical blocks that covered about 1km2, the discontinuous bicycle tracks were connected to be a network. Some one-way routes were transformed to be two-way routes for bicycles. On the basic, the demands of walking transportation should be taken into full consideration. Finally, the cultural and artistic national bicycle routes were built in the ancient urban area (Wei, 2012).

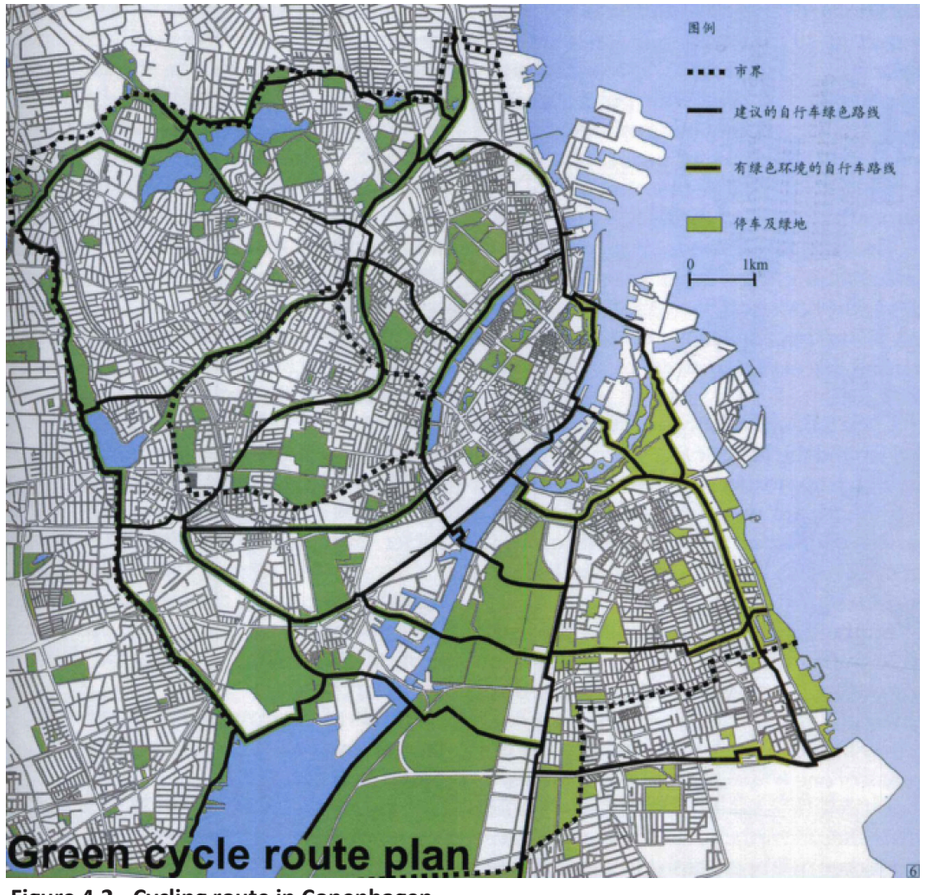


Figure 4.2 - Cycling route in Copenhagen.

4. Combine bicycles and public transit

Bicycle transportation and public transit has its own limitations. Not all transportation demands can be satisfied. “Urban Planning 2001” required that bicycle and public transportation methods be amalgamated. In this way, drivers could have an alternative transportation method. It was important to set up bicycle parking facilities at the first and final public transportation stops. Therefore, bicycle parking facilities were set at all bus stops and near the railway station along the new bus line. It was predicted that the railway stations would have huge demands on bicycle parking. Danish State Railways aimed to transform 25% of bicycle parking lots in the suburbs to be fixed parking sites. 50% were parking lots with roofs. The other bicycle parking lots adopted the form of multi-floor parking stands. In recent years, the improvement work on some suburban stops has been completed (Wei, 2012).

5. Improve bicycle parking facilities

Only one third of people were satisfied with the bicycle parking conditions in the urban area in Copenhagen (Wei, 2012). To respond to this level of satisfaction, the municipal government formulated a plan to provide enough parking facilities. The plan identified four site classifications for bike parking: first, bus stop; second, residence and working place; third, store and commercial centre; fourth, general roads.

The issue of bicycle parking for residential areas and places of employment is a problem about which the public is concerned. The government approved to stop construction of car parking lots in favour of transforming these sites into bicycle parking lots. In addition, bicycle parking stands are set up for residents and relevant personnel in the highly dense residential zone surrounding the urban centre, the action is quite popular and receives public commendation. The municipal government allows the store owners to make use of the residual space of the walking pavement to construct bicycle parking stands. For large-scale shopping centres, the government is responsible for formulating the standard of constructing bicycle parking lots. For the cities with a dense population, the bicycle parking facilities along roads are greatly desired. More parking places should be set (Wei, 2012).

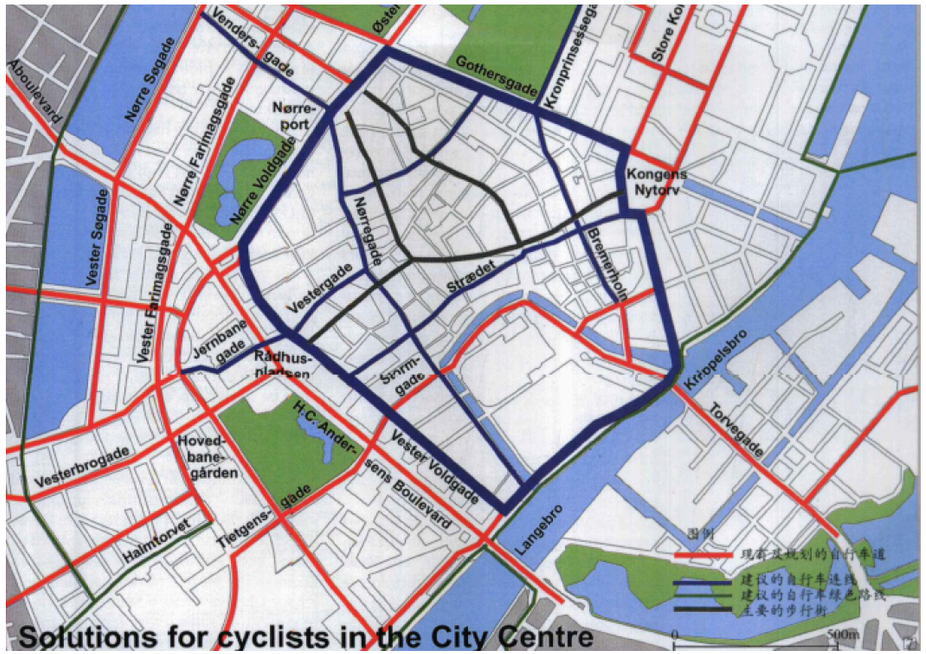


Figure 4.3 - Bicycle rental system in Copenhagen.

6. Improve light control roads

In “Copenhagen’s Transportation Safety Planning”, improving the safety of bicycle transportation is important, especially the bicycle road design at intersections (Wei, 2012). One fund is used to reduce and eliminate the number of bicycle injuries and deaths as well as other injuries in traffic accidents. To improve safety, the car parking line is moved back. Blue-and-white should be drawn on the bicycle tracks at the crossings so that cargo drivers and other motor drivers can clearly see the bikes with waiting signals. The blue-and-white bicycle tracks at the crossings can clarify the bicycle road access rights and passing routes.

7. Maintenance and cleaning of bicycle tracks

Some pits on the road or some uneven roads will arouse people’s dissatisfaction as well as affect people’s overall feelings about the quality of bicycle roads. Therefore, the government allocates specific funds for the maintenance of bicycle tracks. Additionally, there has been one type of equipment used to check bicycle tracks since 2001. The government laid a foundation for deciding the order of maintenance priorities as well as ensuring high-level maintenance. In Copenhagen, in principle, the bicycle tracks on the streets are cleaned every working day. The Bureau of Road and Park formulates cleaning standards and takes charge of cleaning. However, the cleaning task is entrusted to relevant municipal and political groups.

8. Enhance publicity and information spreading

Copenhagen began extensive publicity activities in 1995. The first activity was “Riding to Work” in 1996. This event now occurs annually under the auspices of the Danish Bicycle Association. Certain achievements have been obtained. In 2001, 15,000 people took part in the event. In 2000 and 2001, the municipal government organized “Transportation and Environment Week.” During this period, car transportation was strictly restricted in the central area (Wei, 2012). Civilians were encouraged to use bicycles instead of cars. Additionally, many businesses began to consider making employees’ transportation methods more reasonable. Some measures to encourage bicycle use are implemented. For example, covers and shelters have been added for bicycle parking lots and shower facilities have been installed for employees who ride to work. “Ride to Work” specifically sets 1998 and

2000 as “Company’s Riding Year” to encourage more employees to use bicycles.

Conclusion

The implementation of the plan “City Bike” also brings commercial benefits for the city because it enables people to know that Copenhagen is a bicycle city and makes the city become a tourism destination. According to “Urban Planning,” Copenhagen’s municipal government will also provide more information about bicycles, advocate for citizens to change their transportation methods, introduce new bicycling routes, and let people know that the bicycle use conditions in the central area have been improved.

Figure 4.4 - Bicycle parking in Copenhagen.

2. The Bicycle System in Lyon

Background

On May 19th, 2005, Lyon launched public bike Vélo'v - an automatic public bicycle system. The word Vélo'v consists of French "bike" and English "love," and means "love bike". This system allows users to take away a bike in a rental station and return it to another rental station. According to different prepayment modes, users can use a bicycle freely for 30 min to 1h, and they only need to spend a little money after riding overtime. It is a simple, convenient, and fast system which has been widely accepted by the citizens of Lyon and is used an average of 10,000 times a day. At present, there are 343 rental stations and 400 bicycles in Lyon. Since the system was put into service in 2005 till March of 2009, Vélo'v's users had ridden for 42.12 million km. Compared to vehicle trips, 8.424 tons of carbon emissions had been reduced (Huiming, Yu, & Wei, 2009).

Rental Method and Price

To use a public bike, users must first get a designed magnetic card. To reduce theft, the service provider charges €150 for each card as loss prevention money. If necessary, the money will be deducted directly and automatically from short-term prepaid cards or a cheque will be cashed from long-term prepaid cards. Public bikes can be rented within 24 hours. All those aged not below 14 who have purchased social insurance can rent a bike at any rental station. When renting a bicycle, users only need to put the card at the non-contact card reader and enter their personal password on the touch screen of the service terminal. Users can choose any of the rental bikes on the screen and take the bike from the parking pile within 45 seconds. To remind users, the chosen bike will flicker the light and ring. Users can rent and return bikes for any number of times within a day. For the same bike, users must return it to any Vélo'v station within 24h. If they return the bike beyond the deadline, the operator will deduct a fee from the guarantee deposit. When the bike is rented for 25 minutes, it will ring to remind users of the upcoming end of free time. If there is no available parking pile when users want to return the bike, they only need to put the prepaid card at the card reader, and then can get another 15 minutes of free time. The control screen will display a rental station nearby (Huiming, Yu, & Wei, 2009).

Bike Facility

Each rental station consists of a 2.2-meter-high service terminal, and 0.7-meter-high parking piles for bikes (Huiming, Yu, & Wei, 2009)

1. terminal and rack

Usually, a service terminal is placed at the centre of a rental station; sometimes, it is at either side. The service terminal equipped with bankcards can sell short-term prepaid cards. There are four languages in a server terminal, which can be used for rental and return inquiry. If there are no available bikes or unoccupied parking piles in a rental station, users can look up information on the service terminal. The size of rental station can be adjusted, and there are 10~40 parking piles in a station under normal conditions. In order to provide at least one unoccupied parking pile at a rental station, the number of parking piles in each rental station is 1.94 times as much as that of bikes (Huiming, Yu, & Wei, 2009).

2. bike

When a rental bike is designed, the following factors are considered from the perspective of intensive rental rate: comfort level, convenience, ergonomics, safety, development cost and management control. A bike designed with these considerations is convenient and sturdy, but relatively heavy. Each one weighs 22kg or so, for which about €1,000 is spent as development cost (Huiming, Yu, & Wei, 2009).

Information Features

Each bike and service terminal has an independent serial number. The first digit is named after the corresponding area code, and the rest are named in order according to the construction time of station. In this way, bike allocation, accident investigation, and customer service will be convenient. If necessary, the relevant rental station can be located fast and the specific bike can be found quickly. Each service terminal is composed of a fare meter, computer, bankcard payment system, GPRS antenna and touch control screen. It is connected to each parking pile through underground cables. There is a built-in computer in the bicycle handle bar, which will display whether the bike components are in good condition when users return bike. If one of the components does not conform to the rules, the bike cannot be rented again. The built-in computer feeds data to the operating centre through the wireless short wave installed on the parking pile. The computer transfers the data of bicycle status, mileage, borrowing time and returning time directly to the operating centre's server through GPRS antenna (Huiming, Yu, & Wei, 2009). The computer system software gathers information related to the concrete situation of each rental station, user, and bike. Information gathered includes the number of idle and broken bikes in a rental station, and the frequency of people rent bikes. It can also record detailed rental records, trip distance, average velocity, prepaid balance, riding mileage, cumulative rental time, detailed travel distance, user name, average speed and maximum speed. The information received can be used to supervise the standing supply of bikes and meet users' different requirements in different places and times. A periodic statistical table can be drawn based upon gathered information to show the use of public bikes and the completion status of any planning targets. The computer system is also the main data source for the improvement of the network layout of rental stations in the future.

Rental Station

1. Type

The rental stations of Vélo' v are categorized as either fixed rental station or decentralized rental station. Fixed rental stations are located in main urban public traffic stations, cultural historical sites, squares and scenic spots, public service centres, culture sports facility centres, main industrial zones, university campuses and business centres.. There are 10-30 parking piles in each rental station, as well as racks for 10 private bikes. The function of decentralized rental stations is to connect fixed rental stations, and there is a distance of about 300 m long between them. There are 5-10 parking piles in each decentralized rental station, as well as racks for five private bikes (Huiming, Yu, & Wei, 2009). In the Vélo' v system, parking piles are fused with the stands for private bikes.

2. Point location distribution

The rental stations are mainly distributed in the densely populated regions and commercial districts, as well as by rail transits. There are rental stations in all districts, but the central districts have the largest number of stations. Although the theoretical distance between the stations is 300 m, some distances are only 100 m in busy districts, especially by the main roads. Most distances are over 700 m in some suburbs (Huiming, Yu, & Wei, 2009).

3. Construction features

The facilities and bikes in all the rental stations are grey and red, so that the bikes and service terminals are obvious and serve as unique scenery in the city. This scheme mimics the colour of urban Lyon. Rental stations are usually installed on the side of a sidewalk or road, or in a vehicle parking lot in which the original facilities were already removed. The surface mark is simple and clear. There have been 180 parking lots demolished and replaced by 173 Vélo' v rental stations (Huiming, Yu, & Wei, 2009). When a rental station is installed by the side of a road, no arrow or mark is needed for its location, neither is a reflective pillar needed to mark the barriers on the road. In some stations, handrails have been built for delineation. Rolling advertising boards are not mounted systematically in the rental stations, and some are just installed for the time being: They are just supported by two metal struts and packed by white edges, and their color matches that of the public bikes. The simplicity of facilities is the key reason why the rental stations can be put into service in a short time.

Effect of Implementation

1. The rental features of bike

1) Daytime rental frequency

According to a survey made in February, 2006, morning peak (9:00-10:00) is the first peak period of public bike rental; lunchtime (13:00-15:00) is the second peak period, during which the frequency of rental is 525 per hour; during 17:00-19:00, the frequency of rental reaches to the highest, about 800 per hour, and after that, the frequency will gradually decrease to 250 per hour. At night, some users still rent bikes, but the frequency gradually decreases, and will decrease to 25 per hour during 23:00-5:00, and touch bottom during 6:00-7:00 (Huiming, Yu, & Wei, 2009).

2) Workday and weekend rental frequency

On workdays, particularly from Tuesday to Friday, public bikes are rented most frequently, for 8,700-11,600 times, and 80% of the users use a long-term prepaid card. On weekends, the frequency of rental is very low, and bikes are mainly rented around metro stations. The frequency of rental will decrease sharply on rainy days. Most of the users with a short-term prepaid card rent bikes on Saturday, accounting for 30%-40% of the total number in a week, and the number on Sunday accounts for only 10%-20%. The riders mainly go to some places within a district or the districts nearby, and there is the highest bike flow in the central districts. Statistical data shows that when a bike is rented 315, 000 times, it is rented for 190, 000 times in the central districts or in other districts with the central districts as a destination (Huiming, Yu, & Wei, 2009).

A Change of Residents' Way to Travel

In October 2005, Lyon conducted a survey on 13 bike rental stations in the districts, as well as 1,485 bike users. The purpose of the survery was to establish whether the public bike system had changed the residents' travel mode.

1. Adopter crowd

86% of the public bike users lived in the regions near to the rental stations; 55.1% of the users were younger than 30; 46.6% were aged between 20 and 30; 59.4% were males; 34.4% were civil servants or liberal professionals, mainly aged from 30 to 40; 32% were students, aged between 20 and 30 (Huiming, Yu, & Wei, 2009).

2. Travel purpose

The public bike users had greatly different trip purposes on workdays and weekends. On workdays, 64% went to work, 9% went to school, and 16% went out for entertainment. On weekends, 33% went to work, and 62% went out for shopping and entertainment (Huiming, Yu, & Wei, 2009).

3. The conversion of other travel modes into public bicycle

Respondents were asked, "What way to travel may you choose when there is no rental bike system?" 37% respondents said that they might choose walking, 51% chose public transport, 7% chose to drive a car, 4% chose to bike or another pollution-free way, and 2% said that they would not go out. Based on the investigation, the current bicycle users can be categorized into the following kinds:

1) Private car

Nearly 7% of the public bike users might have driven a car. Investigation shows that public bikes were rented 15,000 times a day during October and November in 2005. That is to say, 1,000 times of travel by car was avoided a day, about 3,000km in length. In total, 219t of carbon emissions were reduced each year (Huiming, Yu, & Wei, 2009). So the contribution of biking to environmental protection cannot be ignored.

2) Public transport

51% of the public bike users would choose to travel by public transit. Few travellers chose both public transport and rental bike in a trip. Only 10% used both transport means simultaneously in a trip, for the reason that Lyon and Villeurbanne are densely populated but not large in size (Huiming, Yu, & Wei, 2009). Metro interchange, for example, is faster only when the distance is long. If the distance is short, riding will be a little faster than metro on the whole journey.

3) Walk

37% of the public bike users choose to be pedestrians when the bike rental system is unavailable. In most northern European cities, the proportion of travel by bike is 30% higher than France's (20%), but the proportion of travel on foot is lower than France's. Due to the appearance of public bike, those who walked have chosen rental bikes (Huiming, Yu, & Wei, 2009).

4) Private bike
4% of the respondents which had always used a private bike, have begun to use public bike, for two reasons: first, it is more convenient to park public bike than private bike in streets; second, the quality of public bike is generally better than that of private bike. Since only 4% used a private bike, most of the public bike users are emerging riders in this city. They find that it is safer and faster to ride a bike in urban areas than they imagined. The investigation shows that 59.8% of the respondents thought that there were enough rental stations; 77.2% thought that there were not enough bikes; 72.6% thought that there were too many idle parking piles. 64.5% of the respondents gave 4 or more marks out of 5 to the public bike system (Huiming, Yu, & Wei, 2009).

Promotion Policy
173 rental stations were put into service in the first stage. The number of bikes increased to 3,000 at the end of 2006 and to 4,000 in 2007. In the second stage, Lyon passed two basic policies: strengthen public bike services and render diversified bike services to other target users (Huiming, Yu, & Wei, 2009).

1. The developing plan of public bike facilities
Public bike systems will develop according to one of two trains of thought in the future. The first idea is to intensify the central districts: expand the size of the rental stations with complete facilities, set up new rental stations in the compact building zones, and expand the scale of 14 newly built rental stations and 10 old rental stations (Huiming, Yu, & Wei, 2009). The second idea is to lay networks: set up rental stations uniformly, use the strategy of “station agglomeration” to solve the problems about the insufficient capacity of some rental stations, and popularize travel by bike in the local densely populated districts.

2. Private bike service
The public bike system is not aimed at meeting the requirements of all those who want to travel by bike, but providing lots of opportunities for people to rent bikes. Lyon hopes to provide the bikes that can be rented in turn to meet special

Figure 4.5 - Bicycle rental infrastructure in Lyon.

requirements.

1) Provide students with professional services

Bicycles are an ideal transport means for students, and they are the main users of the public bike system. The price of a private bike and the possibility of larceny have hindered students from using a bike. Public bike cannot meet all the requirements of travel in campus, so Lyon's government is considering whether or not to establish a second-hand bike market for students and supplying them with other trip methods.

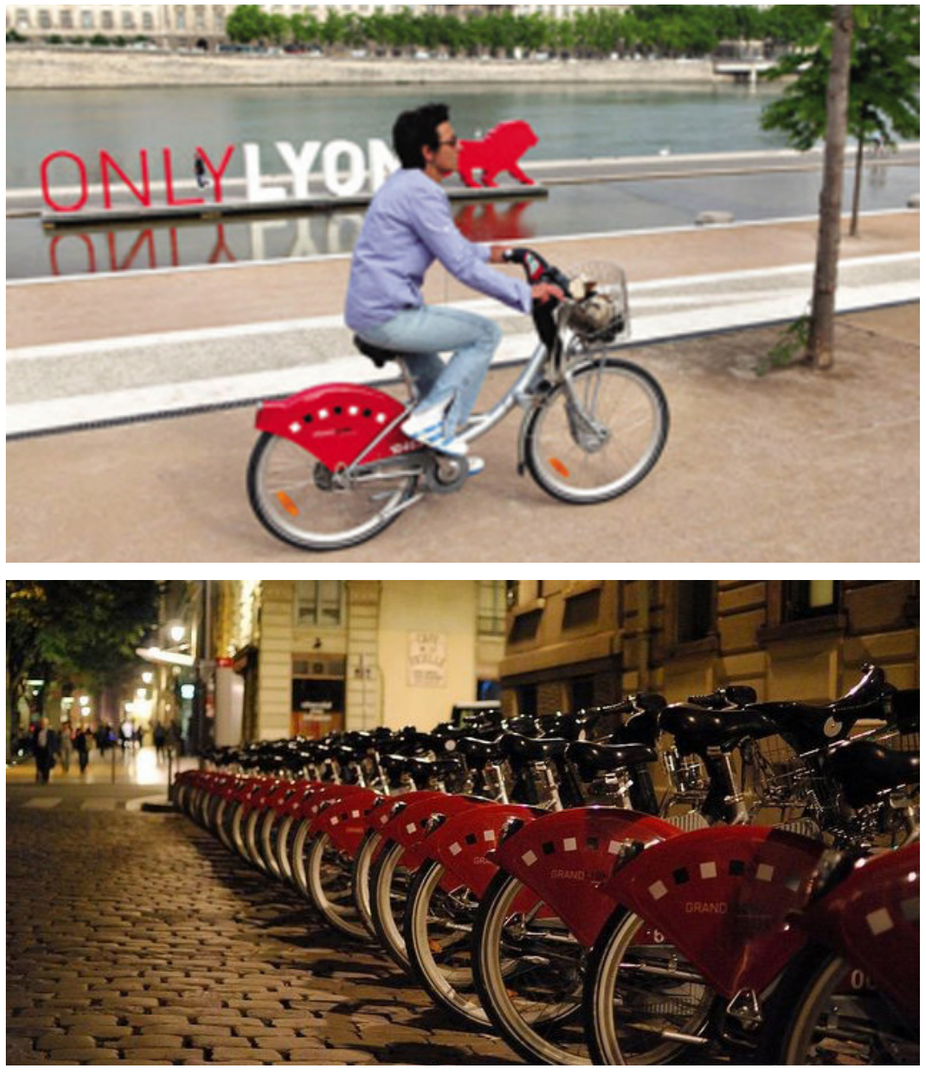
2) A new service for private bike parking

It is hard to find a space in the residential quarters in central Lyon to park bike, and it is not safe to park it on the street. So many people do not intend to buy a bike, thus they cannot use it. The lack of safe parking lots for bicycles is a barrier that blocks the city from popularizing travel by bike. Therefore, Lyon has introduced a policy about setting up racks for private bikes in the vicinity of roads, scenic spots and residential districts. In the developing plan of Lyon's pollution-free travel mode, 300-500 km cycle tracks will be built by 2010, and 500 new racks will be installed each year based upon the current number (Huiming, Yu, & Wei, 2009). Its goal is to set up bike parking lots in all dwelling districts, so as to enlarge the coverage of the bike network and eliminate blind spots to the greatest extent.

Conclusion

An international consensus for coping with motorization development supports the popularization of pollution-free transport means as public transport and the related formulation of the urban traffic policies. The development of the public bicycle system in Lyon has provided ideas for solving urban transport problems, as well as the promotion of energy conservation and emission reduction. In the construction of whole system, the high-level of informationalization has accumulated plenty of data for system scheduling, evaluation and improvement. The simple system composition and facilities can put them into service in a short time, and make them convenient for users. Based on the successful public bicycle system, Lyon has created conditions for all bike trips by building cycle tracks, adding bike parking facilities and providing professional services for special groups.

Figure 4.6 - The branding and bike design of bicycle system in Lyon.



I also did some research on other countries' bicycle system, such as, Germany and Netherlands.

Germany

After half a century of an era dedicated to automobile use in Germany, people's concepts of travel and health have changed. It is widely believed that riding a bicycle in a short distance is safe, economical and bodybuilding. Under the guidance of government, the original bicycle lane is moved next to the sidewalk, and designed as the bicycle lane. In Cologne, Frankfurt, Munich and other cities, bicycle lane is like a colored ribbon inlayed on both sides of the road. In Germany, bicycle lanes are higher than vehicle lanes and lower than sidewalk lanes, about one meter wide (Fengniao, 2010). The color of bicycle lanes is obviously different from surrounding lanes. The color is very well-marked, including dark red, dark green and black.

Netherlands

The Netherlands is a world-renowned kingdom of bicycles. In that country, bicycles are as popular as automobiles, an appreciation which creates a unique landscape. The bicycle in the Netherlands has a long history. As early as 1890, Netherland built the world's first bike lane. In 1937, Rotterdam built the world's first bike tunnel. Since an energy crisis occurred in 1974, the government in the Netherlands has actively used policies to lead the bicycle to become an important green transport means, and apply the idea of green transport into land use and urban planning. Now, the length of bike lanes in the Netherlands exceeds 17,000 km and each person has two bicycles, on average. The roads in the Netherlands' suburbs basically adopt the "five-lane" form. The middle lane is the motor vehicle lane, the other two lanes are sidewalks, and the bicycle lane is between the motor vehicle lane and sidewalk. Between the motor vehicle lane and the bicycle lane, there is a green belt. The symbol used to designate a bicycle lane in the Netherlands is obvious. The bicycle lane is paved with flat tile-like stones, making it obviously different from the motor vehicle lane and sidewalk that are paved with red stones. At each intersection, there is a bicycle lane sign: a bicycle in a round and blue board. Relevant facilities on both sides of bicycle lane are complete, such as bicycle repair shops, rental shops and parking lots (Discoverer, 2015).

Figure 4.7 - People love riding in Germany.

Figure 4.8 - Netherlander are riding.

Design Principles

Through the research and case study of public bike systems, the cycle network should meet cyclists' needs in six requirements: coherence, directness, attractiveness, safety, ecology and comfort of the network (Angela & Craig, 2014). To build a safe, convenient and educational cycle network, I think we should pay attention to the following points:

1. Good planning and design provides easy access to public bike share systems. Public bicycle systems can connect public transport and provide people with opportunities of fitness and entertainment as an ideal transport tool for short trips. The station settings of bikes should be combined with functional orientation and estimate attracted traffic according to urban population and employment. Meanwhile, we should establish a scientific ranked distribution, consider building density, land properties, residents' travel characteristics and other factors comprehensively. Stations should be established in residential areas, commercial and public buildings, subway stations, bus stations and other areas with many buildings and people in order to meet diverse transportation needs of the residents. By connecting with the public transport such as bus stations and subway, people can make more extensive use of bicycles, which can solve the problem of long-distance travel by bike. Bike stations should connect various destinations continuously, directly and conveniently so that cyclists can save travel time in order to reach their destinations quickly and efficiently.

2. Good design of bike lanes can make bike use more safe and comfortable. The safer the design of bike lanes, the more people will be willing to use bicycles. We should focus more on the safety of bike lanes while crafting their design, including cycle lanes which are wide enough, segregation cycleways, clear signage, and appropriate lightings on cycle ways. Based on Li et al.'s research, separated bike lanes make cyclists feel much safer and more comfortable than on-road lanes (Angela & Craig, 2014). Separated bike lanes should be set up especially on busy roads. Clear signage, traffic lights showing intersection implement and where to join a cycleway, should be considered. Also, the design of lighting on some dark

roads is necessary to consider (Angela & Craig, 2014). Furthermore, dangerous sections, such as, junctions, intersections and roundabouts on cycle lanes should receive special considerations for cyclists (Dill, 2009). Comfortable design of bike lanes can enhance people's utilization ratio of cycle networks, which includes high quality material of cycleway pavements.

3. Create parking spots with an educational design. Parking spots include parking piles and service terminals. The design of space of parking spots should be convenient for people to park and rent a car as well as marking, funny, ecological and educational. We can make parking spots connect with the surroundings using design. For example, we can make it visually connected with the landscape in the design of the surroundings of ecological park. In this way, people can enjoy the ecological spatial design of parking spots and obtain environmental knowledge while parking. The parking spots in the city after repeated utilization will be educated by environmental protection and enhance awareness of environmental protection.

4. Appropriate design of facilities includes the design of service terminals, bicycles and parking piles. We can manage public bike share systems through advanced electronics, information integration, wireless communications and Internet technology. The service terminals in rental stations are composed of meters, computers, bank card payment system, GPRS antenna and touch screen, and are connected by cables and parking piles from the underground. Service terminals can sell short-term pre-paid cards. Besides, service terminals can be set with multiple languages to check records of car rental. If there is no car or parking lots in a car rental point, users can check the information of the nearest rental point. We should consider the following factors for bike design: comfort, convenience and ergonomics. Every bike or each service terminal has its own number to make the deployment of vehicles, accident investigation and customer service easy. Once people need to locate the rental point, they can specify a particular car. There is a built-in computer on the handlebar of the bicycle. When users return the bike, it will show the status of safety components. If a component is not in compliance with

the regulations, the bike can not be rented. Built-in computer can offer the centre the mileage data of the bike by wireless shortwave in the parking piles and send the data of bike status, time of taking and returning the car and other data to the server in the operation centre through GRPS. We can build a convenient car rental and pick-up system through high technology. The hi-tech and humanistic design of bicycle infrastructure, makes people aware that cycling is an interesting, attractive and popular way to travel. In this way, people will change their perceptions to riding a bicycle is a fashion and proud thing, instead of driving a car.

5. Unite the urban green space and urban green slow-down system so that people can access the ecological park in the city through the cycle network. Connect urban green park in cycle network so that people can make use of cycle network to spend leisure time in the park while traveling and working. Introduce bicycling as a lifestyle to people and encourage bicycling as a casual and relaxed sport.

6. Combine with urban attractions and historical heritage. Connect with urban historical heritage and other tourist attractions through cycle network to enrich functions of the network, increase its entertainment feature and make it more attractive to people.

Figure 4.9 - Bicycle path in green spaces.

five

Site Selection and Design Intention

Site selection and potentials

In order to design a relatively complete green bicycle system, I set my site in Nanjing, where I spent my five years of undergraduate life. I am relatively familiar with this city and have deep love for it. Nanjing, as a famous historic and cultural city, is one of the four great ancient capitals and one of the six well-known historical capitals in China. Also, it is the largest existing ancient city in China. In 472 BC, Gou Jian, the King of Country Yue started the history of Nanjing after conquering Country Wu, till now, Nanjing has been a city with the history of 2471 years (Baidubaike, 2015).

Nanjing not only has a long history, but also is a well-known metropolis of education. There are more than 50 colleges and universities here, comprehensively ranking second in China, next only to the capital Beijing. I believe that the comprehensive quality of the environmental ethics of university students determines the destiny and future of the nation as well as the country. Whether students will enter into the public departments such as the government, or into enterprises and institutions in the future, they will have a great impact on the environment. They shall bear the consequences of the environmental behaviors of the preceding generation while their environmental behaviors will determine the survival and development condition of the next generation. Therefore, to a great extent, the level of students' environmental ethics determines whether the sustainable development strategy of our country and that of all humans can be effectively implemented (Zhengyao & Ling, 2006). As long as the environmental awareness of college students is improved, then the environment can be well protected. In addition, university students are usually well educated and support improvements to their own environmental awareness by experiences with ecological design. The environmental awareness of the whole nation can be improved using ecological design to establish a green travel system in such a city with so many university students.

At the same time, Nanjing is a newly emerging city full of vitality and going through rapid development. In August 2014, Nanjing held the Youth Olympic Games. After that, the local government decided to retain the facilities of the Youth Olympic

Figure 5.0 - Nanjing is a modern city.

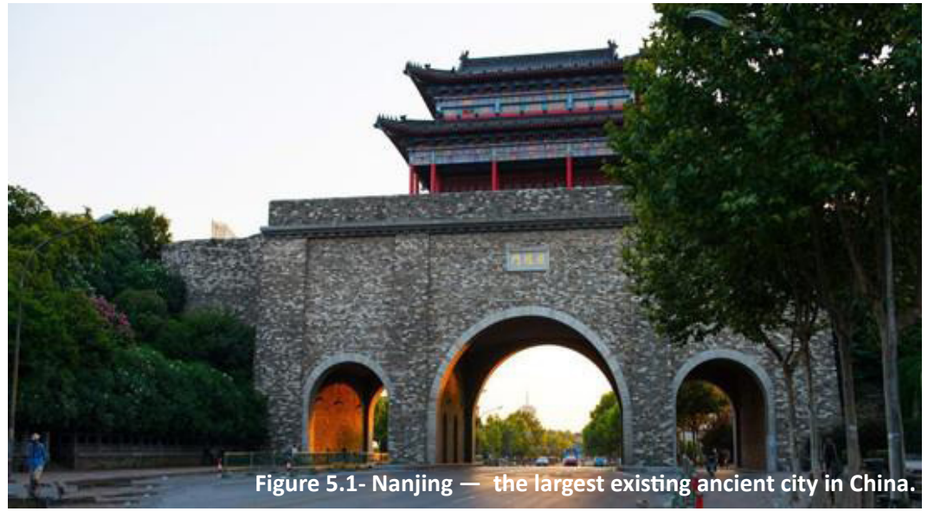


Figure 5.1- Nanjing — the largest existing ancient city in China.

Games. Apart from retaining some stadiums, this action aims to promote people's awareness of fitness. During the closing ceremony of the London Olympics, the mayor of Nanjing met with the president of the World Sports Meeting Hein Verbruggen, and the chairman of the World Cycling Union McQuade, hoping that the World Cycling Union can hold the three races (outdoor cycling race, mountain biking race, indoor cycling race) in Nanjing, thus promoting the green travel to public. The base was slated for demolition after competition, but now the Nanjing government hopes to retain this venue as a heritage of the Youth Olympic Games through the introduction of cycling events. At the same time, the government hopes to make it a carrier of fitness activities for the public. The chairman of the World Cycling Union McQuade has expressed his willingness to promote the cycling activity through cooperation between the World Cycling Union and Nanjing. He has predicted that in the next 5-10 years, China will be among the top three countries in the world, which are strong in cycling development (Sinadichan, 2012). The fast economic development of Nanjing created 242 smog days during 2013 (Sinahouse, 2015). This situation is closely related to the large amount of vehicles in the city. So a bicycle infrastructure is urgent for Nanjing.

Nanjing will put in a group of public bicycles in the subway stations and bus stations, build a number of bicycle clubs and construct a number of bike lanes, so as to arouse people's interest in cycling. Nanjing currently has more than 100,000 citizens in favour of cycling—those who purchase sports bikes and equipment—and more than 10 cycling clubs. Every year, there are 20-30 cycling races held in Nanjing. The government is planning to establish more cycling clubs and enable more people to participate. According to the preliminary plan, in the future, there will be 10, 000 members in the cycling association. The government will support this membership (Sinadichan, 2012). With a series of incentive measures taken by the Nanjing government to encourage the low-carbon travel of the public, there is great potential and high feasibility to establish a green ecological travel system in Nanjing.

NANJING 2014 YOUTH OLYMPIC GAMES

YOG DNA

Figure 5.2 - Nanjing University Of Technology

Site Location

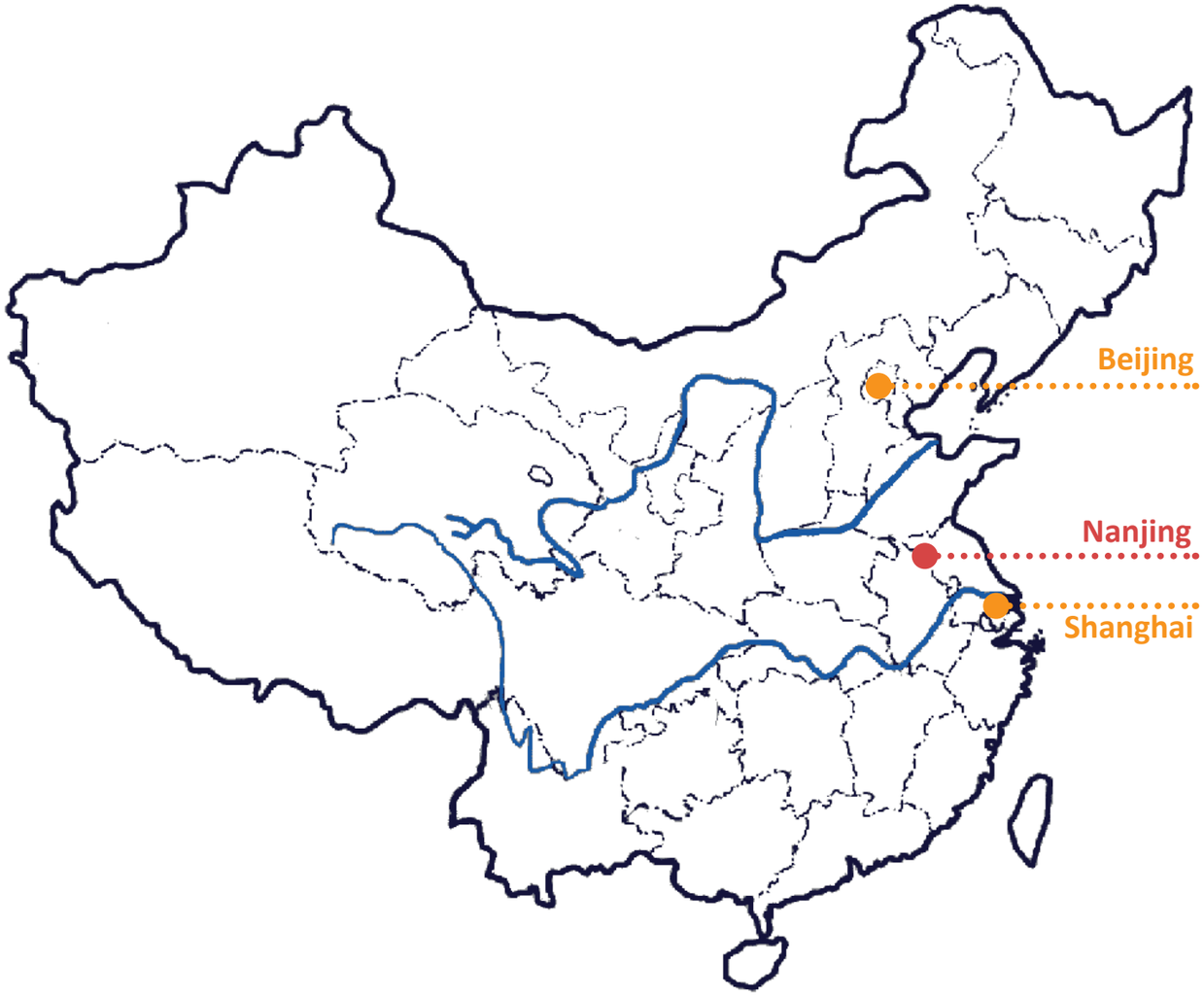



Figure 5.3 - Modern Nanjing

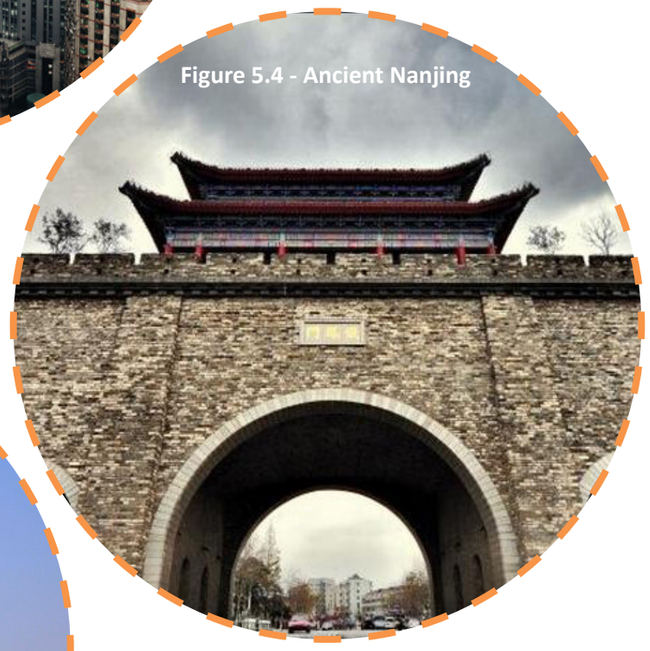


Figure 5.4 - Ancient Nanjing


Figure 5.5 - Xuanwu lake

Design Intention

Based on the research, the proposed public bicycle system construction will be divided into hardware construction and software construction. The hardware includes a network of bicycle routes, cycling corridors, parking spots, rental stations, intersections, bollards, fences, signs, bicycle location maps, traffic lights, racks and bicycle design. The software includes a public bicycle business model and other management measures. As part of urban infrastructure, bicycle lanes provide increasingly rich services for urban residents. Its single function is changed to multi-service function. As a linear landscape element, a bicycle lane needs to connect and go through urban lands. Its main function determines suitable locations, while also linking the lane with other functional lands. A bicycle lane system plays a strong role of medium. In the context of rapid Nanjing urbanization, preliminary establishment of an urban bicycle lane system can fully develop the values of leisure and ecological education about natural lands at the urban fringe, such as mountains, riversides and ancient walls. In addition, the proposed bicycle routes would connect the separate and hidden heritage places to form a new urban history experience system. At present, this system can be used as the supplement of insufficient leisure resources in Nanjing. In the future, this system can lead the lands along with the bicycle lanes to become the urban green spaces.

A public bicycle system consists of multiple and many sections of bicycle routes. Different bicycle lanes have different main functions due to the different travel purposes of bicycle users, so that routes with different themes of experience are created for citizens. Therefore, building bicycle routes through classification is an effective way to ensure the achievement of diverse functions of bicycle lanes. According to the main service functions of an urban bicycle lane and the spacial characteristics of Nanjing city, the proposed bicycle lanes can be summarized into two categories: recreational and functional. Recreational cycle lanes connect green spaces, heritages, canals, ancient walls, recreational places and tourist attractions. Functional cycle lanes connect public transit, public buildings, universities, and residential areas.

The purpose of planning and designing bicycle lanes for urban movement facilitates transport and shopping, provides travel service, and connects residential areas with administrative offices, industrial areas and other public facilities. Convenience and safety are the most important principles of the planning and design of bicycle lanes. The current urban bicycle lane in Nanjing belongs to this category. Due to consideration of this category of bicycle lane as well as motor vehicle lanes and sidewalks in the transportation planning, a mixed traffic situation has occurred. In the planning, the bicycle lane is merely combined with urban land units. At present, there are many problems related to urban bicycle lanes, such as conflict and intersection with vehicle lanes. Moreover, vehicles operate and park on the bicycle lane. There is a low continuity of bicycle lane, and cyclists are exposed to pollution from automobile exhaust.

Figure 5.6 - Modern Nanjing

six

Bicycle Network & Mapping

MAP of Yangtze River

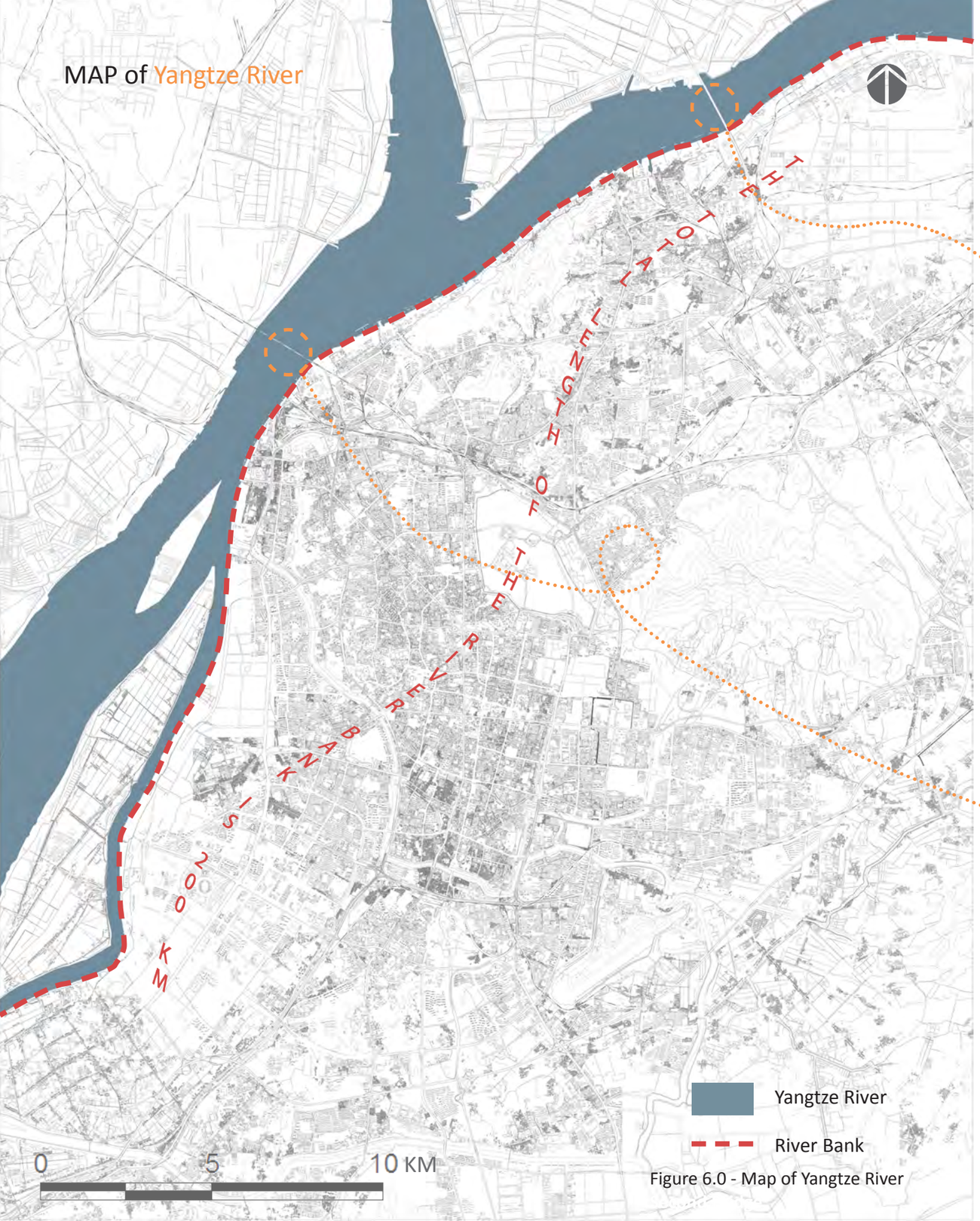


Figure 6.0 - Map of Yangtze River

As I mentioned, the city of Nanjing has a great potential to build as a bicycle city. However, there is no established routes network in Nanjing right now, nor any bicycle rental stations and infrastructure. My plan is first to build a integrated bicycle routes network, according to the recreational features and functional features in Nanjing. Then I will choose some typical corridors in the network to do bicycle lane design. Moreover, I will propose the branding of Nanjing bicycle system and design of bicycle system components. Another element I take into consideration is bike rental system. I will introduce how to rent a bike and the information of rental system. At last, I choose a typical site in Nanjing to do a detail design of bike rental station. At this chapter, I would like to propose the bicycle routes network which is based on the characteristics of Nanjing city.

The view of Yangtze River in Nanjing

Figure 6.1 - Yangtze River Second Bridge

Figure 6.2 - Yangtze River view

Figure 6.3 - Yangtze River Bridge

Figure 6.4 - Map of whole water body

Figure 6.5 - In Nanjing, the area of water occupies more than 11% of the total area.

MAP of River + Canals

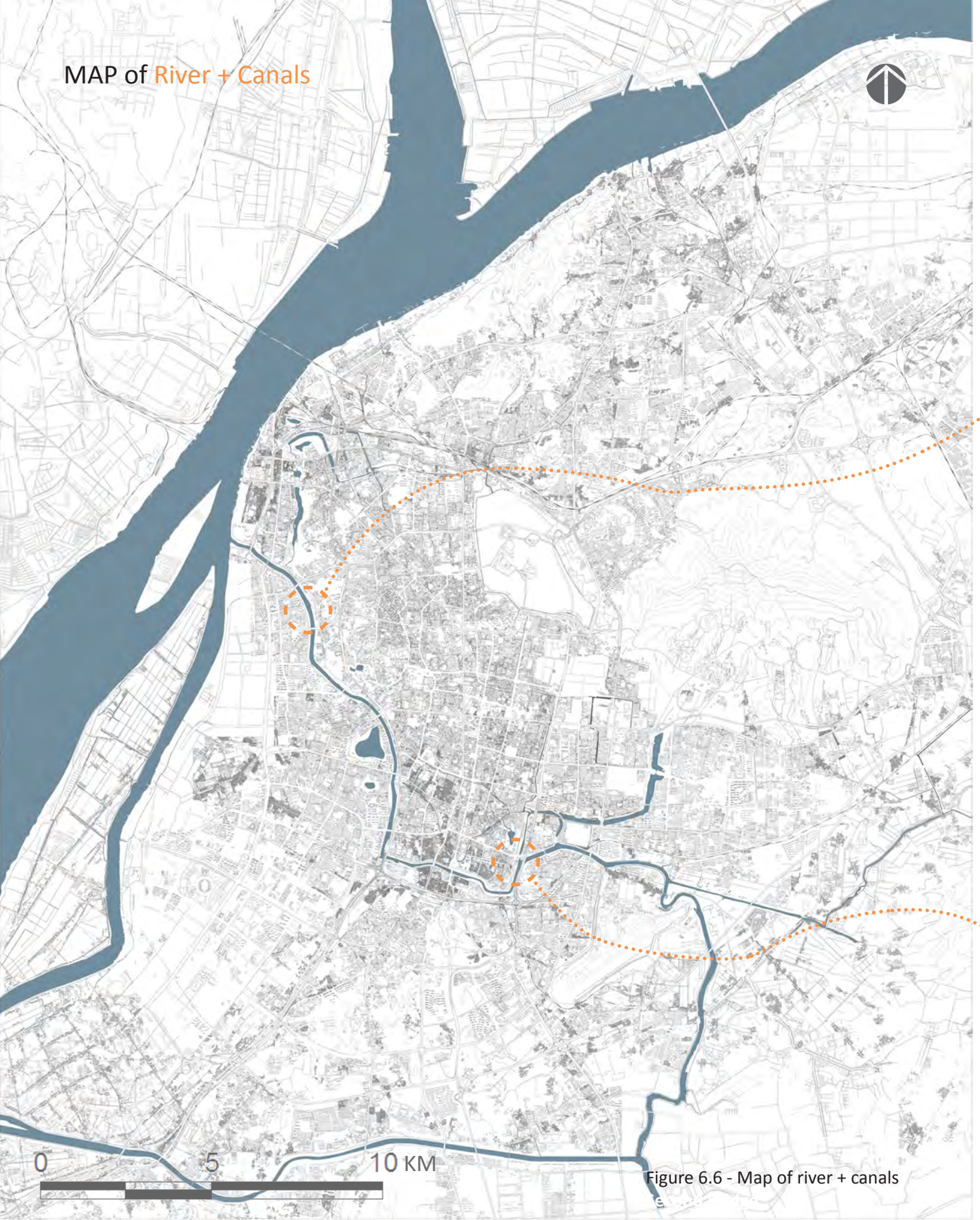


Figure 6.6 - Map of river + canals

The view of Canals in Nanjing

Figure 6.7 - Views of canals in Nanjing.

MAP of Parks + Major Green Spaces

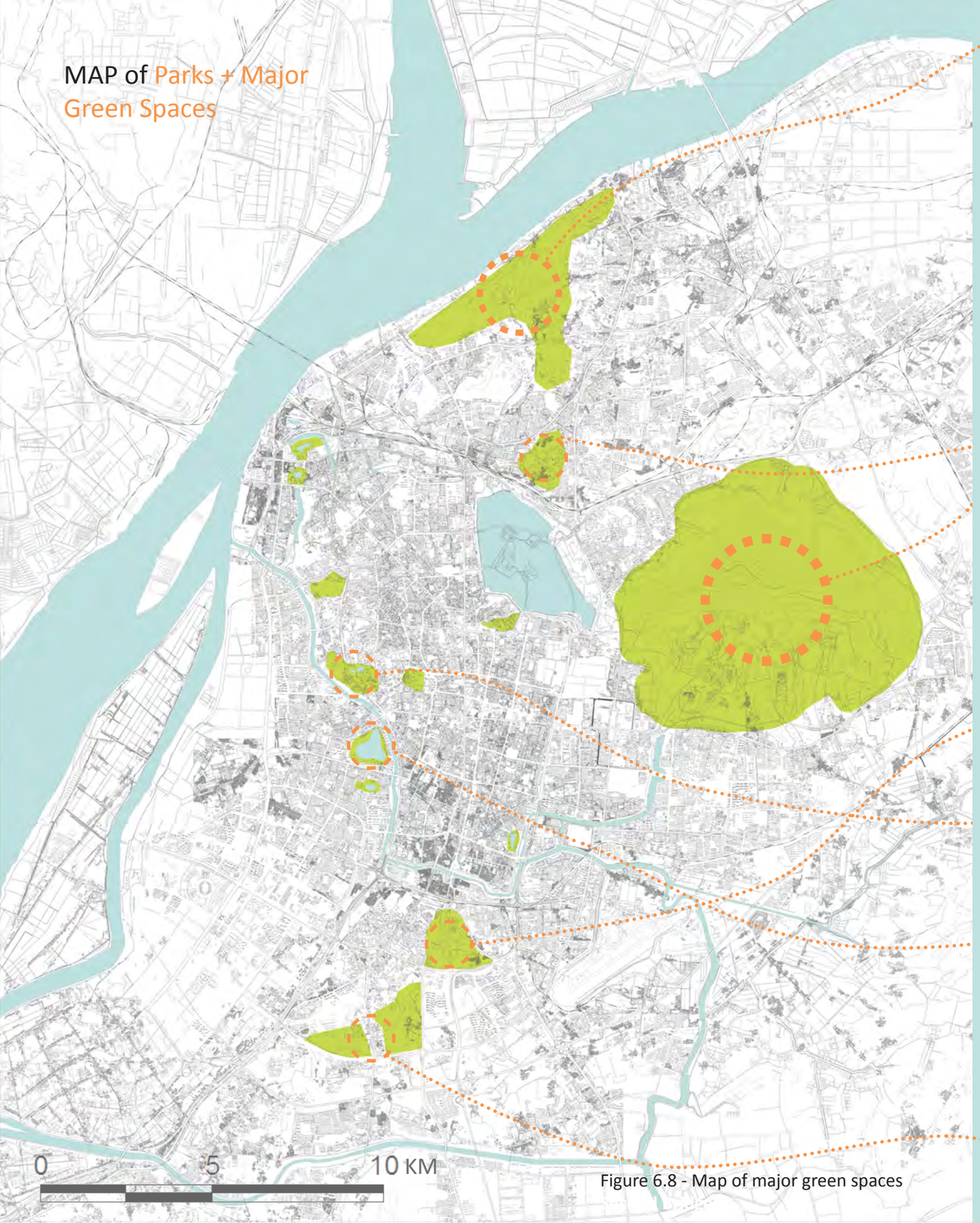
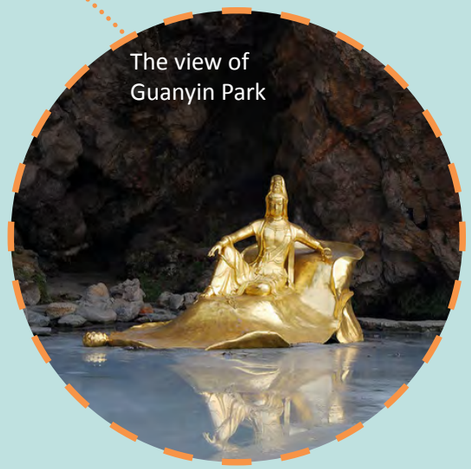


Figure 6.8 - Map of major green spaces


The view of Zijin Mountain


The view of Hongshan Zoo


The view of Guanyin Park


The view of Yuhuatai Park


The view of Shitoucheng Park


The view of Mochou Lake


The view of Juhuatai Park

Figure 6.9 - Views of green spaces in Nanjing.

MAP of Ancient City Walls

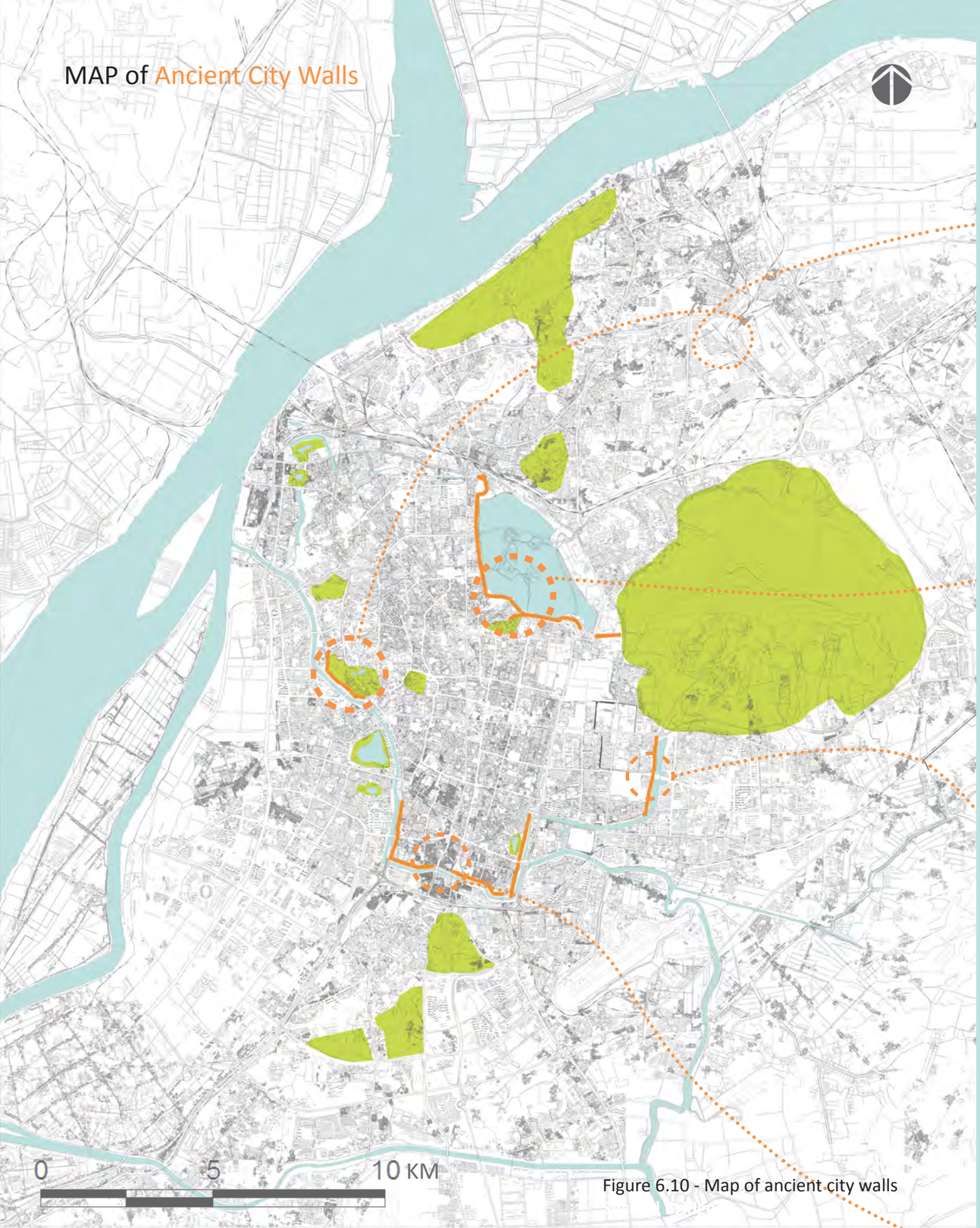


Figure 6.10 - Map of ancient city walls

The view of
ancient city walls
in Nanjing

Figure 6.11 - Views of ancient wall in Nanjing.

MAP of Historical Tourist Attractions

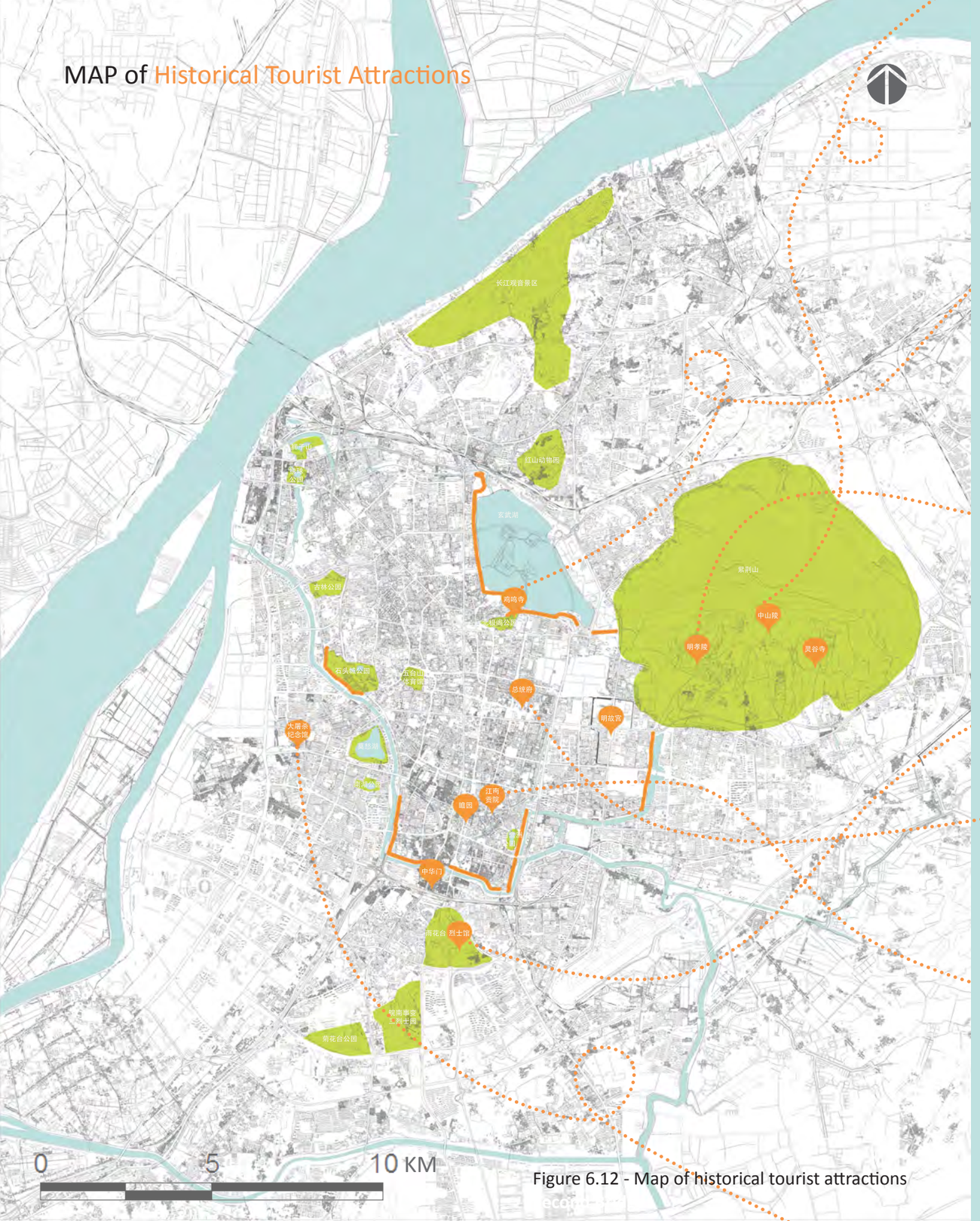
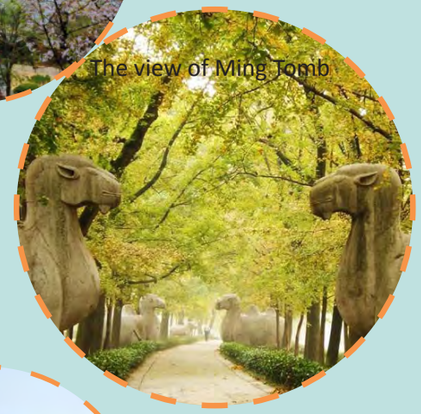


Figure 6.12 - Map of historical tourist attractions


The view of Jiming Temple


The view of Ming Tomb

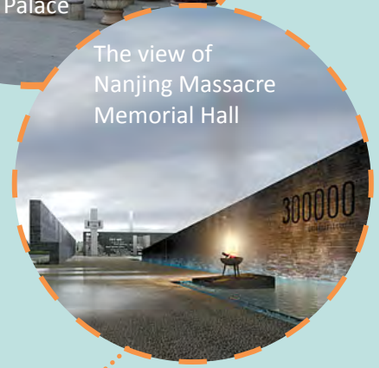

The view of Zhongshan Tomb

Figure 6.13 - Views of historical tourist attractions in Nanjing.


The view of Martyrs' Memorial Park

The view of Presidential Palace

The view of Jiangnan Examination Hall



The view of Nanjing Massacre Memorial Hall

MAP of Proposed Cycling Recreational Route

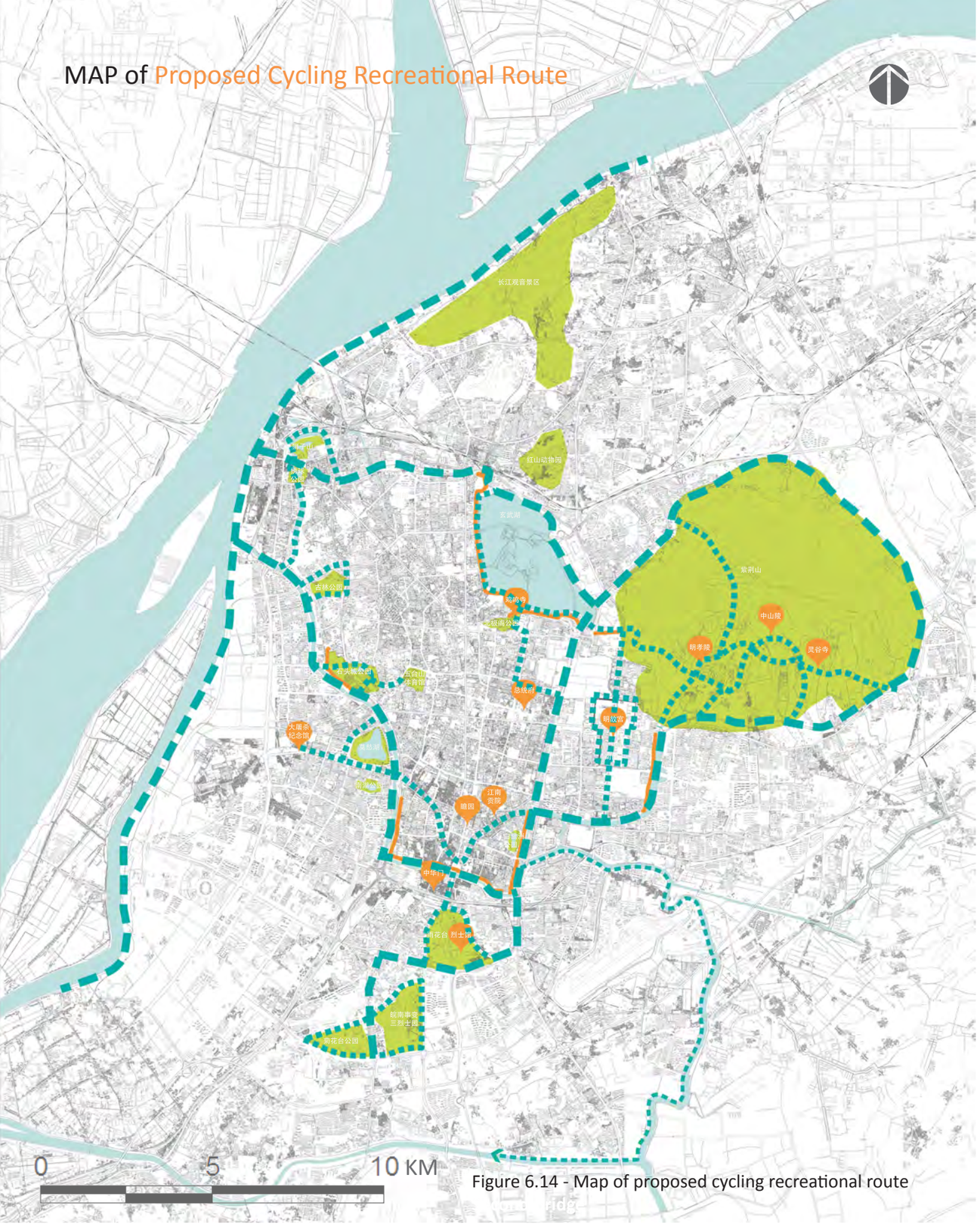


Figure 6.14 - Map of proposed cycling recreational route

MAP of Subway Lines

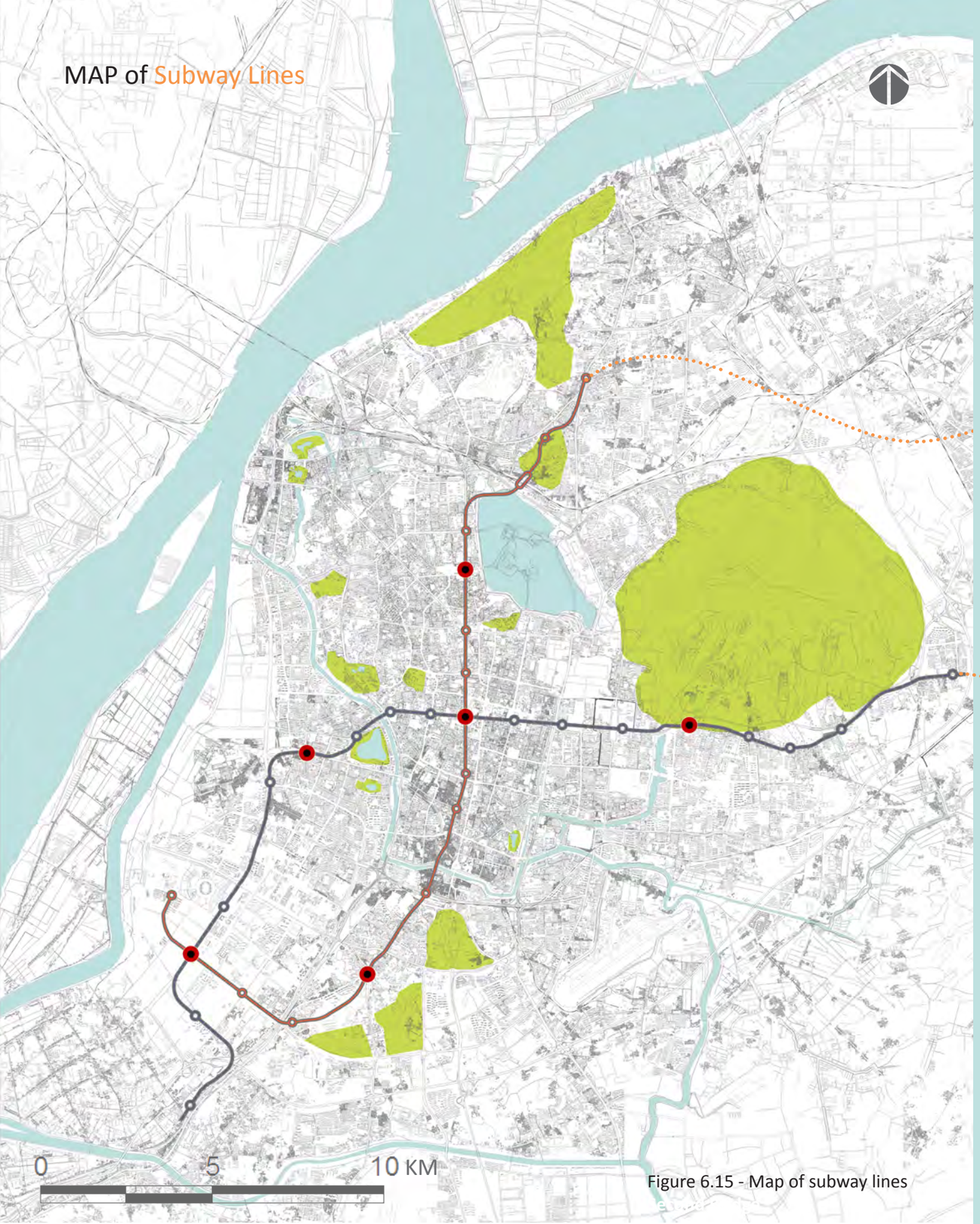


Figure 6.15 - Map of subway lines

The view of
Subway Lines
in Nanjing

Line 1

Line 2

Figure 6.16 - Views of subway lines in Nanjing.

MAP of Important Public Buildings

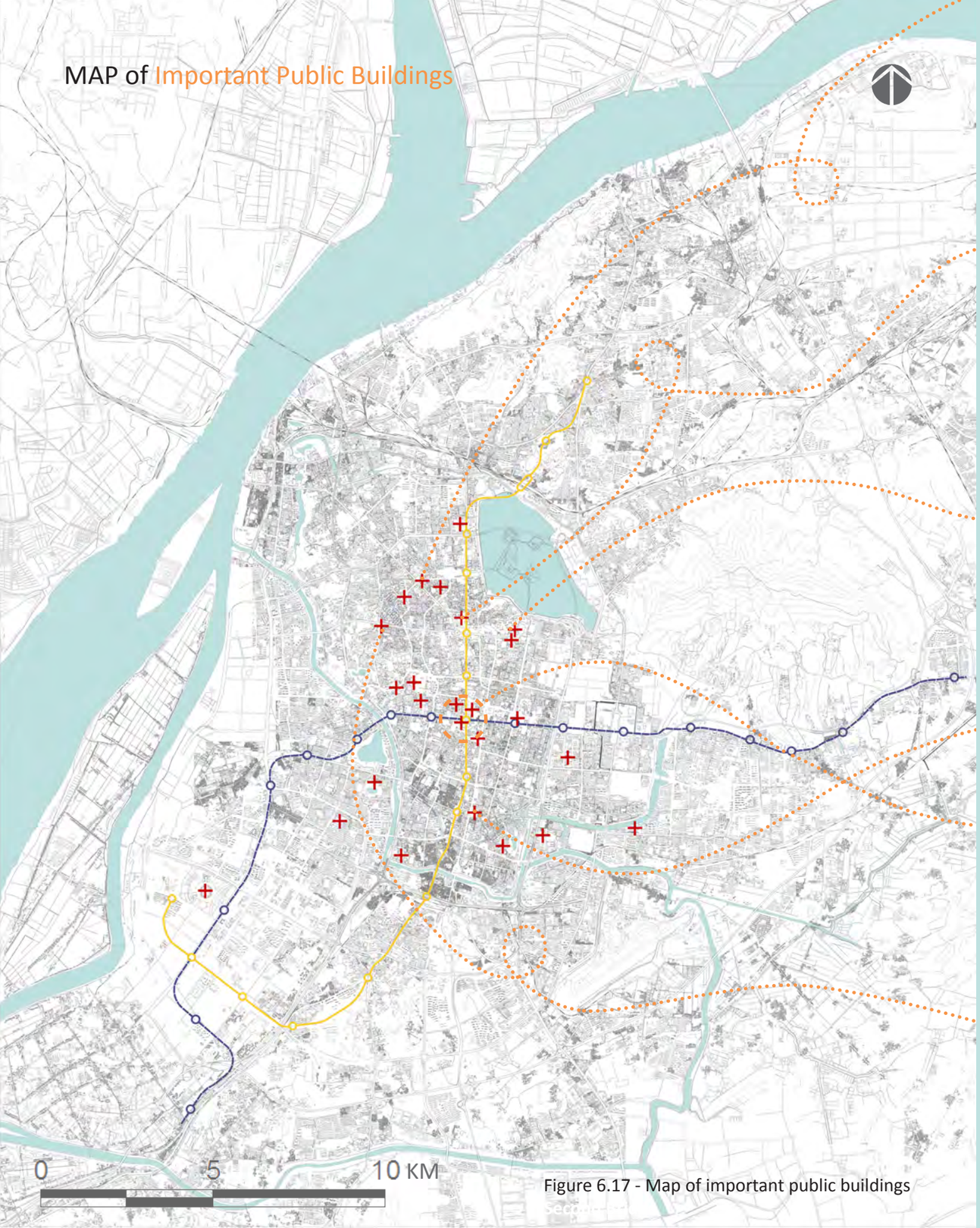


Figure 6.17 - Map of important public buildings


The view of
Central Business District
in Nanjing


The view of
Nanjing Municipal
Government


The view of
The first hospital
of Nanjing


The view of
Central Shopping District


The view of
Jiangsu People's
Government

Figure 6.18 - Views of important public buildings in Nanjing.

MAP of High Density Residential Areas

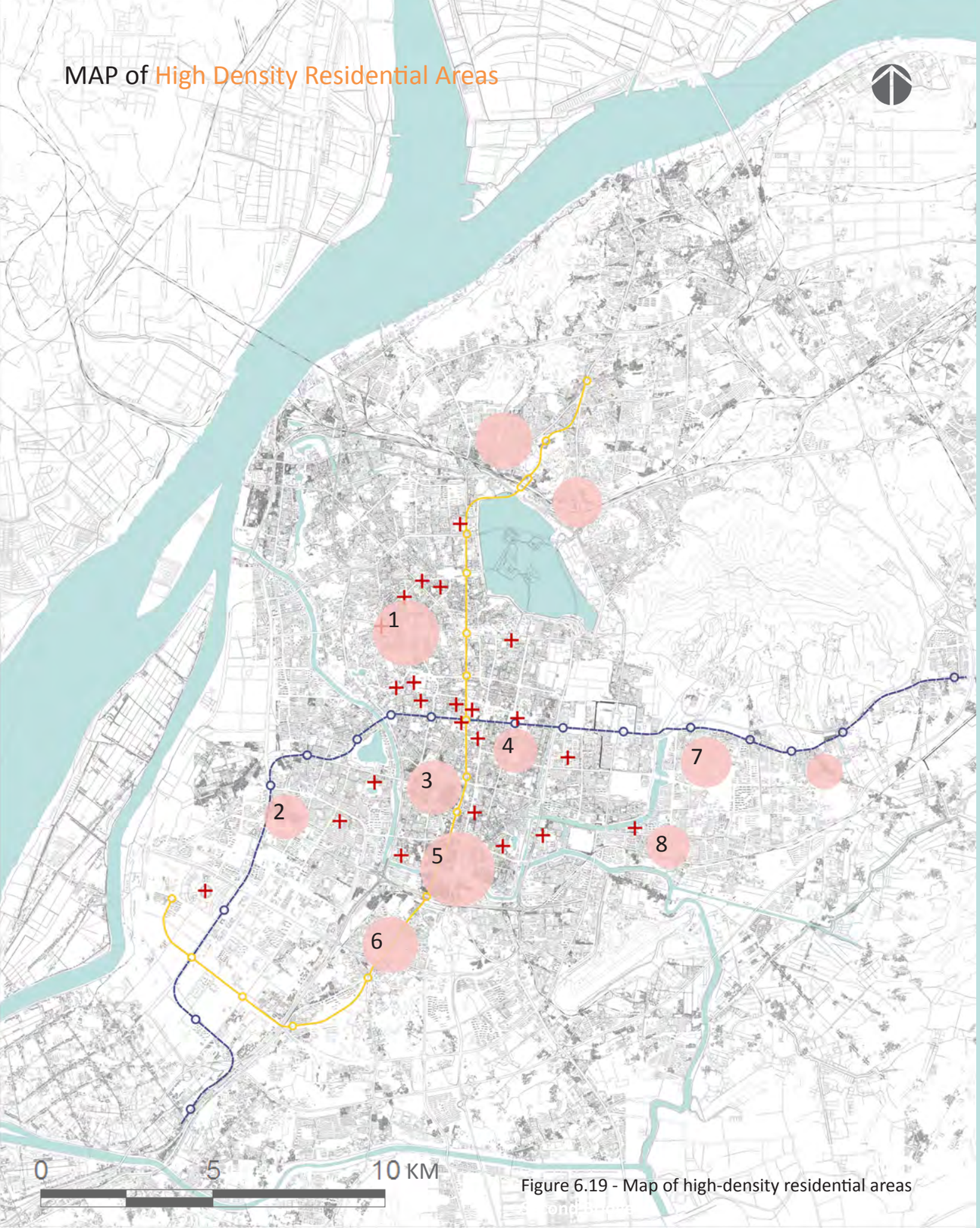


Figure 6.19 - Map of high-density residential areas

The view of high-density residential areas in Nanjing

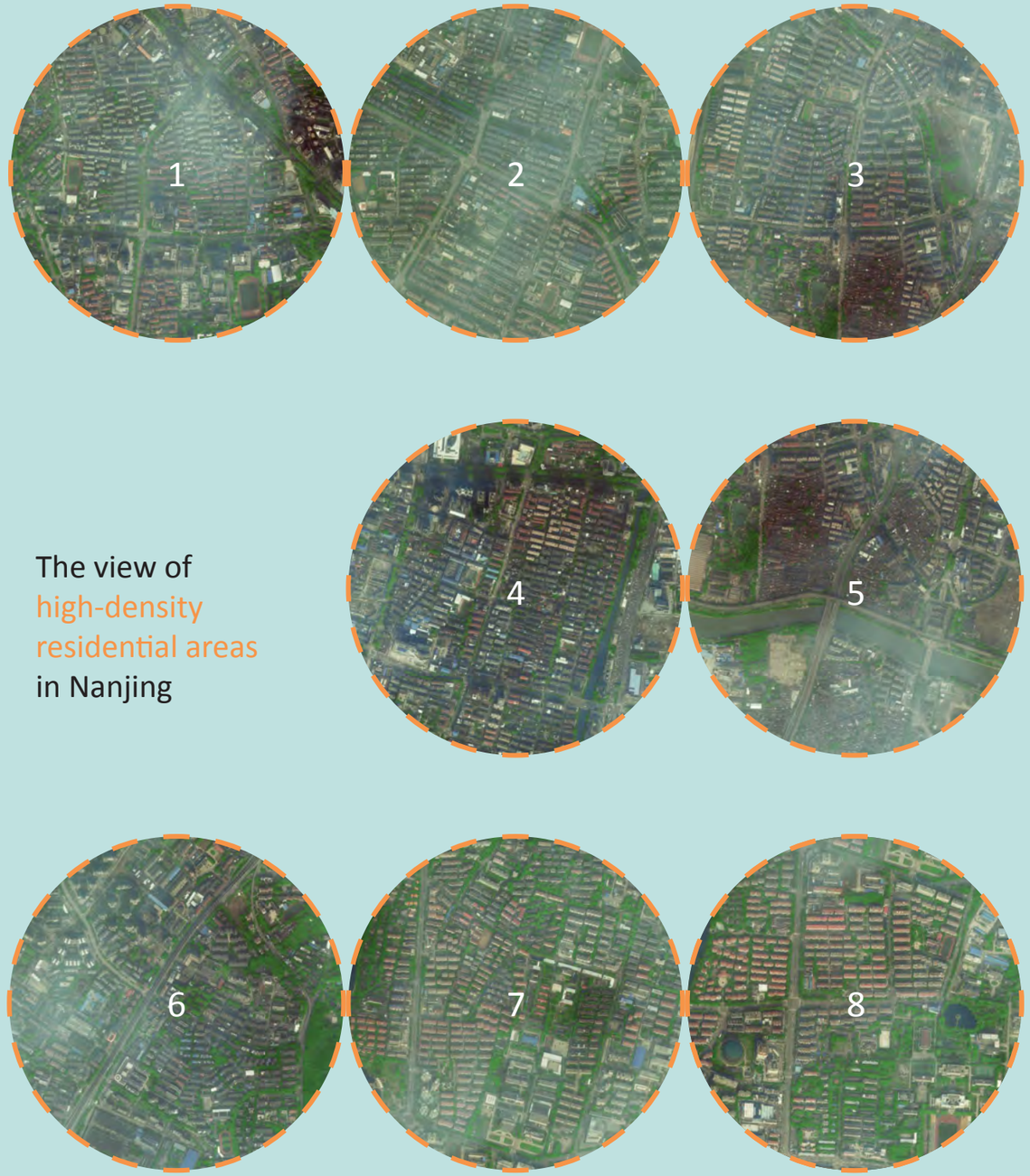


Figure 6.20 - Views of residential areas in Nanjing.

MAP of Major Universities

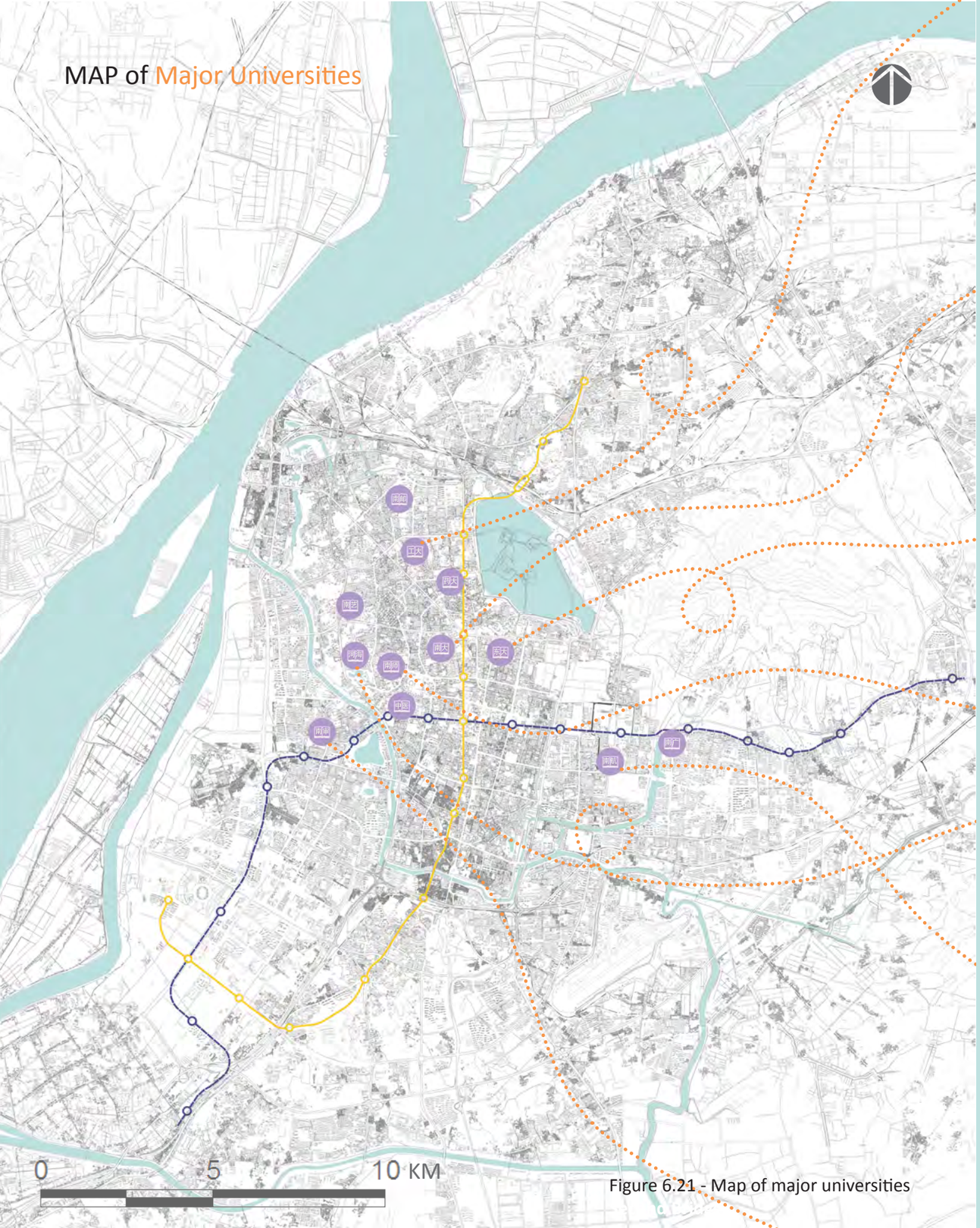


Figure 6.21 - Map of major universities

Figure 6.22 - Views of major universities in Nanjing.

MAP of Proposed Cycling Functional Route

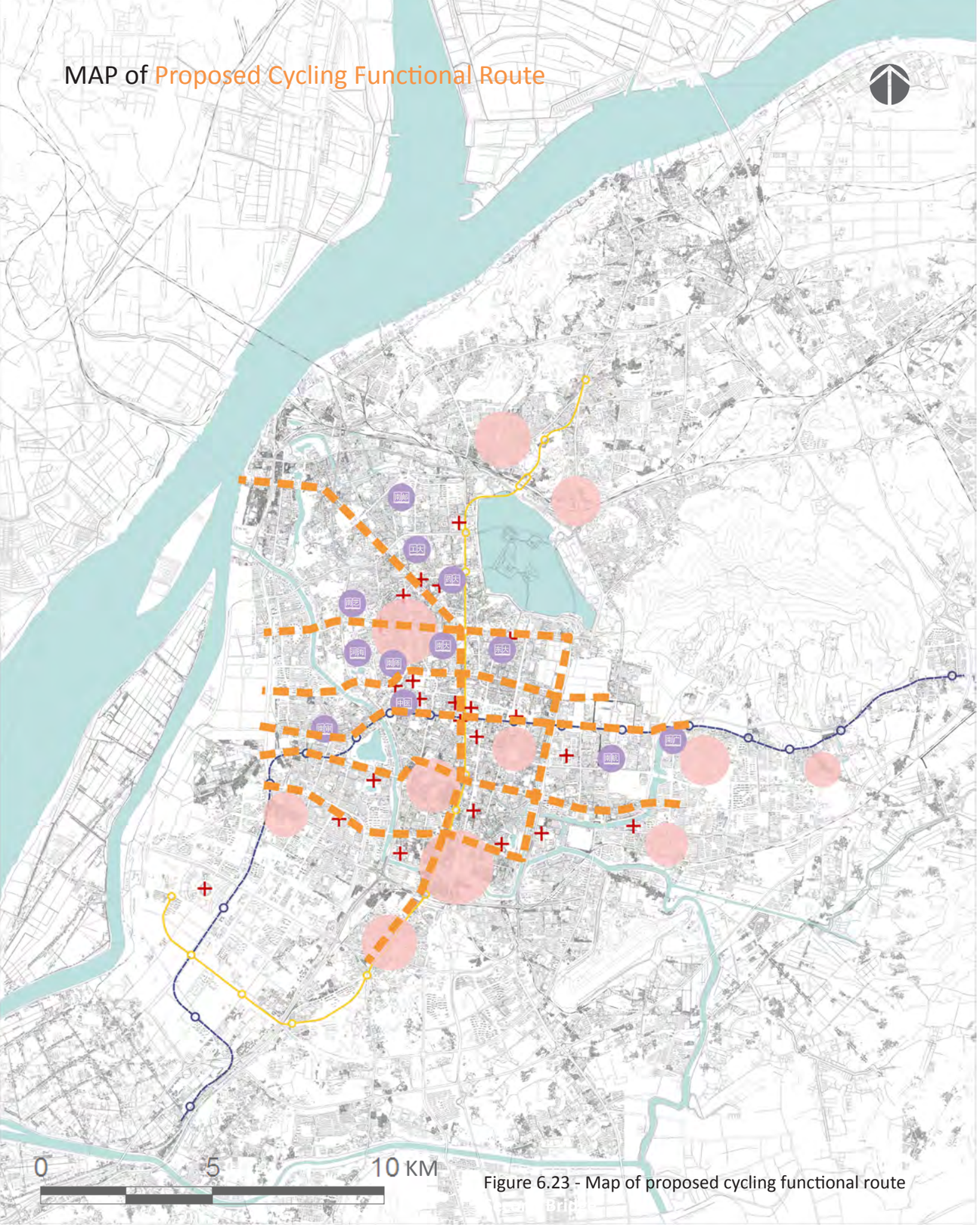
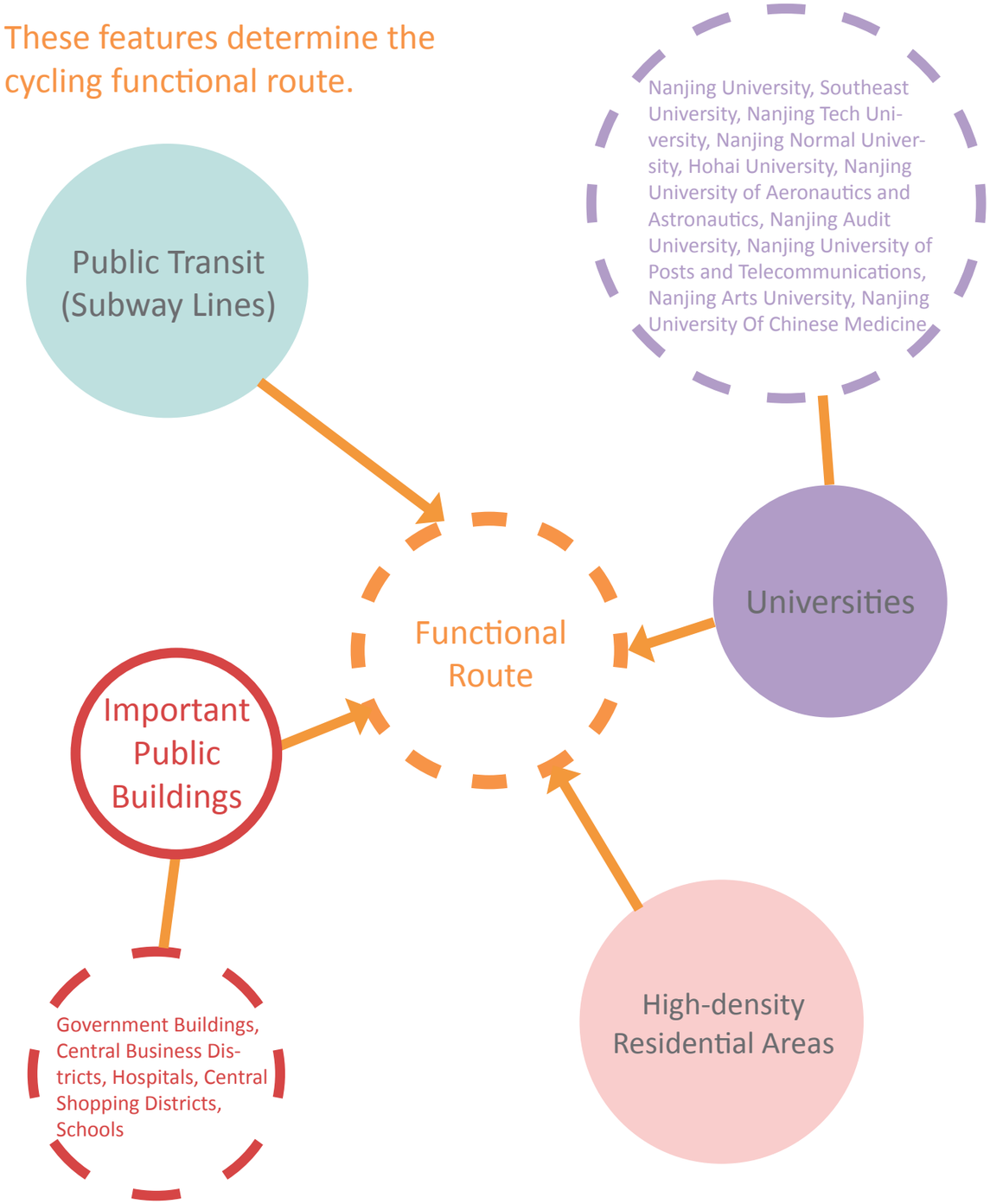


Figure 6.23 - Map of proposed cycling functional route

These features determine the cycling functional route.



MAP of Proposed Cycle Recreational Route + Functional Route

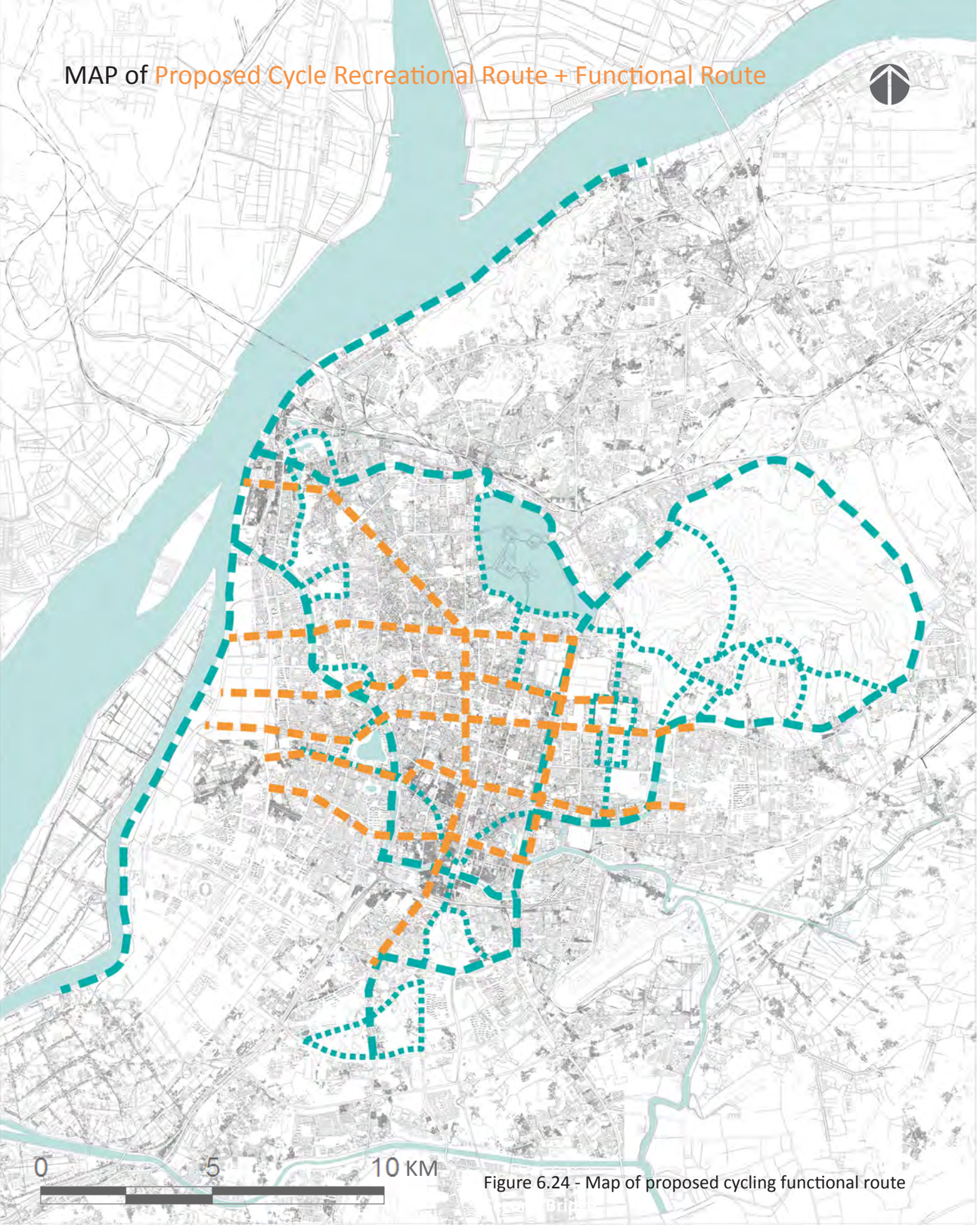
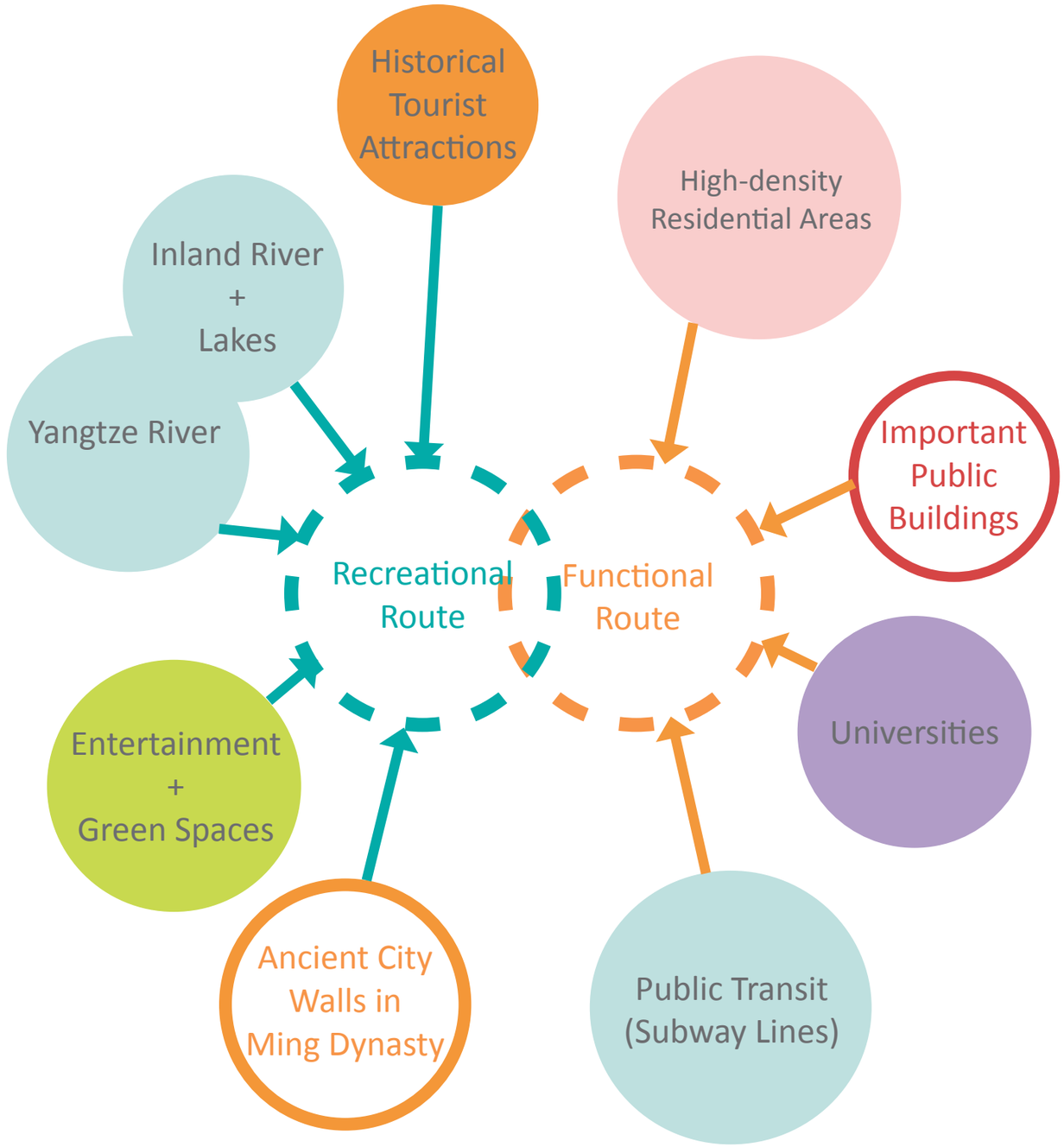


Figure 6.24 - Map of proposed cycling functional route



seven

Cycle Corridors Design

MAP of Seven Major Corridors' Locations In Proposed Route

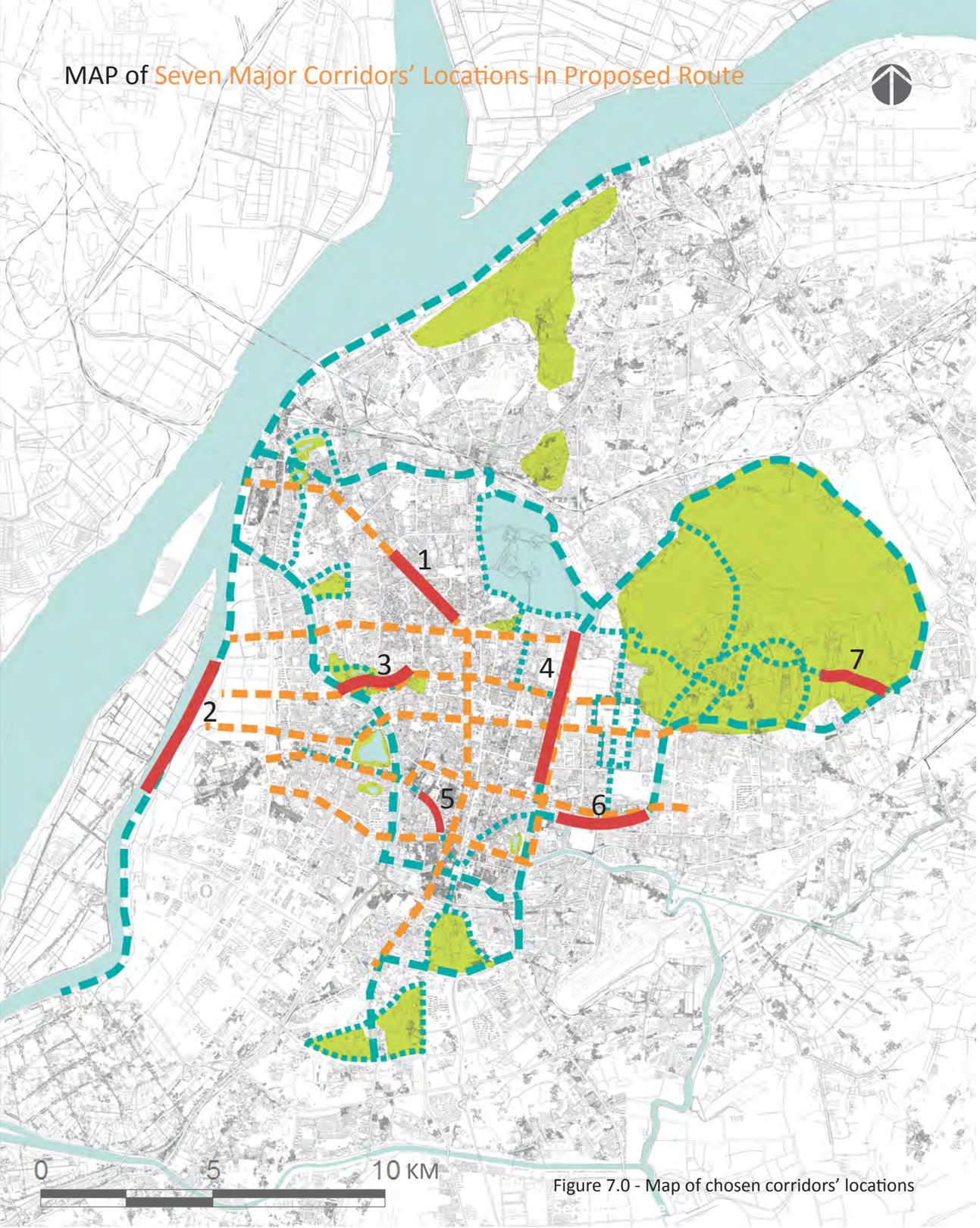


Figure 7.0 - Map of chosen corridors' locations

Figure 7.1 - Views of chosen corridors

To build a integrated bicycle system, first, I choose seven typical corridors in the network for designing the bicycle path. When I start to look at the corridors, I learn from the existing Nanjing Roads. The beautiful border trees in Nanjing have a long history. To solve the terrible traffic jam, the government try to broaden the roads. Many border trees are cut and transferred to other places, but only 18% of the transferred trees will survive in a new circumstance(link 9). My strategy is to keep and protect the existing trees. On this base, I would like to create a better environment for cyclists to encourage people start to ride and stop driving.

Corridor 1 — Shanxi Road Section

The first one is Shanxi Road. It's a quite wide and busy street with 2-direction 4-lane vehicle movement and 2-lane parking. There are 2 lines of green belt to separate sidewalk and roadway. Now pedestrian and cyclist are sharing the sidewalk. Though the sidewalk on each side is wide enough for both of them. But it is still unsafe and inconvenient to share the lane on same height and same paver. To create a better movement environment, first I place a line of traffic fence in the middle of the vehicle movement road. Thus, the vehicles are organized.

Consider the width of sidewalk and the protection of border tree roots, I didn't change the elevation of sidewalk. I change the paver from brick to asphalt in 3 meter for cycle lane and have bike symbol on the lane. Between pedestrian lane and bicycle lane, there is a line of ground light. Thus, pedestrian and cyclist can easily share the sidewalk.

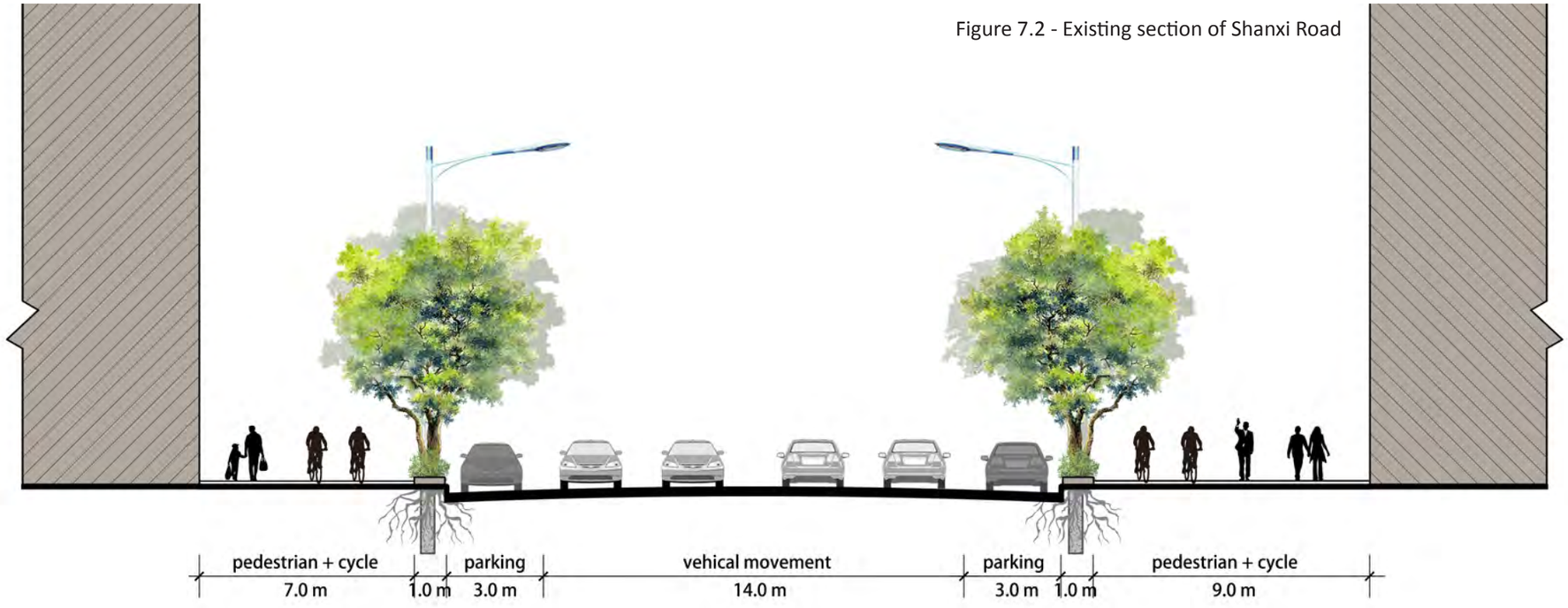


Figure 7.2 - Existing section of Shanxi Road

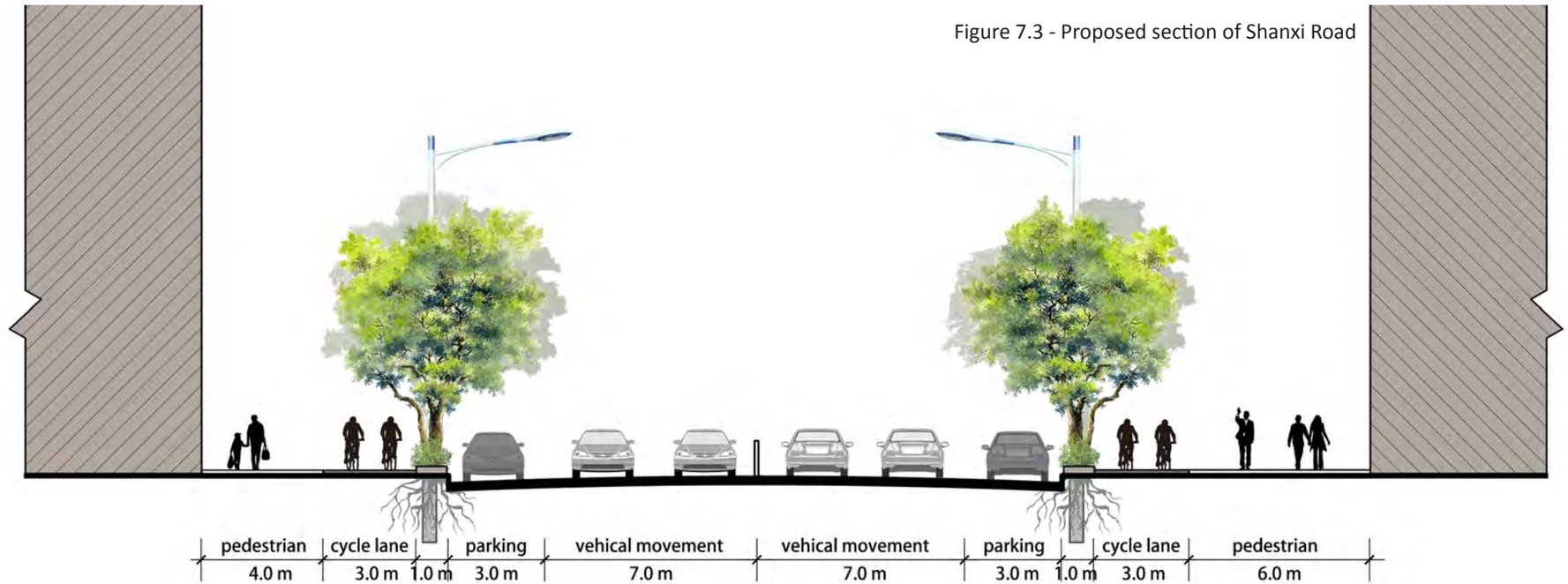


Figure 7.3 - Proposed section of Shanxi Road

Corridor 1
Plan

Existing

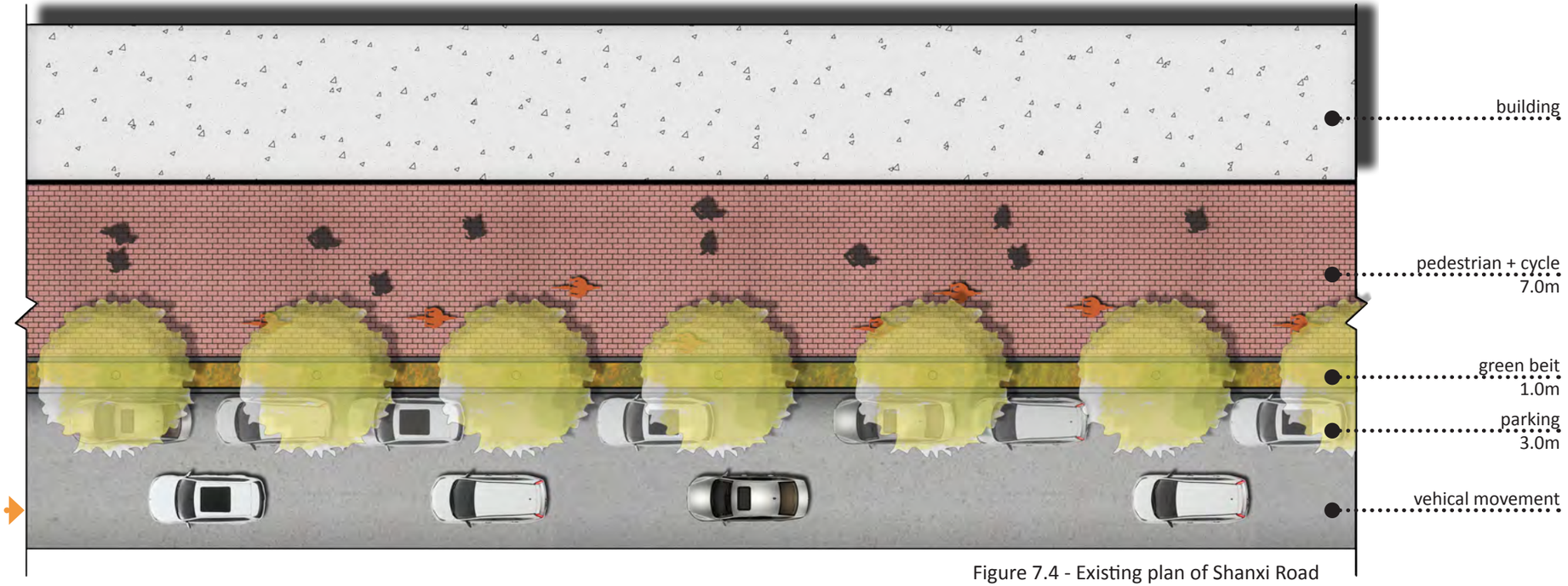


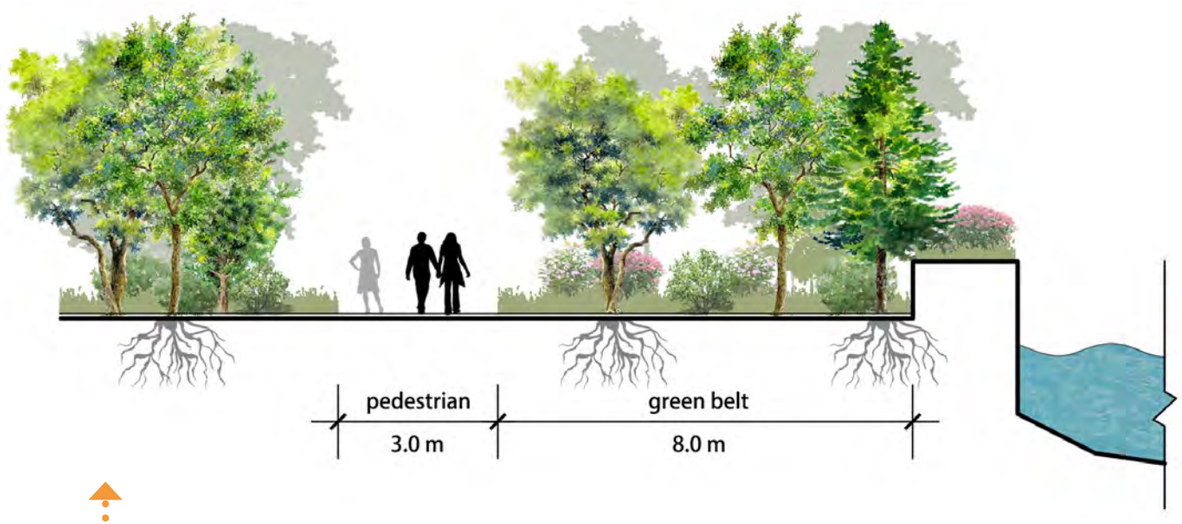
Figure 7.4 - Existing plan of Shanxi Road

Proposal

Figure 7.5 - Proposed plan of Shanxi Road

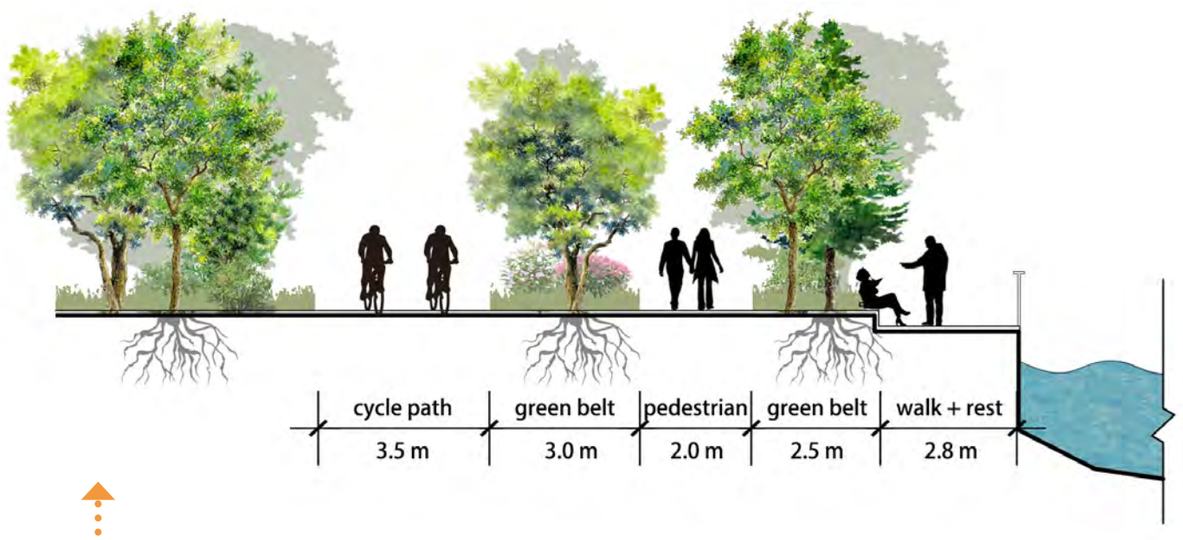
Corridor 2 — Yangtzejiang Road Section

The second corridor is Yangtzejiang Road, which is along Yangze River. Now there is only a 3-meter sidewalk in there area. To provide a functional and enjoyable way. I broaden the existing sideway to 3.5 meter and make it as a bicycle lane only for cyclists. A 2-meter pedestrian lane is created between the vegetations and a 2.8 meter sidewalk with benches is designed along river for people to have rest and enjoy the river-view.
Green asphalt is used as cycle lane material, which is prepared using a clear binder and coloured aggregate. The two pedestrian lanes are connected at some points.



Existing

Figure 7.6 - Existing section of Yangtzejiang Road



Proposal

Figure 7.7 - Proposed section of Yangtzejiang Road

Corridor 2
Plan

Figure 7.8 - Existing plan of Yangtzejiang Road

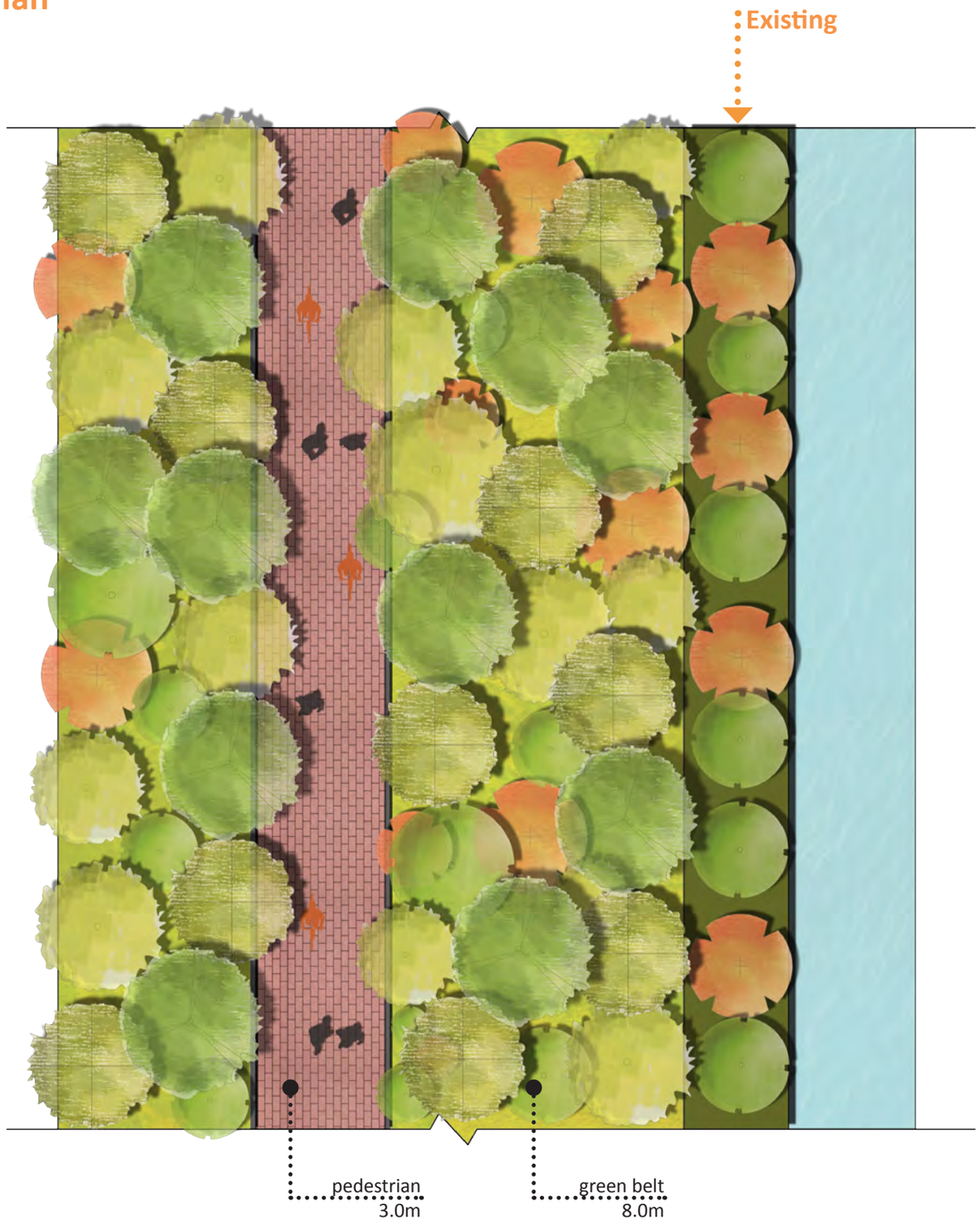
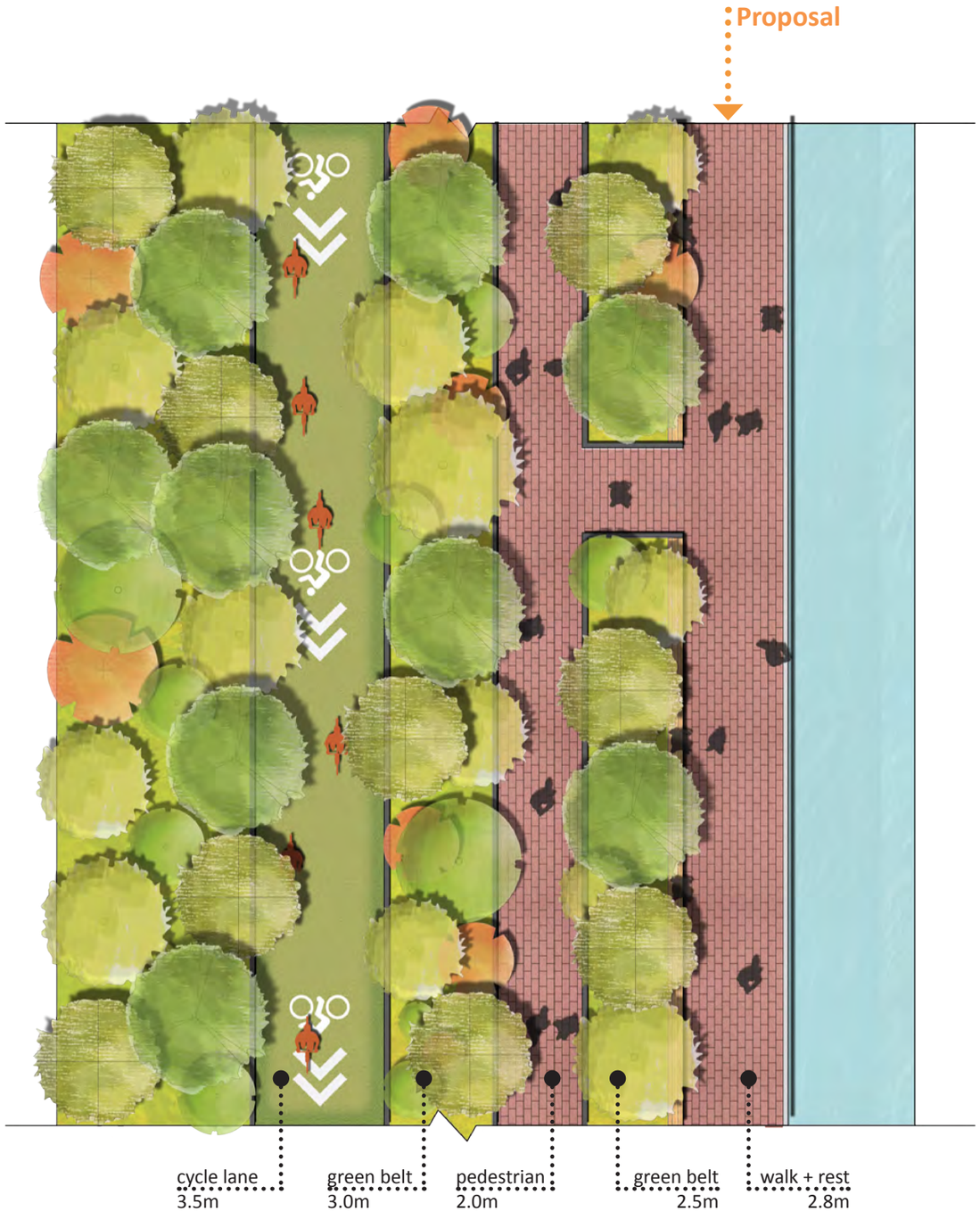


Figure 7.9 - Proposed plan of Yangtzejiang Road



Corridor 3 — Guangzhou Road

Figure 7.10 - Existing section of Guangzhou Road

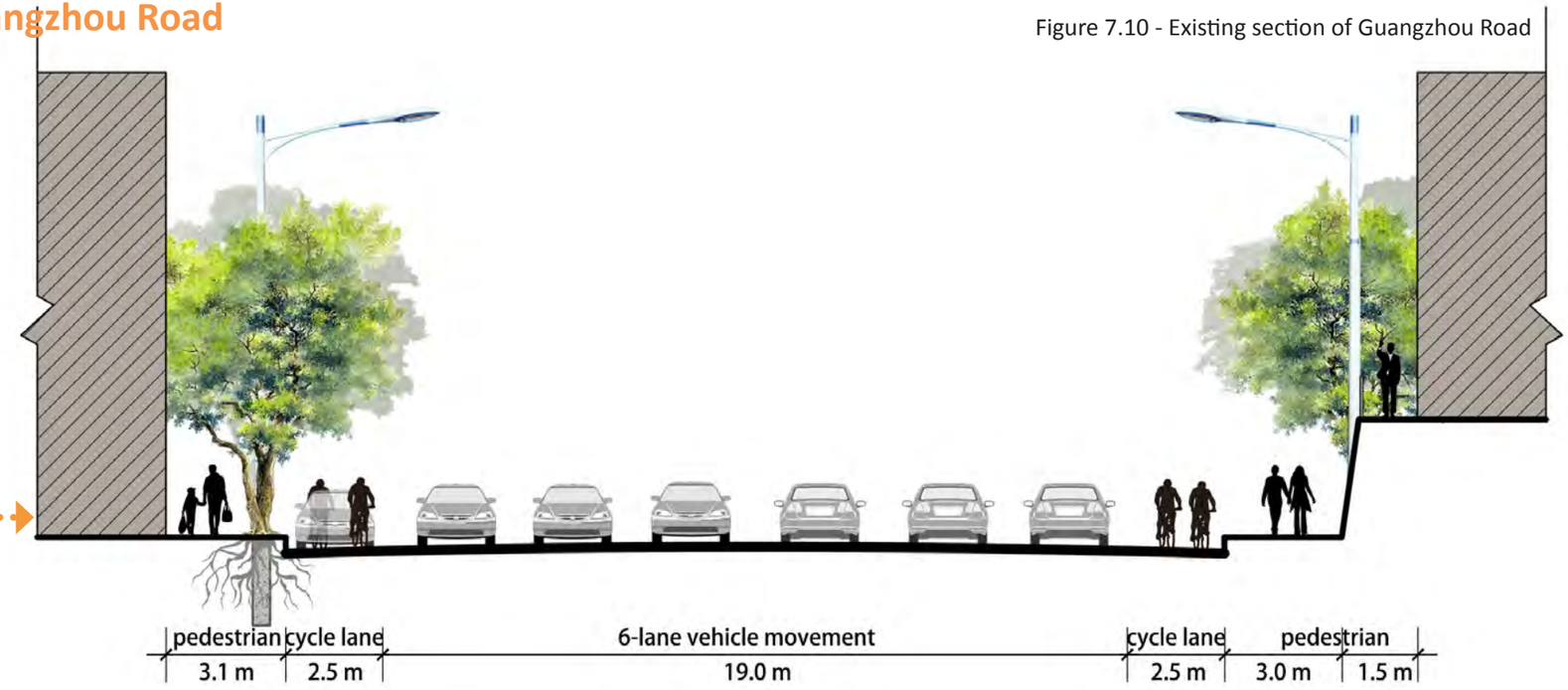
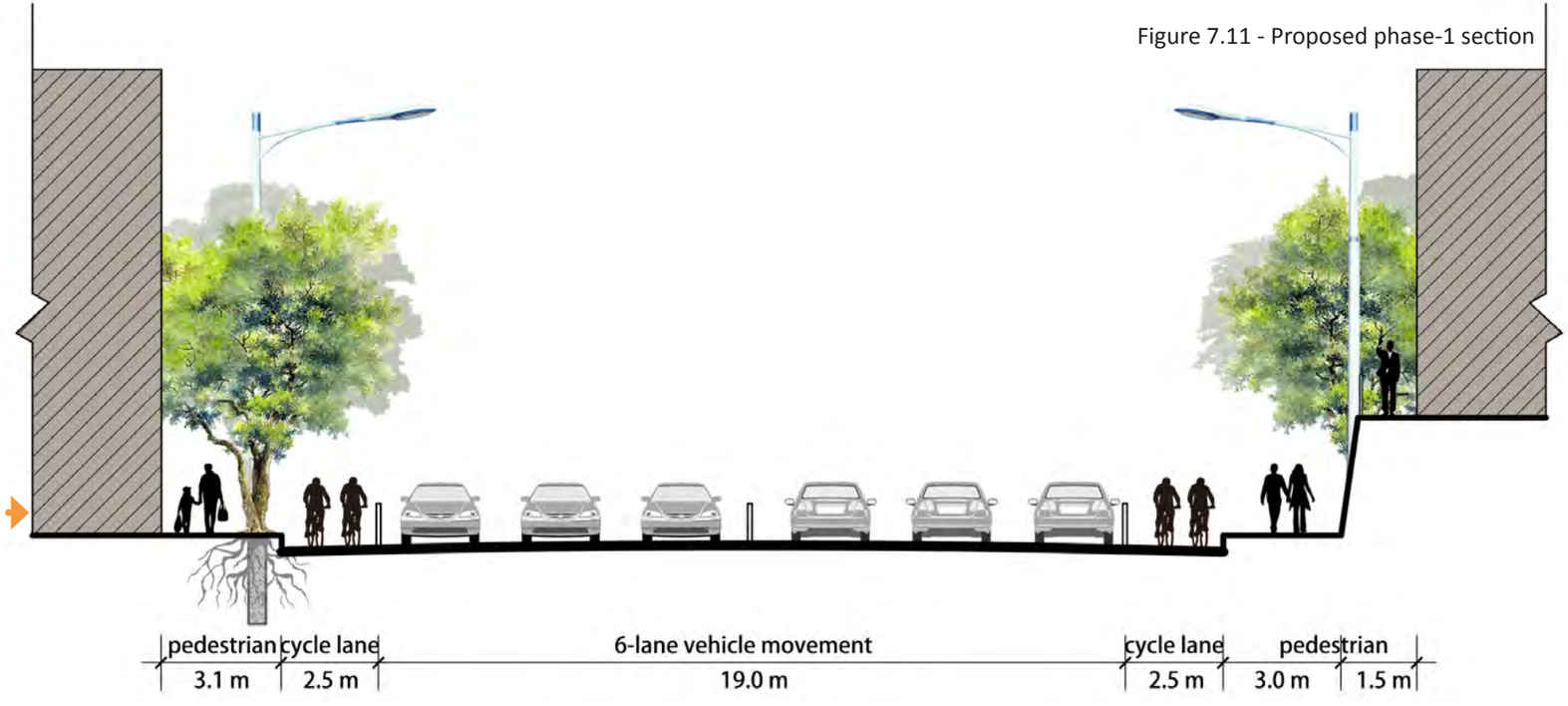


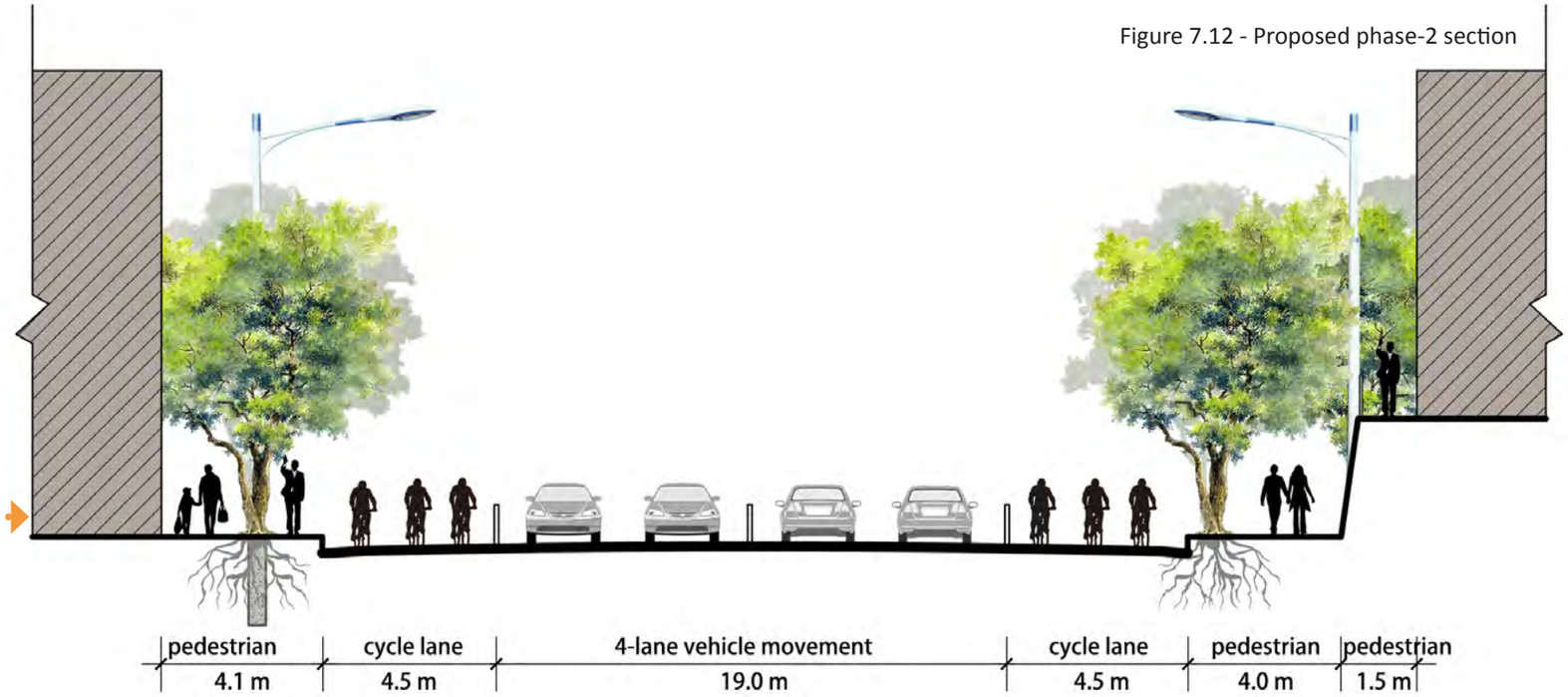
Figure 7.11 - Proposed phase-1 section



The third one is Guangzhou Road. This is a busy and important road in Nanjing. The current road is 24-meter wide, with 2-direction-6-lane vehicle movement and 2-lane cycleway. Now, the drivers always occupy the cycle lane as parking lane. There is no divisions between cyclists and drivers, which makes cycling dangerous and inconvenient. I provide 3 proposal in different phase. Phase 1, only traffic fences are added to separate cycleway and driveway. This change organized the road without any influence on traffic flow.

Corridor 3

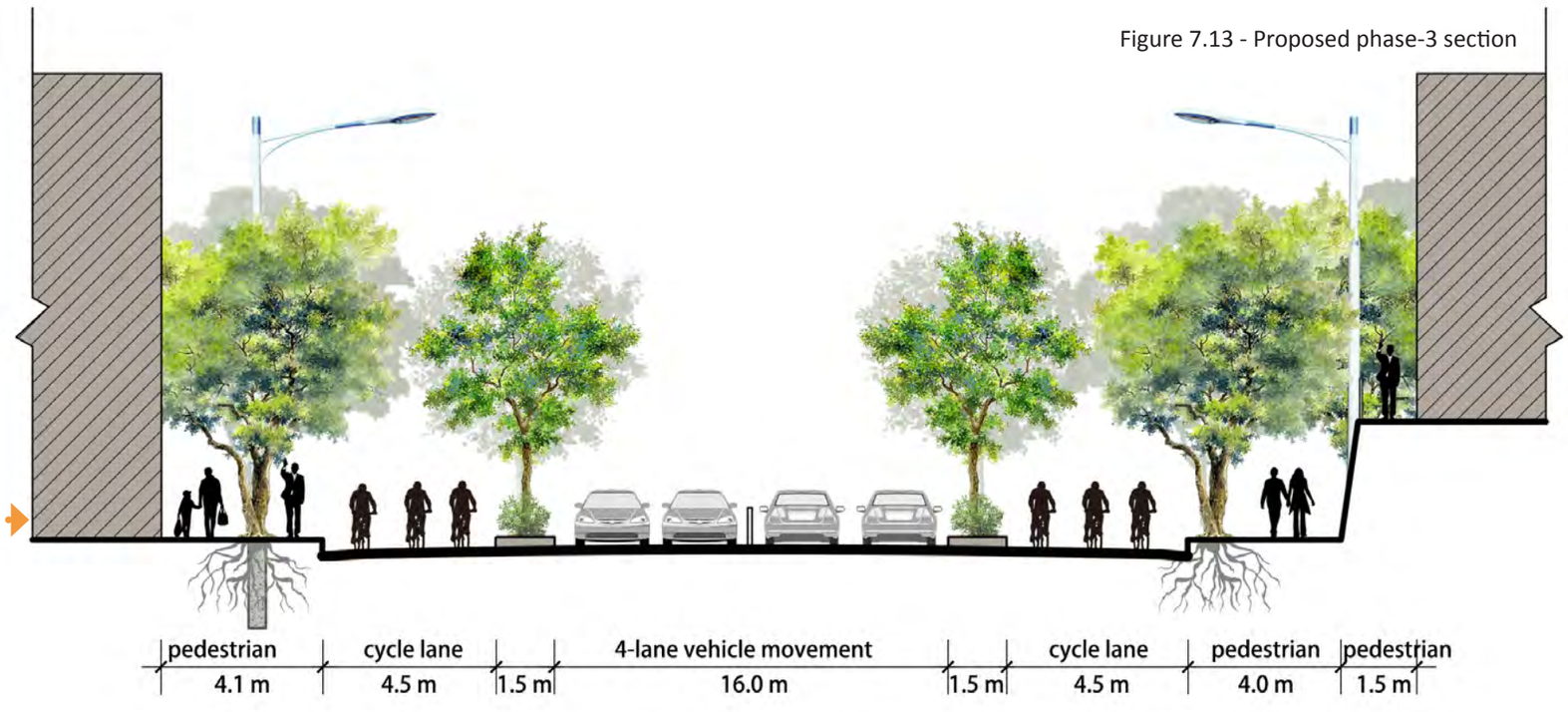
Figure 7.12 - Proposed phase-2 section



Phase 2

Phase 2, I took two lanes from the 6-lane vehicle area to make the cycle-way wider. In this way to encourage more people riding instead of driving. Moreover, I add one line of border tree between the pedestrians and cyclists.

Figure 7.13 - Proposed phase-3 section



Phase 3

Phase 3, more space is occupied from driveway to design as green belt. As Nanjing is famous for its beautiful and ancient border trees, I proposed 2 lines of trees in the green belt. This creates a convenient and enjoyable space for cyclists and makes people realize cycling has a better environment than driving. In this way, make the road back to cyclists.

Corridor 4 — Longpan Middle Road

Longpan Middle Road is chosen as the fourth corridor. Now, on one side of the road, pedestrian and cyclist are sharing a narrow sidewalk. While on the other side, the space is bounteous with a 5-meter green belt. I keep the narrow side as walkway only for pedestrian. And put the cyclist to the other side. Making it a 3.5-meter 2 direction cycleway.

Figure 7.14 - Existing section of Longpan Middle Road

Existing

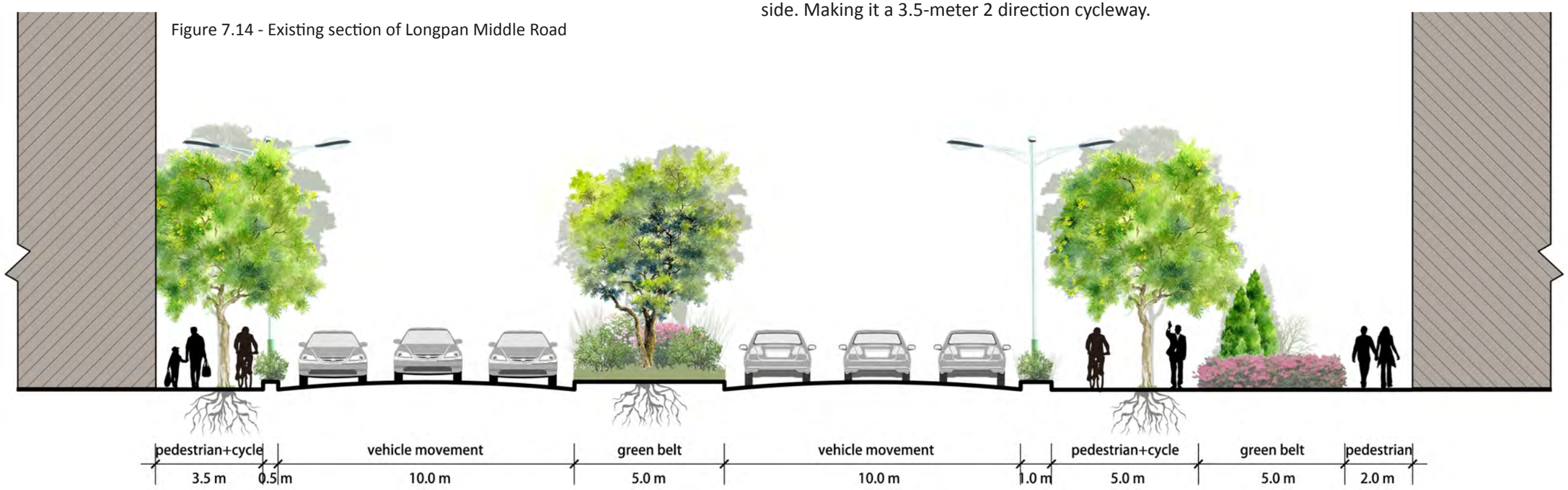
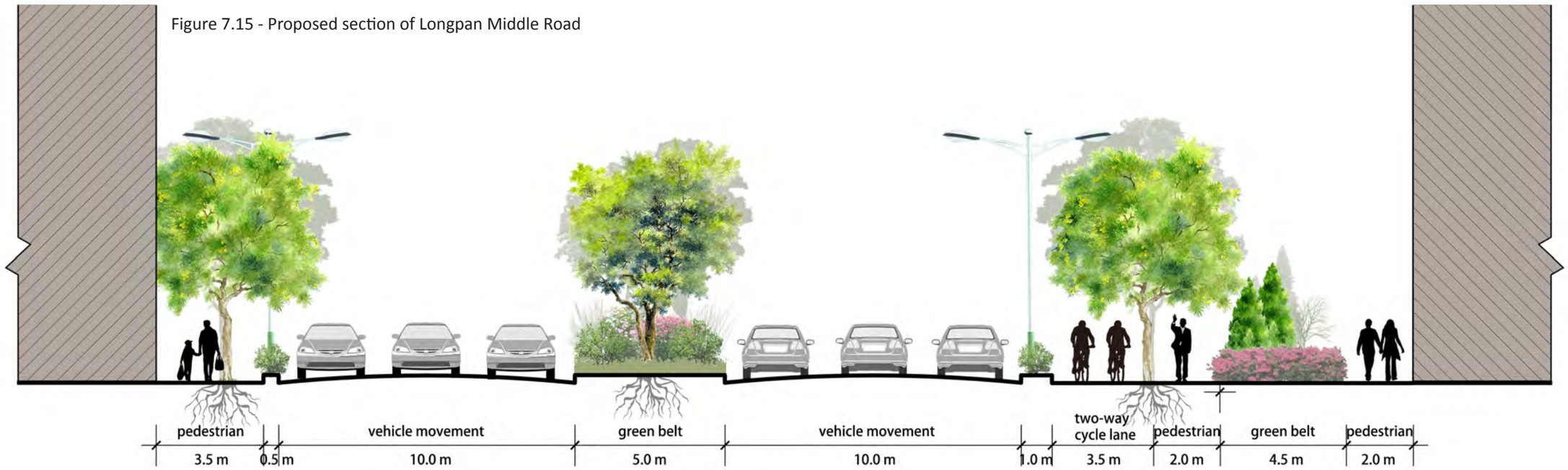


Figure 7.15 - Proposed section of Longpan Middle Road

Proposal



Corridor 5 — Chuanban Alley Section

The fifth corridor — Chuanban Alley is along canal. It's an alley at the back of residential buildings. There is a 3.5-meter lane in brick paver next to the garage door of residents. And a -meter asphalt lane next to canal. Divers occupy a 2.5-meter lane as parking. Now pedestrian, cyclists, and drivers are sharing an area only 7 meters wide. Though, there is not a big vehicle flow here. The alley is still not safe and efficient for people, especially for cyclists. To make it a better area, the bicycle lane will run along the canal side. Thus, the cyclists will go through this area easily with beautiful canal view. The path along the building side will be 6-meter wide, in order to have enough space for vehicle to turn into the garage. Consider the vehicle flow is light, pedestrian will share the path, which is paved by brick. And a green belt is placed between the two lanes.

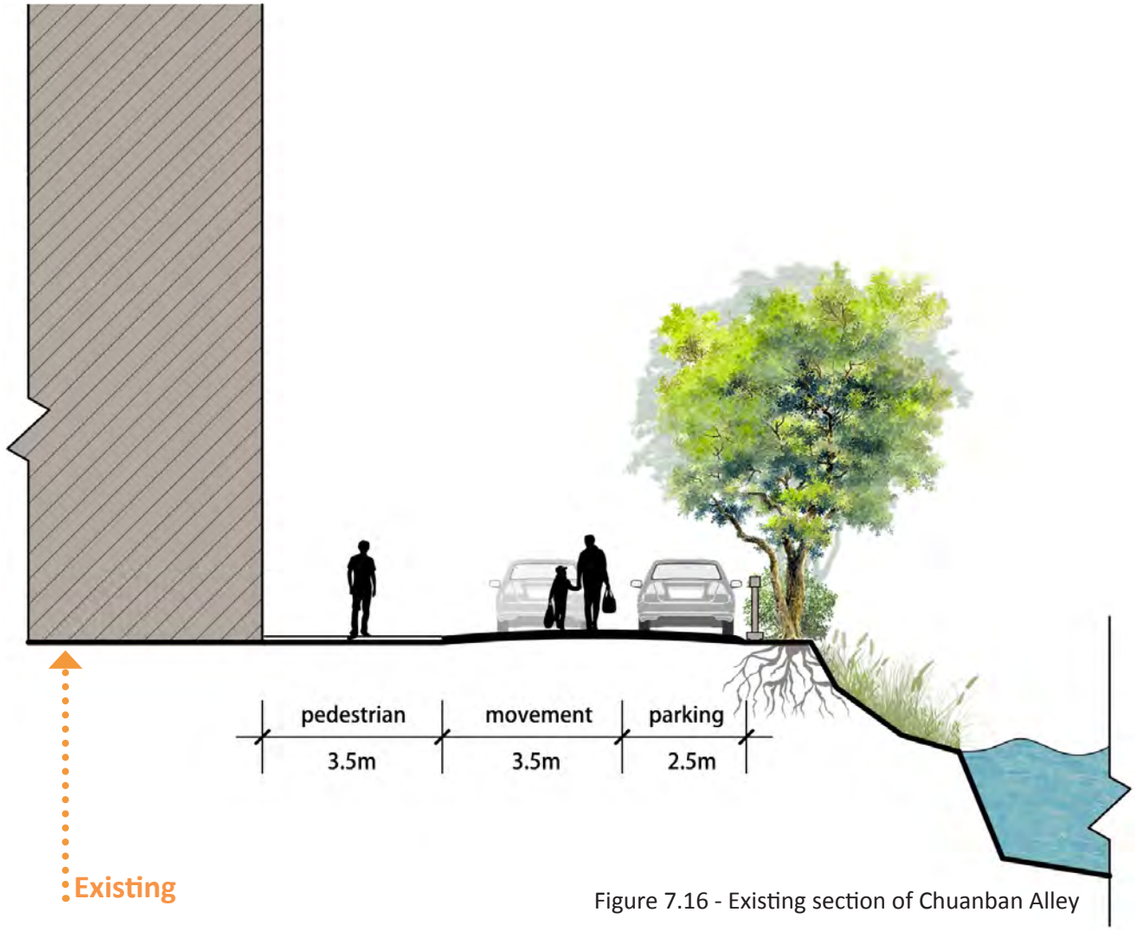


Figure 7.16 - Existing section of Chuanban Alley

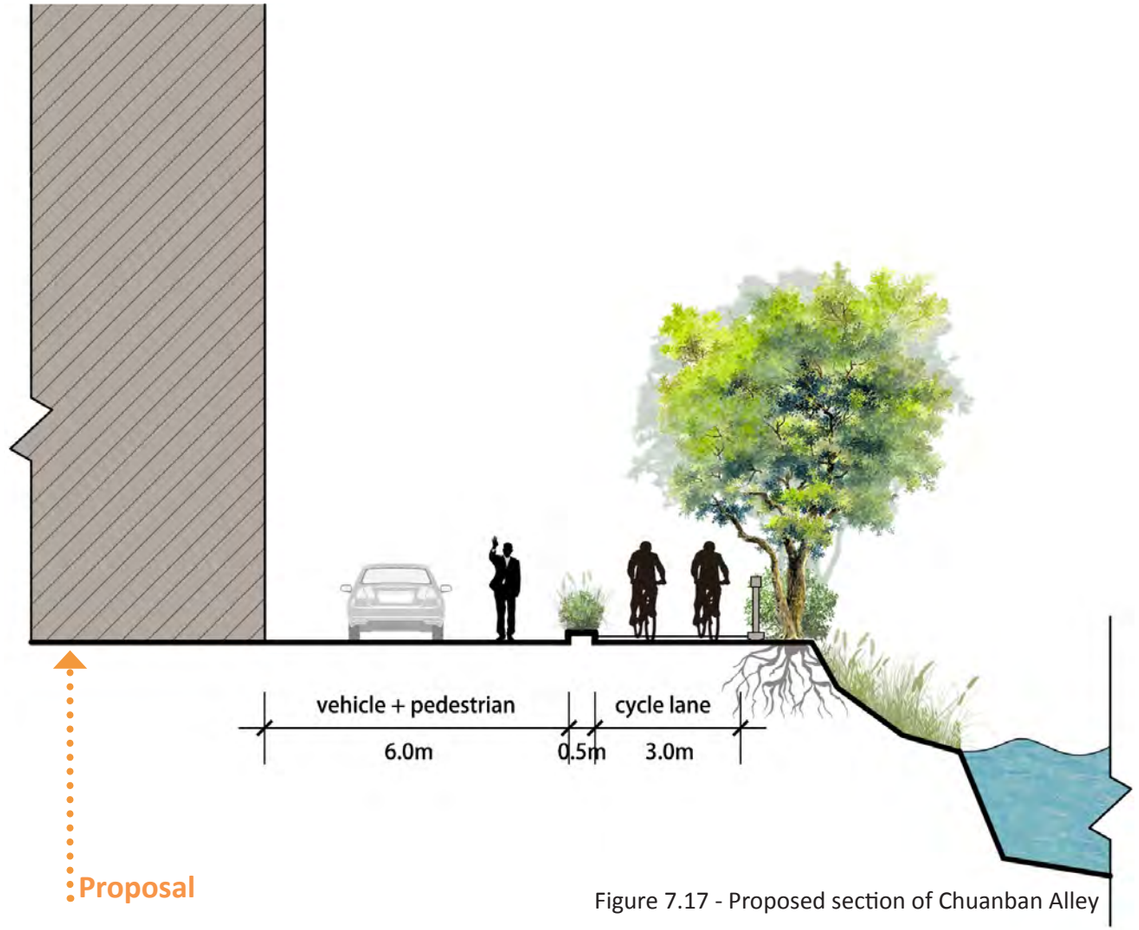


Figure 7.17 - Proposed section of Chuanban Alley

Corridor 5
Plan

Figure 7.17 - Existing plan of Chuanban Alley

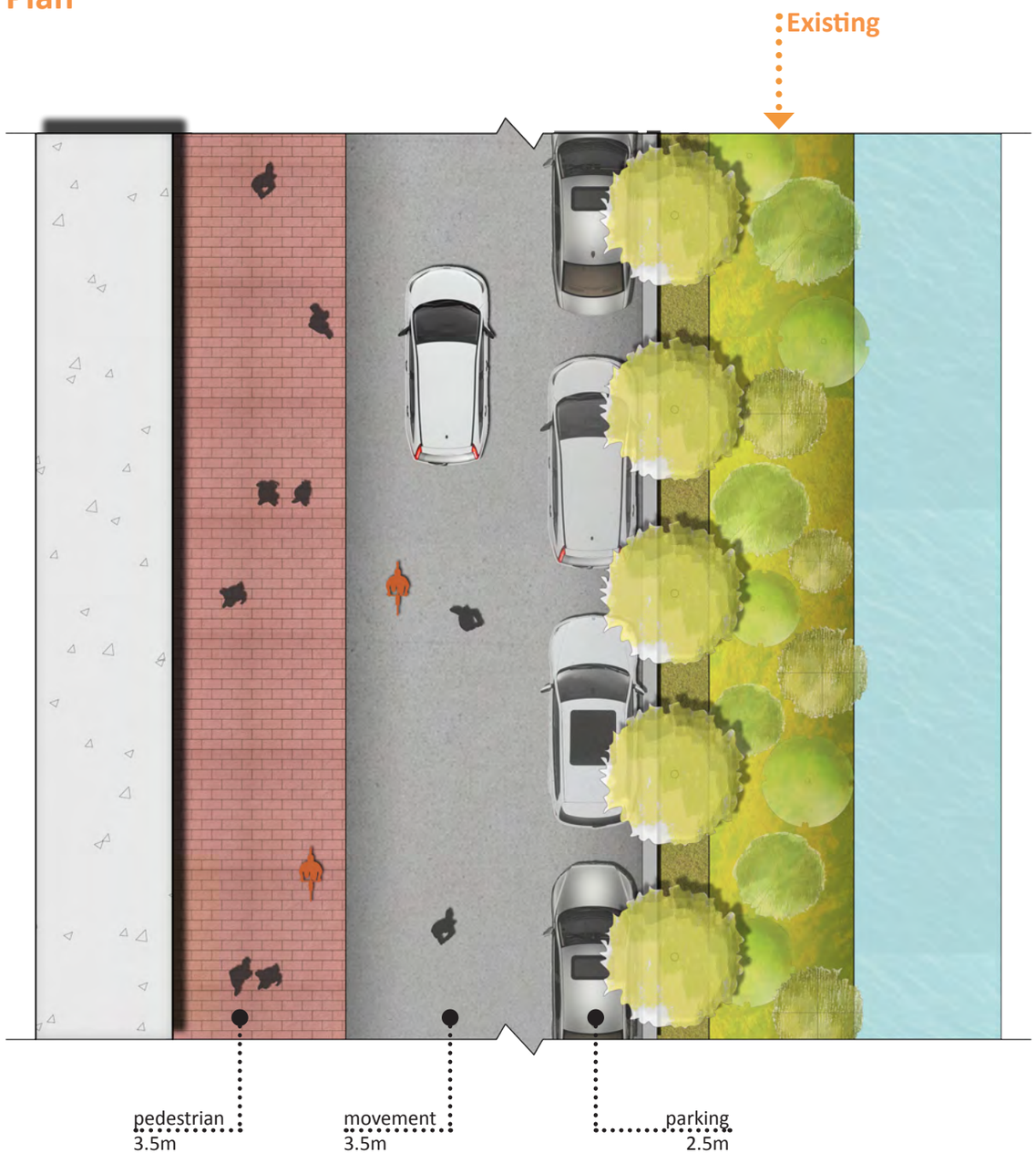
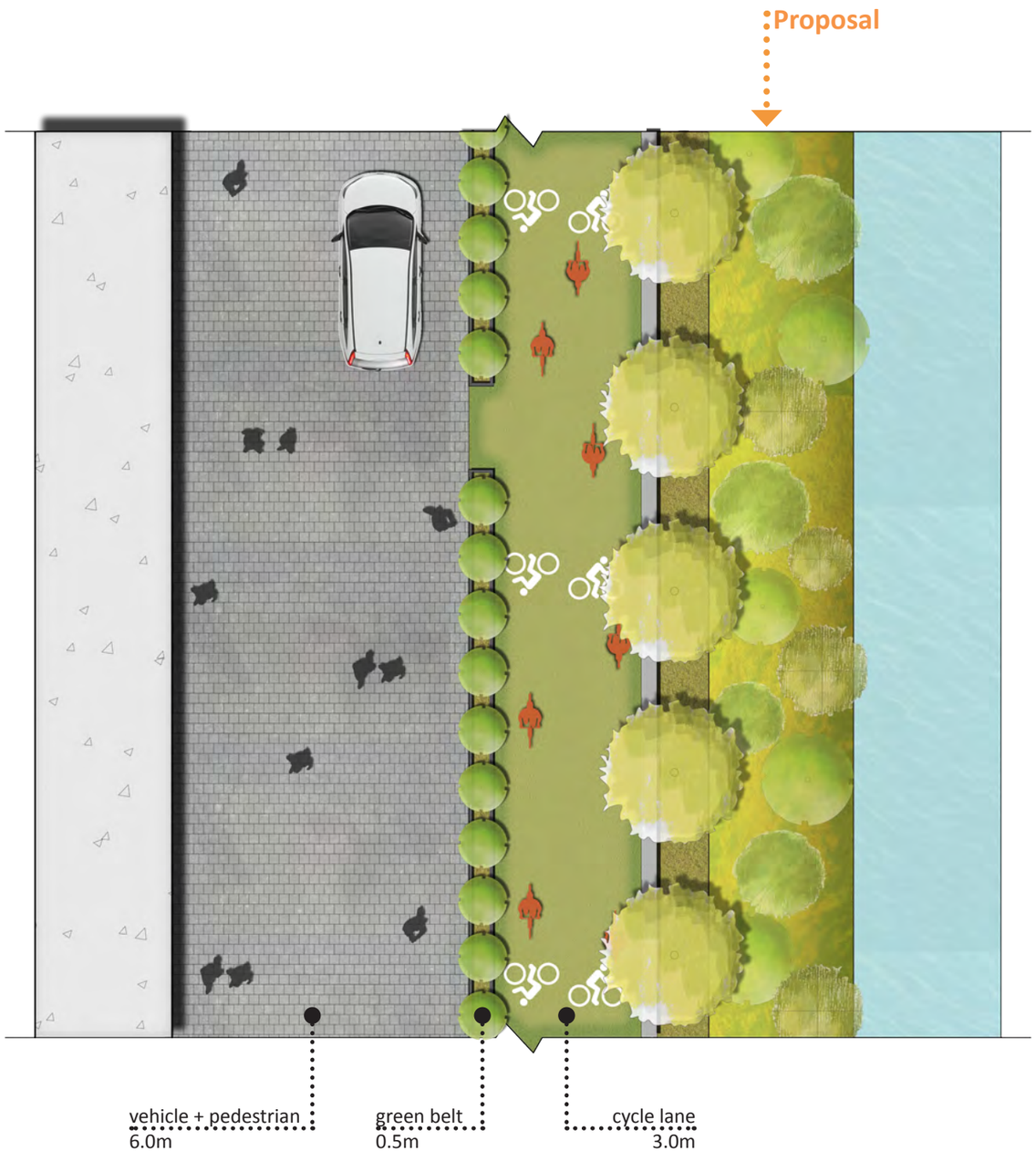
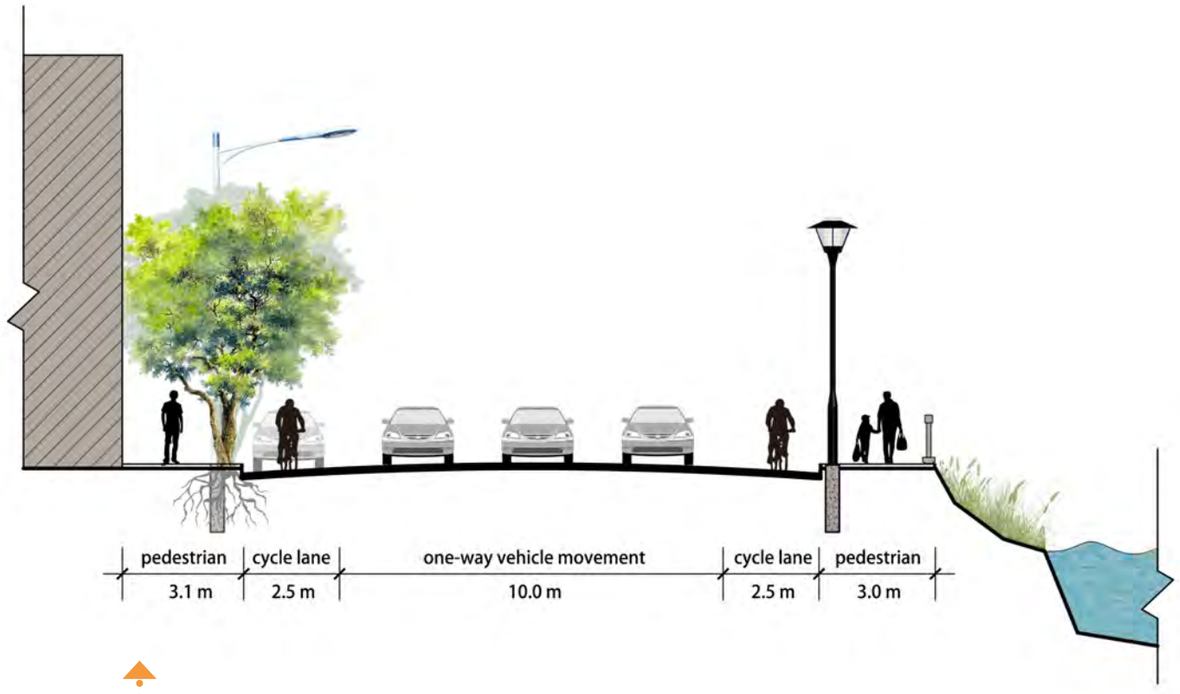


Figure 7.18 - Proposed plan of Chuanban Alley



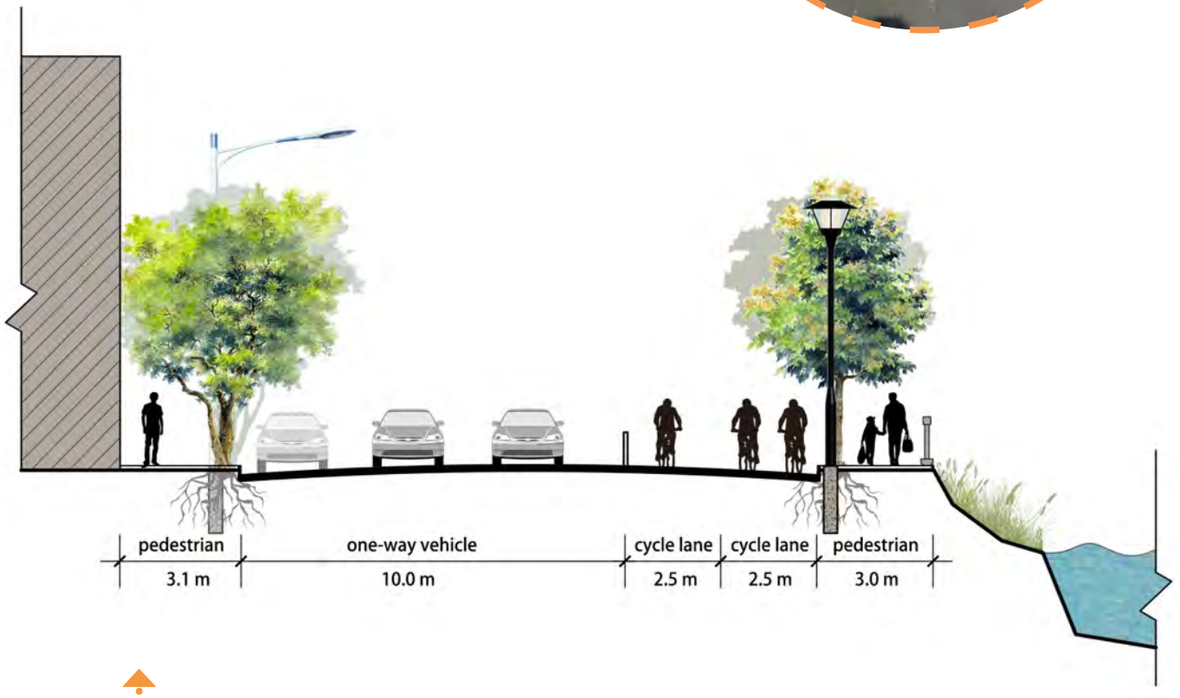
Corridor 6 — Daming Road

Daming Road is another corridor long canal. Now there has a 10-meter one-way direction vehicle lane and two cycle lanes. The driver always occupy one cycle lane for parking. To encourage cycling, a 5-meter wide lane is designed for cyclist along canal. And the rest 10-meter wide lane is one-way vehicle lane.



Existing

Figure 7.19 - Existing section of Daming Road



Proposal

Figure 7.20 - Proposed section of Daming Road

Corridor 7 — Lingdong Road

Existing

Lingdong Road is in Zijin Mountain, where has beautiful views along the road. This is one of the favourite places cyclists love. But now there is no cycle lane. Cyclists have to share the road with vehicles. To make the cyclists enjoy the route, I propose a 3.5-meter cycle lane among trees and vegetations.

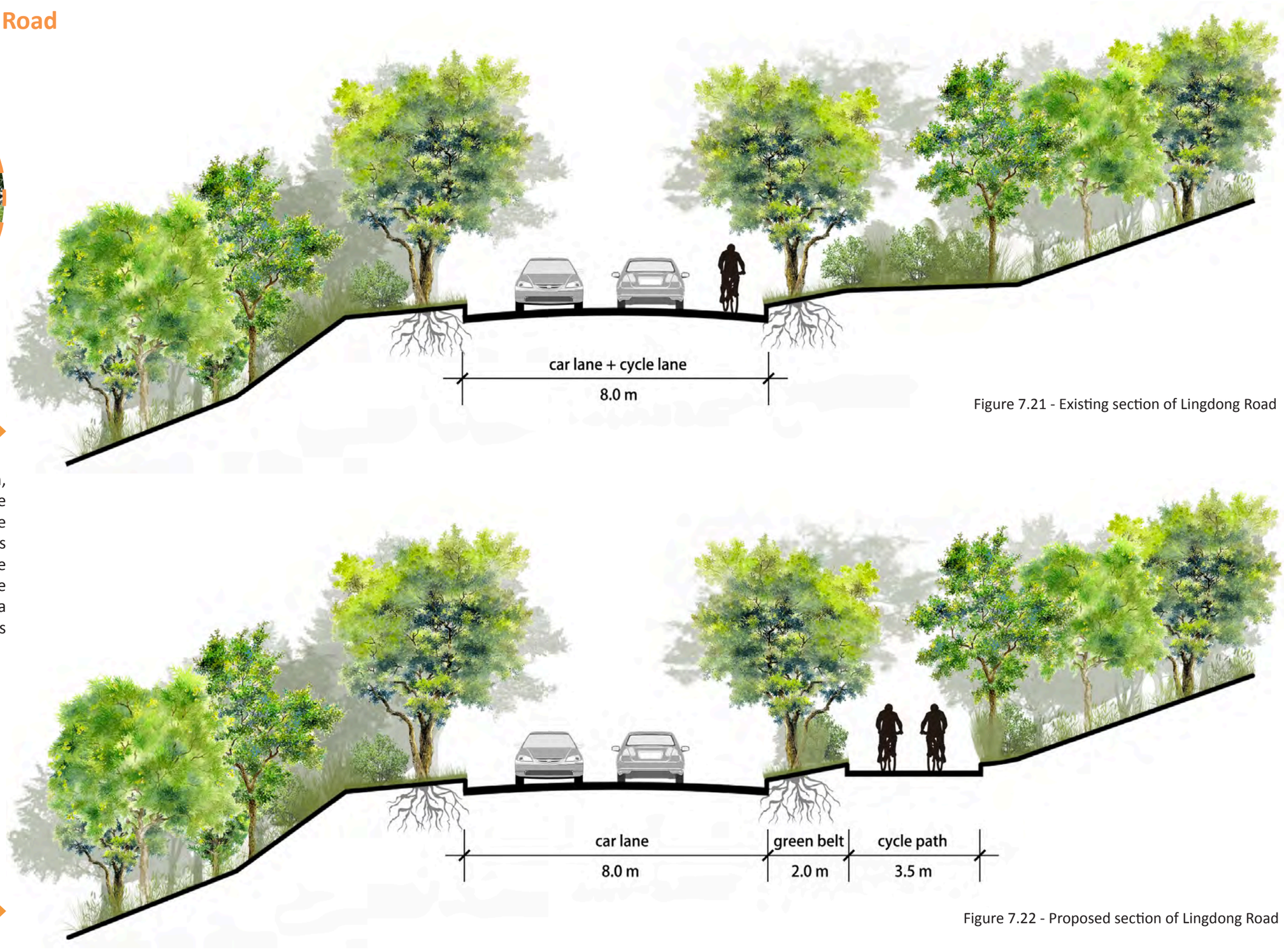


Figure 7.21 - Existing section of Lingdong Road

Proposal

Figure 7.22 - Proposed section of Lingdong Road

eight

Branding Introducing + Components Design of Bicycle System






The views of components of cycling system







Figure 8.0 - Images of components of cycling system

After refine the routes and corridors, I look at the design of various components of the whole cycling infrastructure, which includes, path, fence, bollard, paver, sign, intersection, storage, location map, lighting and rental system. In order to make more people ride a bike, the design of these components play a significant role. My plan is not only making them convenient and functional, but also combine the branding into the deign. In this way, help people to realize they are protecting the environment when they are riding.

INTRODUCE of Branding of Cycle System

Figure 8.1 - Hwamei Bird

Figure 8.2 - Bird and smog in the city

A branding is created to promote the bicycle network. Smog not only has negative affects on people, but also on most animals, especially birds. Birds must be capable of high rates of gas exchange because their oxygen consumption at rest is higher than that of all other vertebrates, including mammals, and it increases many times during flight. The gas volume of the bird lung is small compared with that of mammals, but the lung is connected to voluminous air sacs by a series of tubes, making the total volume of the respiratory system about twice that of mammals of comparable size. Birds have high demand of air quality. Now, birds are apparently falling out of the sky because of the intense smog. Moreover, the terrible smog blocks bird's view, many birds hit on buildings and poles. Thrush (Hwamei) the city bird of Nanjing is chosen as a part of the logo. My goal is to encourage people to ride instead of drive to reduce smog, by creating a functional, efficient, recreational and attractive bicycle system. In this way, people feel free to bike, birds feel free to fly, and they both feel free to breath in the city. My plan is to combine the branding into design. Therefore, people can realize they are protecting the environment when they are riding.

Figure 8.3 - Proposed logo

Two choices of Logo

DESIGN of Intersection

Figure 8.4 - Existing photos

Exsiting photos and diagram of the junction — Zhongshan South Road @ Sanyuan Alley

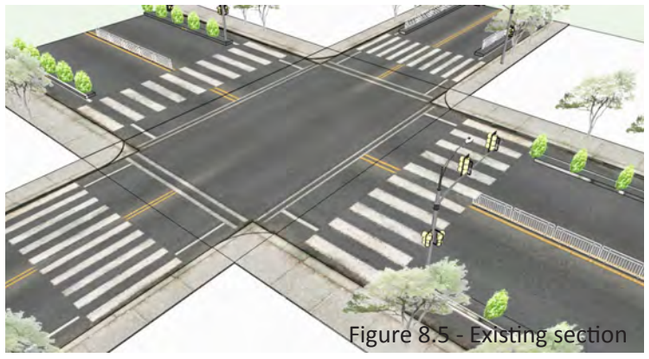


Figure 8.5 - Existing section

The intersection design is important in the whole bicycle system. I choose an junction in Nanjing. Now it is a busy junction, while pedestrian, cyclists and drivers mixed together. Cyclists don't have higher priority than drivers. I design a connected route in the junction for cyclists with 4 traffic islands at each corner. These traffic islands are the result of the tight radius for right turning cars to decrease their speeds on the intersection. This not only creates a safe waiting place for people cycling, but also a waiting place for exactly one car in that turn. It is right before the crossing place for people walking and cycling, but it is at the same time out-of-the-way from straight going motor traffic. The advantage of this design is threefold: creating a safe place for motor traffic, for people cycling and for people walking.

Proposal Intersection Paver Design

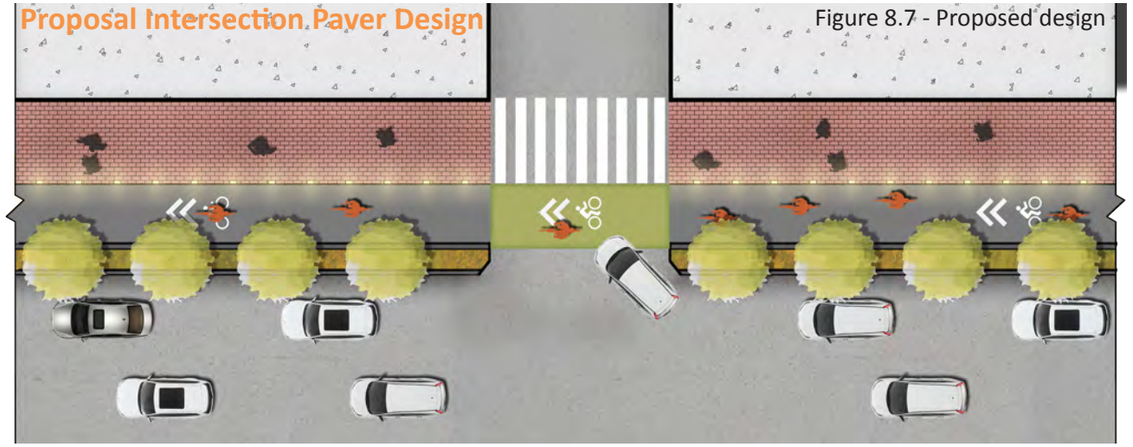


Figure 8.7 - Proposed design

At some intersection of the road, the cycle lane paver is changed colour from grey to green. Thus, make both cyclists and drivers realize there is an intersection between bike and car.

Figure 8.6 - Existing section

Proposal Junction Design

DESIGN of Bollard

For the bollards design, I put the Huamei bird profile in the centre of circle. During night, the lighting bird can help to lead the road.

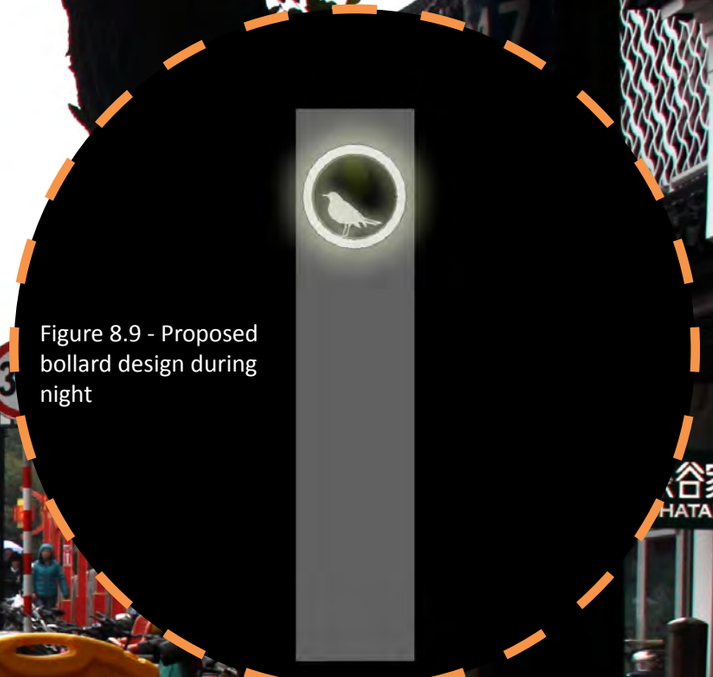


Figure 8.9 - Proposed bollard design during night

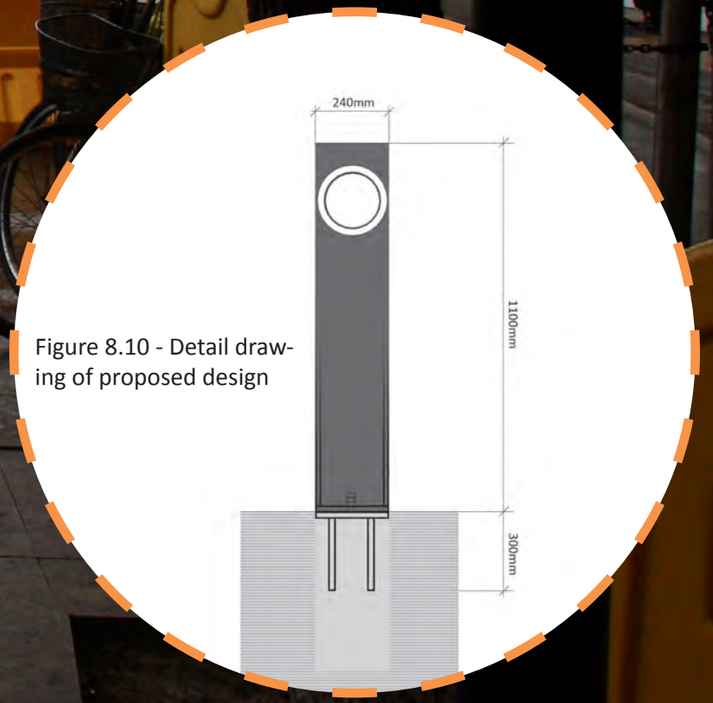


Figure 8.10 - Detail drawing of proposed design

Figure 8.8 - Proposed bollard design

DESIGN of Fence 1

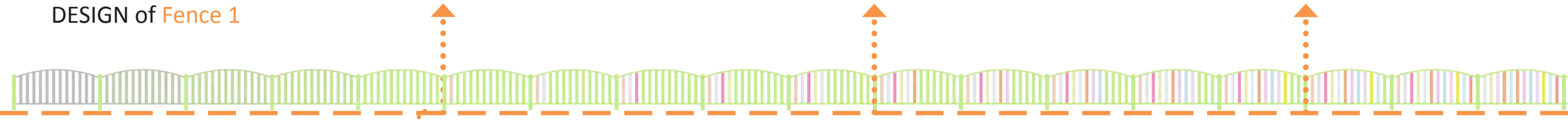
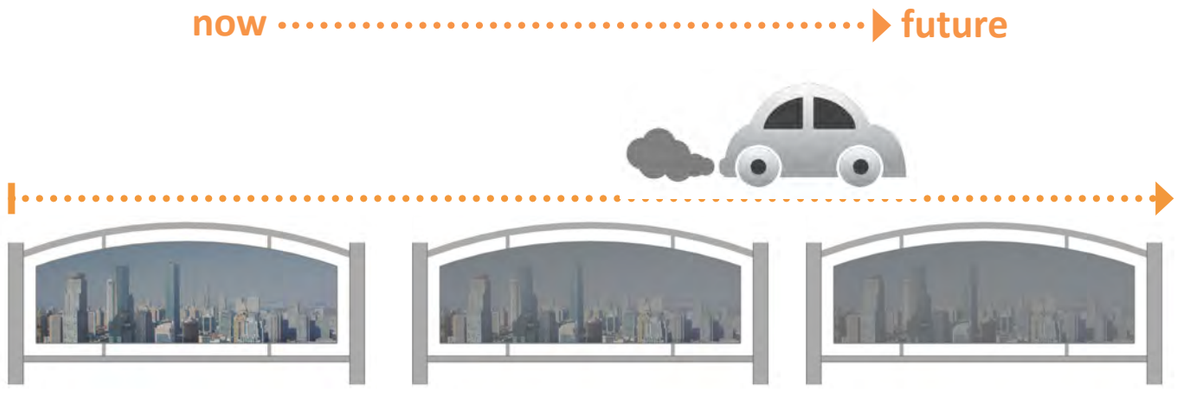


Figure 8.11 - Elevation of proposed fence design 1

Figure 8.12 - Proposed design of fence 1

Figure 8.13 - Proposed fence design at traffic light



DESIGN of Fence at Traffic Light Area

Another important element in the path system is traffic fence. In China, most lanes on the roads are separated by fence. I propose 3 fence designs. The first one has two sides in different colours. The bicycle side starts with grey, then it changes to green. At the end of road, it turns to be colourful. This process tells a story that when people cycle more, the world will change from a grey one to a colourful one. While on the vehicle side, the fence is consistent grey.

There are 3 images on fence at the end of road, where people may meet the traffic light. On the bicycle side, the first one shows the current smog situation in Nanjing. Then the smog turns better in the last two images. On the vehicle side, where starts with the same image, the smog becomes more and more terrible in the last images.People can easily see the difference from the image.

Figure 8.14 - Elevation of proposed fence design 2

DESIGN of Fence 2

For another fence design, I adopt the shape of horse--head wall, which is a popular building form in ancient China. This kind of wall can be seen in many places in the city. Some flying birds shape are hollow out of the fence, which give nice shadow on the road.

Figure 8.15 - Proposed fence design 2

DESIGN of Fence 3

Another fence design has the same shape as previous one, but with different colour and materials, which response a colourful facade of street.

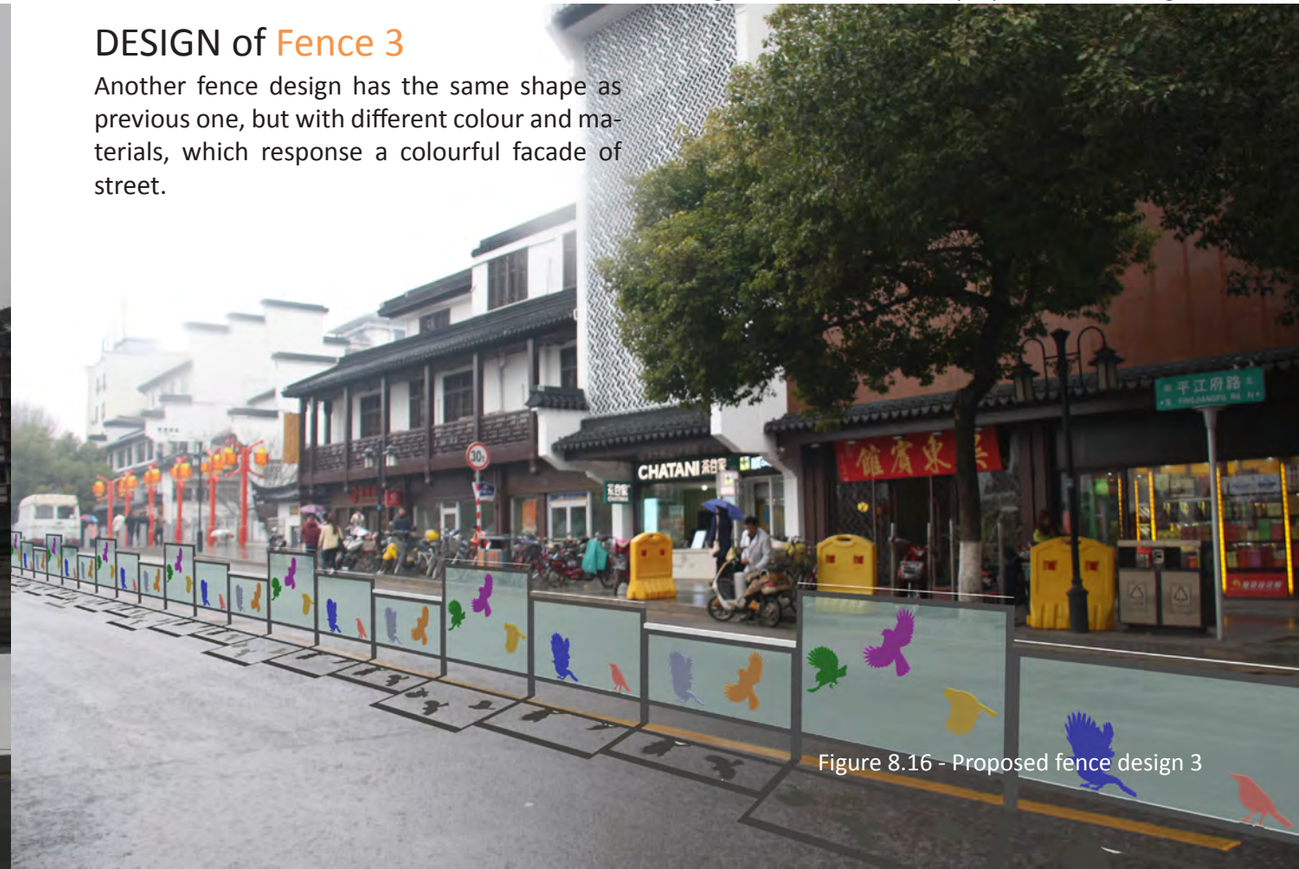


Figure 8.16 - Proposed fence design 3

DESIGN of Signs

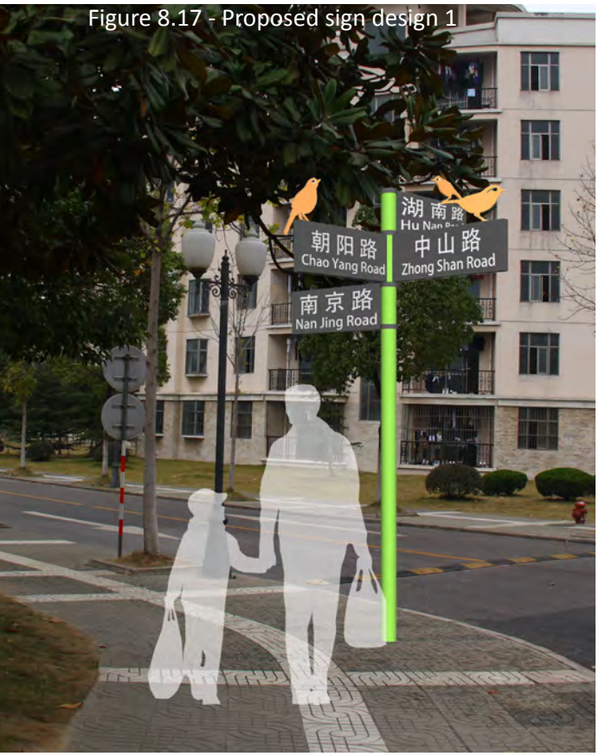


Figure 8.17 - Proposed sign design 1

Figure 8.18 - Proposed sign design 2

Figure 8.19 - Proposed sign design 3

in urban environment

These are the design of sings in urban environment. The signs with birds on them represent the roads with bicycle lane.

signs in park

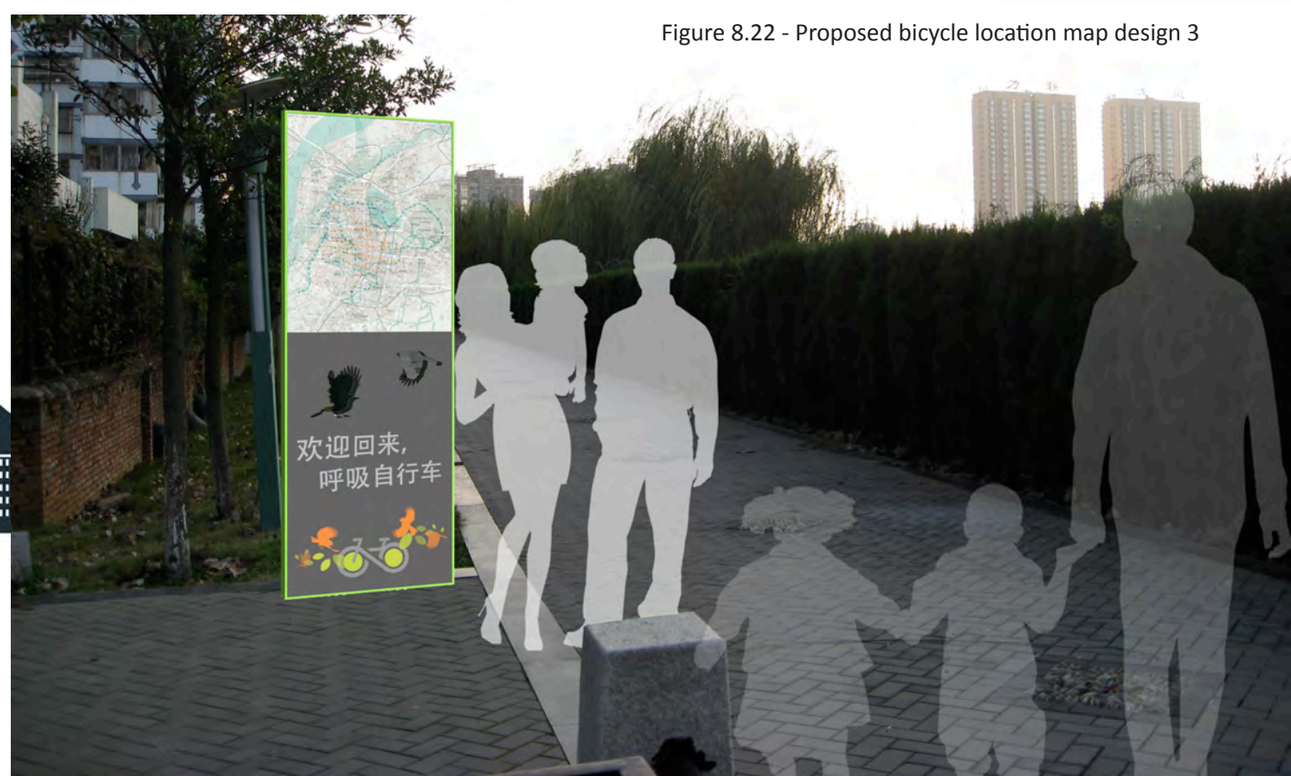
DESIGN of Bicycle Location Map

Figure 8.20 - Proposed bicycle location map design 1

Figure 8.21 - Proposed bicycle location map design 2

The bicycle location maps spread out in the city. People can easily find where they are and where is the nearest bicycle route. The maps will will let cyclists follow their way easily and go to their destination quickly.

Figure 8.22 - Proposed bicycle location map design 3



DESIGN of Bicycle Traffic Light

Another components I take into consider is the bicycle traffic light. When the traffic lights turn green, they make Hwamei chirp, which makes people notice the light and think about the cycle branding.

Based on the research, in bad weathers days, people feel less like to cycle. The proposed bicycle traffic light turns green sooner than vehicle ones during rainy, windy or snowy days, which makes people easier to cycle.

Bicycle traffic light makes Hwamei chirp when it turns green.

possible design forms of bicycle traffic light

Bicycle traffic light turns green sooner than vehicle in bad weather.

Figure 8.23 - Proposed bicycle traffic light design

Figure 8.24-1

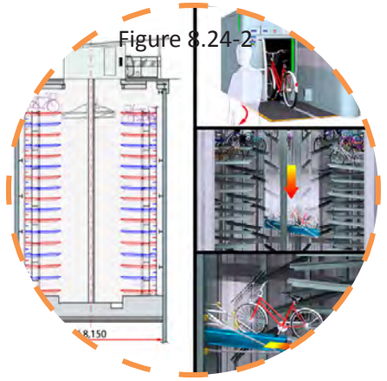


Figure 8.24-2

The views of various kinds of bike storage

Bike storage is an important element in biking system. Now there are many different kinds of bile storage, includes, underground parking, ground parking, vertical parking, storage room and so on.

Figure 8.24 - Series of images of bike storage

DESIGN of Bicycle Rack

I design some birds shape bicycle rack to match the branding and bike system.

Figure 8.25 - Proposed bike rack design 1

Figure 8.26 - Proposed bike rack design 2

Figure 8.27 - Proposed bike rack design 3

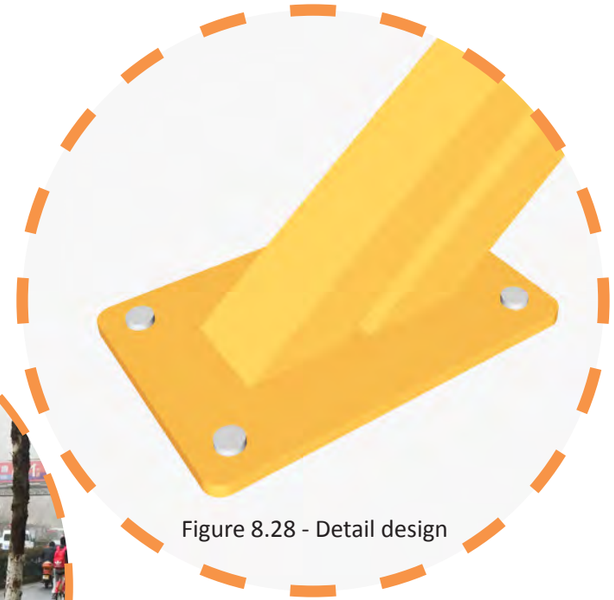


Figure 8.28 - Detail design

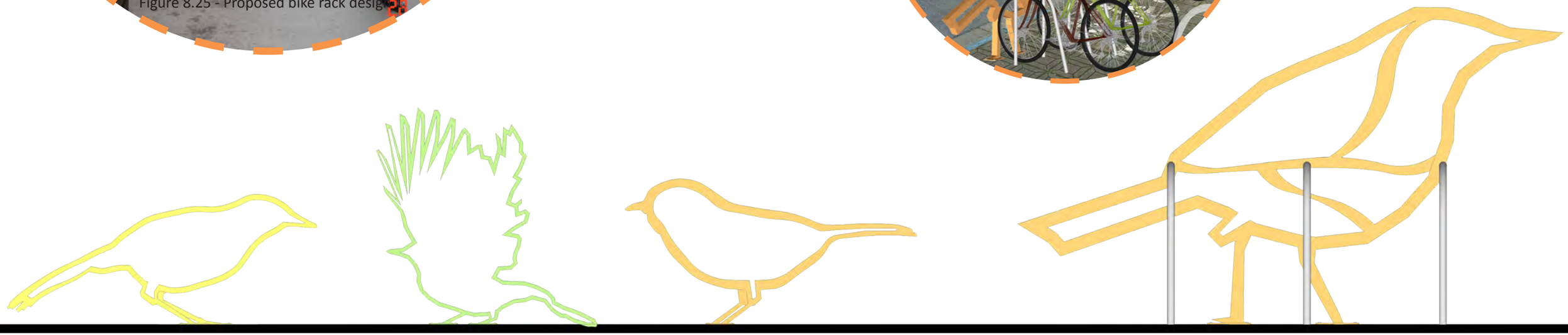


Figure 8.29 - Elevation of proposed rack

This is a junction in Nanjing. It is the current condition, which does not make people feel cycle friendly. This one shows the situation after design. Consistent bicycle infrastructure designs with branding can be seen everywhere, creating a functional and enjoyable cycling environment.

Existing Street — Chitoucheng Road

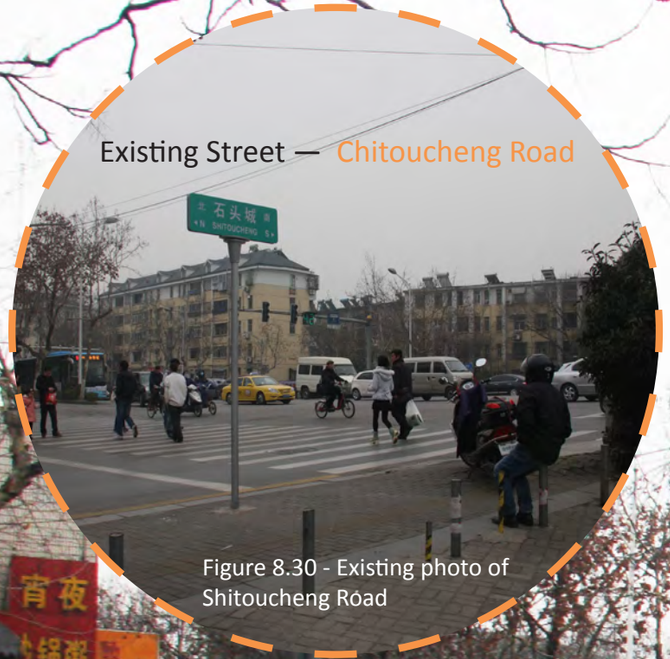


Figure 8.30 - Existing photo of Shitoucheng Road

Figure 8.31 - Proposed design of Shitoucheng Road

Proposed Design of Street

PROCESS of How to Rent A Bike

Figure 8.32 - Process of how to rental a bike.

Then I move to rental system design. First, citizens and tourists can go to any retails or offices in the city to apply for an bicycle identify card and pay 50 dollars deposit. Then they can check online to find the nearest bike rental spot. You can take a bike by easily using the card to tap the lock. Then you can run a bike in the city.

When you return it, make sure hear a click on the lock. Then you can check how long and how far you have rode and how many calories you burnt on the bicycle terminal or any electronic devices with your personal account. The fee for rent a bike is very inexpensive. In the first hour, it is free. Based on the research, more than 95% people rent a bike for free.

DESIGN of Bike

The rental bike has many standard features, such as adjustable seat, LED light, luggage rack, frame, puncture free tires. It also has electric generator and battery which help to generate electric power and store it for other use. With the smart bike, cyclist can have more enjoyable and interesting expe-rience while riding.

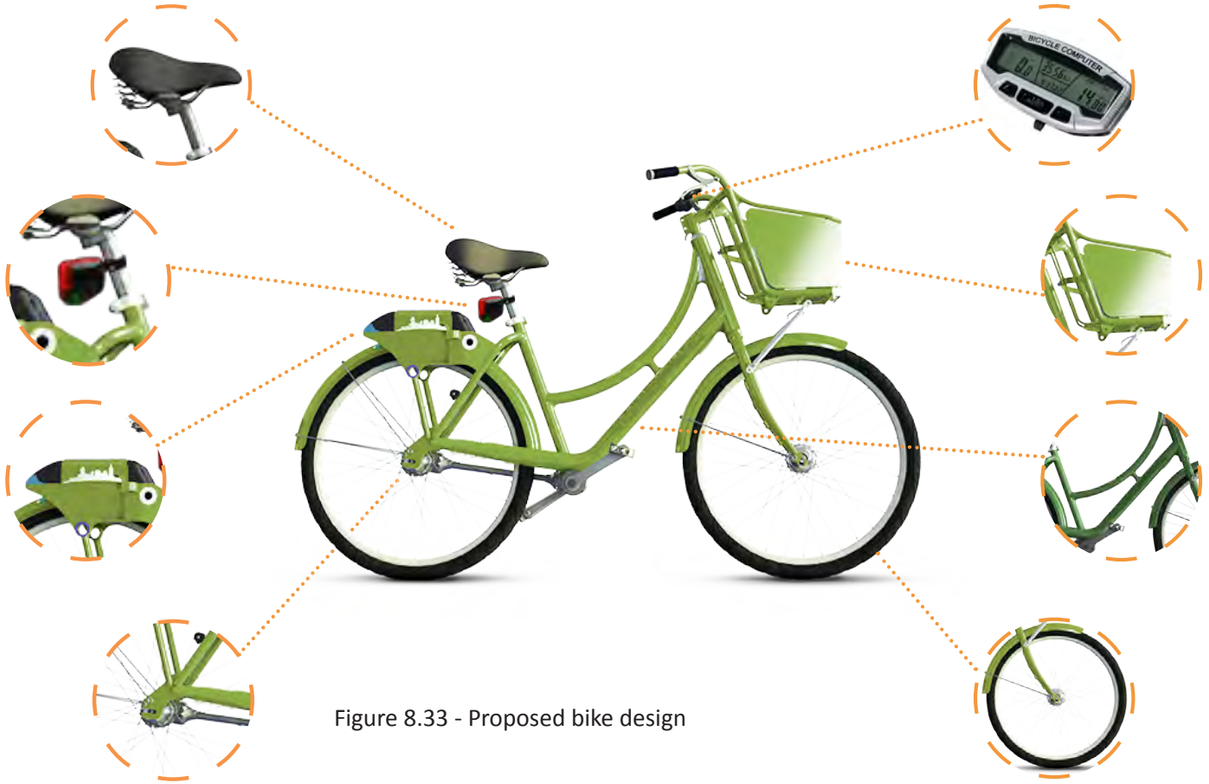


Figure 8.33 - Proposed bike design

Adjustable Seat
The seat is comfortable and adjustable with a handle that controls the gas lift.

LED Lights
The Built-in lights are placed under the seat, and automatically turn on when the bike is being used and project “no smog” sign on to the road.

Battery
The battery is a 37 V 10.000 mA lithium-ion battery. Battery will charge while riding the bike, it will not only provides assistance for riding, and also store electric power which can transfer to bike stations for other use.

Electric Generator
The electric generator is a 250 Watt motor, placed on the wheel. It provides assis-tance up to 22 km/hour, and automatically switches off when the brakes are in use, and also generator electricity while riding the bike.

Bicycle Computer
The computer is weather resistant, it shows and re-cords the speed and dis-tance of bike riding, and reports back to the system every minute of the day.

Luggage Rack
The front luggage rack can carry up to 15 kilos and se-cures the luggage with a spring.

Frame
The frame is built in alu-minum with internal cable routing for lower mainte-nance.

Puncture free tires
The Puncture-resistant tires are filled with a foam that makes the bike comfortable to ride, but without risking a puncture.

To attract different groups of people, other possible models of bikes are provided.

This is the LED light placed under the seat, and automatically turn on when the bike is being used and project “no smog” sign on to the road.

Figure 8.34 - Proposed bike lighting design 1

Figure 8.35 - Proposed bike lighting design 2

DESIGN of Electronic Shared Information

Many screens are designed to spread out in the city. The screen shows the data of total users, total distance people rode, and total emission of air pollutants cyclists help to reduced per day. This information is collected by the bicycle computer and calculated by computer system.

Besides the data, the screen also shows two compared images of the city's smog condition before and after people start to cycle a lot. Other similar information and environmental protection advertisement are shown on the screen. In this way, to strengthen the relations between cycling and environmental protection in people's mind.

Figure 8.36 - Proposed design of electronic shared information

MAP of Bicycle Rental Spots Density

0 5 10 KM

Figure 8.37 - Map of bicycle rental spot density

2KM

Based on the research, the distance between each bicycle rental spot should be 500M~800M.

There should be approximate 8 bicycle docking spots in a circle of 2KM in diameter in urban area.

2KM

In parks, there do not have lots of cyclists. So, there only have retal spots at each major entrance of parks and tourist attractions.

MAP of Important Bike Station Locations

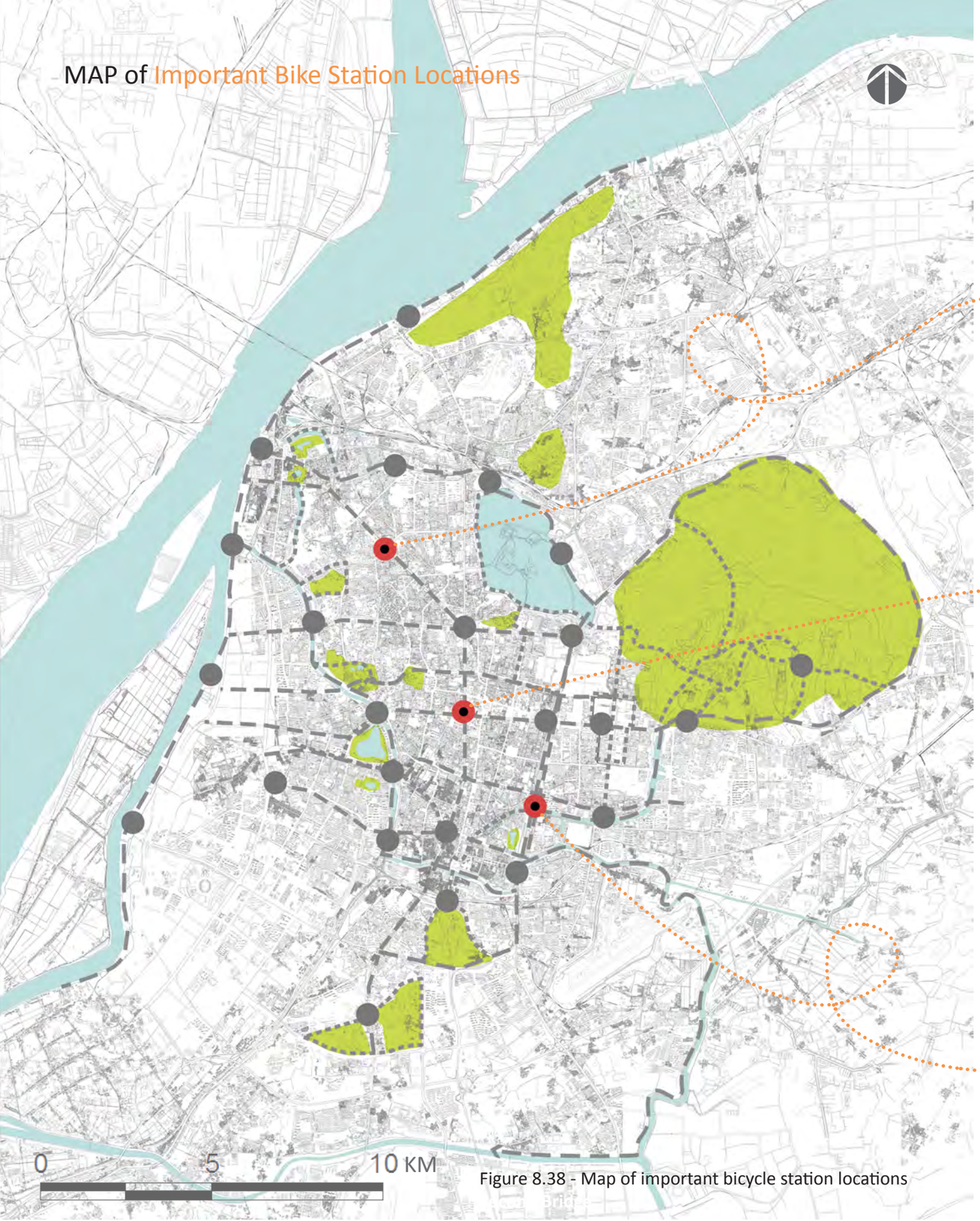


Figure 8.38 - Map of important bicycle station locations

Figure 8.39

Shanxi Road — The center of commercial areas.

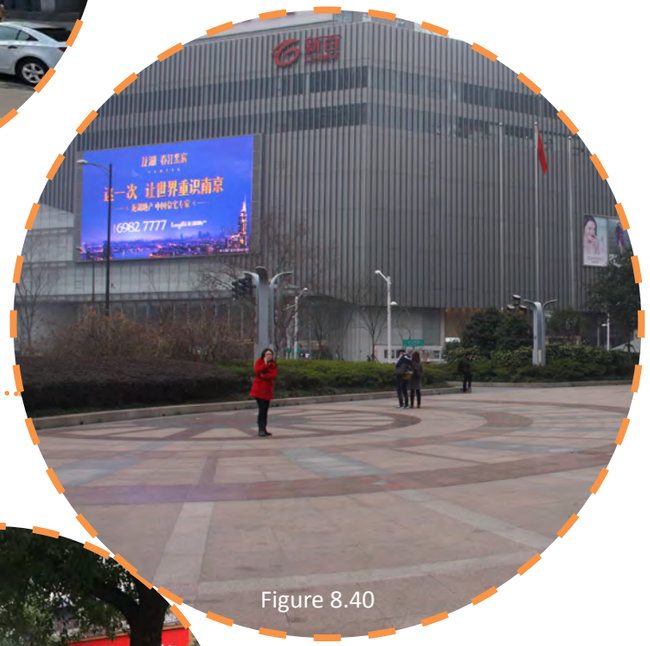
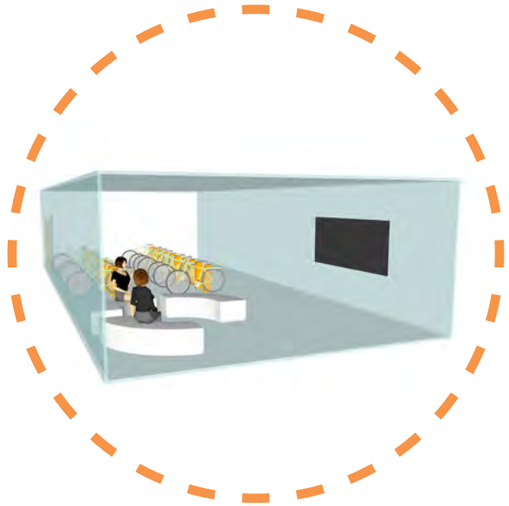


Figure 8.40

Xinjiekou — The center of shopping malls.

Figure 8.41

Jiankang Road — The center of historical tourist attraction.



This graphic gives people a overall view of how bike stations distribute in the city. And the possible bike station types.

Figure 8.42 - Diagrams of bike rental stations

DESIGN of Bike Station 1 — Jiankang Road

The view during the day

Morning View

This bike station use LC glass (Polyvision privacy glass), which is an electrically activated, switchable glazing technology glass. At the beginning of the day, the station is grey and opaque. People cannot see the street view behind the glass wall. It looks like smog pervading in the city.

When more and more people rent bikes and return bikes during the day, electricity is collected from bike battery, which instantly changes the glass from frosted grey to transparent. People can clearly see the street behind. This indicates when people bike more, the smog will be less and the city will be more clear.

Figure 8.43 - Proposed design of bike rental station

nine

Site Analysis + Design

MAP of Plaza Location

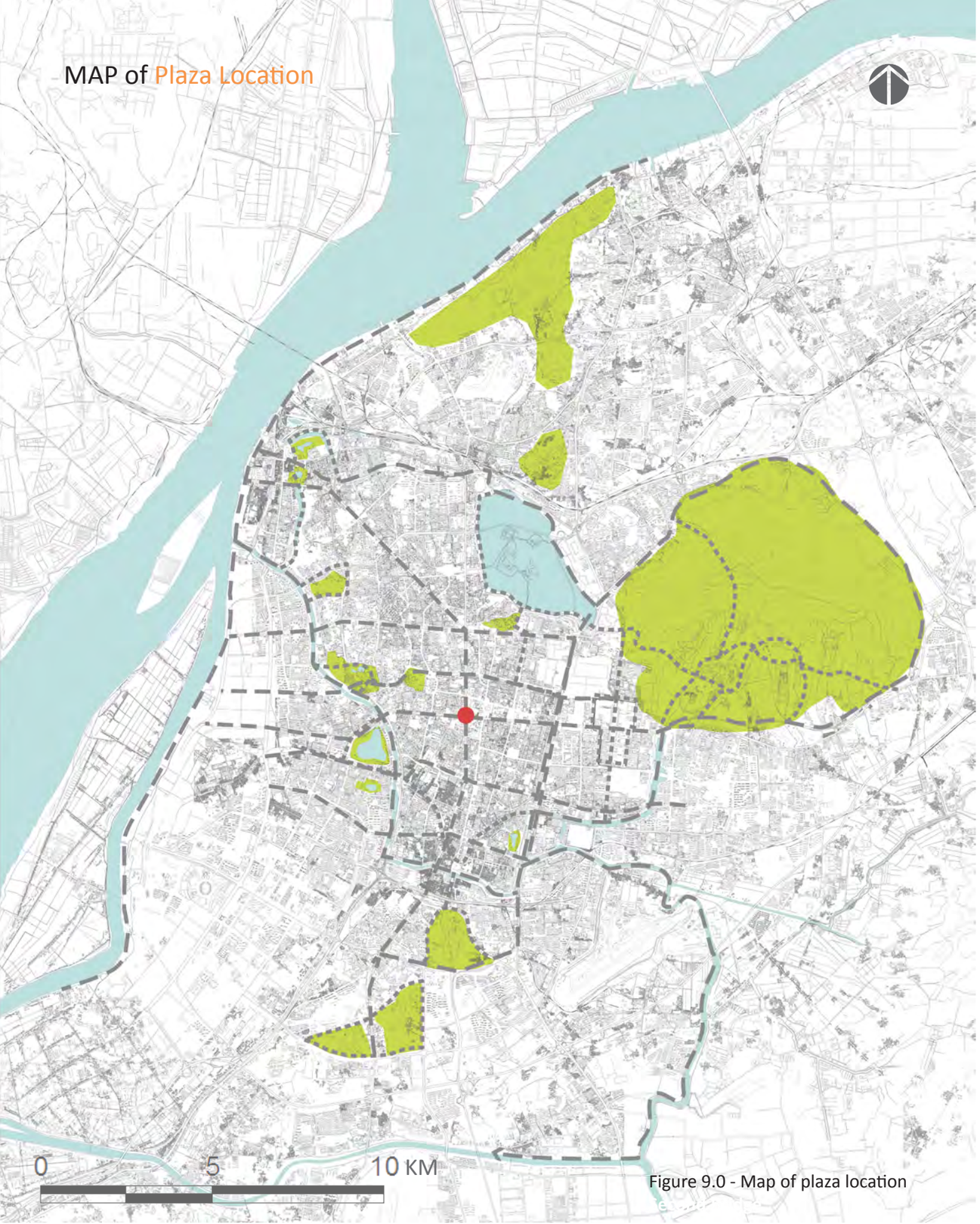


Figure 9.0 - Map of plaza location

Figure 9.1 - Photos of plaza surrounding environment

At the last chapter, I choose one of the most important intersections in Nanjing and propose an option for bike station design. The site locates in the commercial centre, which is at the corner of Hanzhong Road and Zhongshan Road. The plaza is at the front of East Shopping Mall, surrounded by Jinling Hotel, Xinbai Shopping Mall and Deji Shopping Mall. It is one of the busiest places in Nanjing.

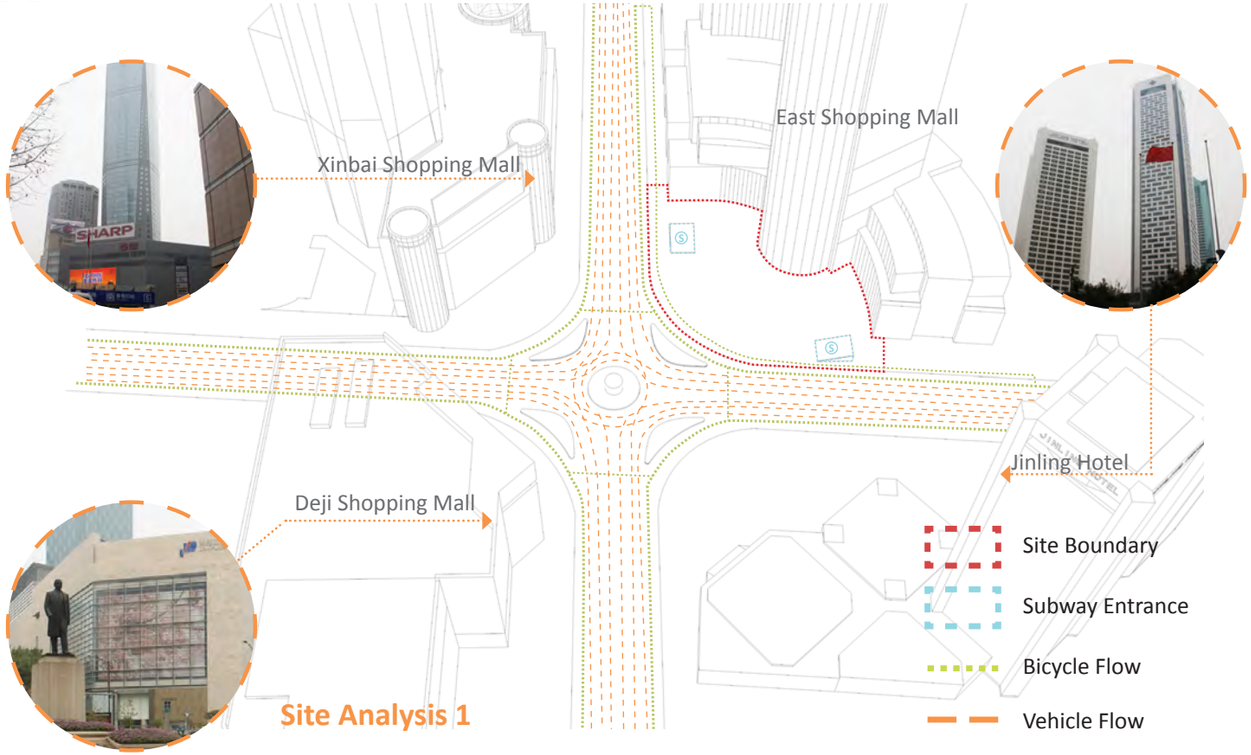


Figure 9.2 - Site analysis 1

Site Analysis 1
The dash orange lines represents heavy vehicle flow. The green lines are bicycle flow. There are two entrances of subway on the site.

Site Analysis 2
There has heavy pedestrian flow on the site. Some from shopping mall, some from subway entrances, some from 2 surrounding roads connecting to other buildings. Now this area is barely designed and spaces are not used efficiently. It can be seen from the diagram, few people walk through here.

Site Analysis 3
Now there have no entrances for cyclists till the end of the road, that is inconvenient for cyclists. Some bikers ride through this way. A few people ride through here. Here is an existing bike parking area, which makes the road more crowded.

Site Analysis

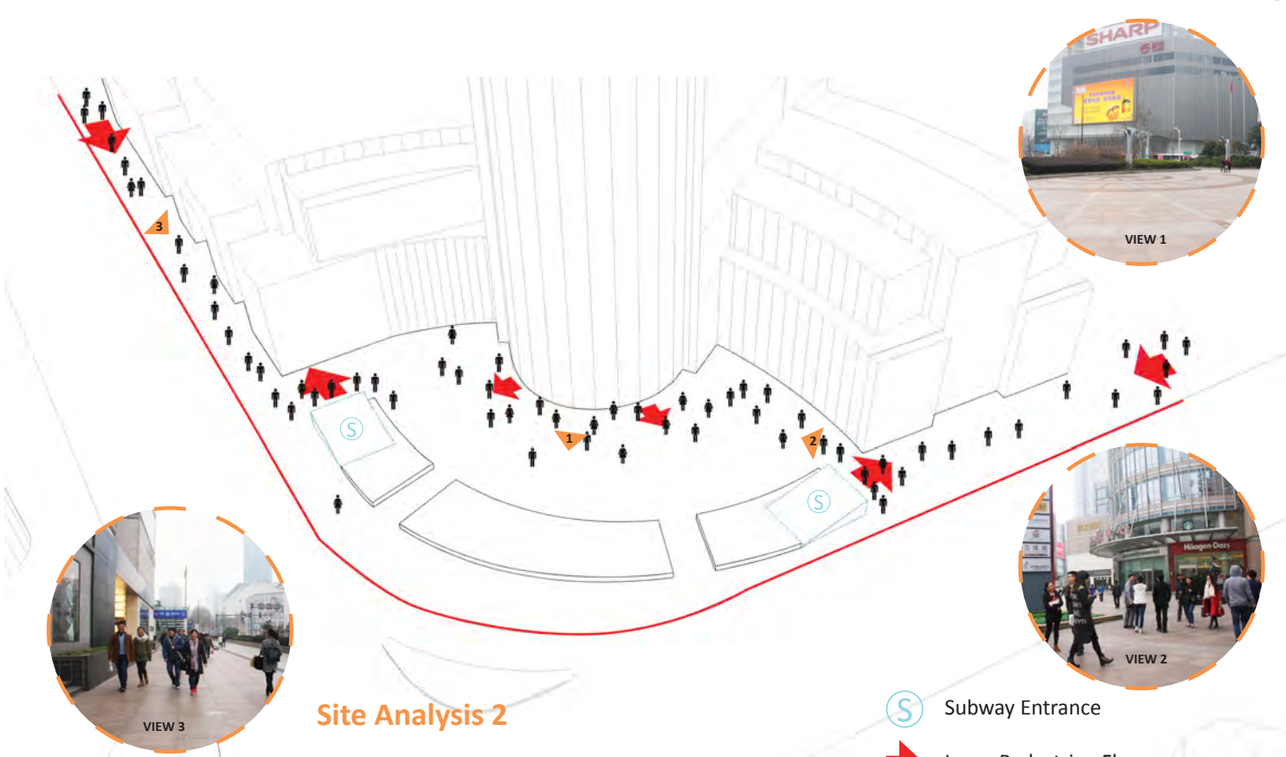


Figure 9.3 - Site analysis 2

Figure 9.4 - Site analysis 3

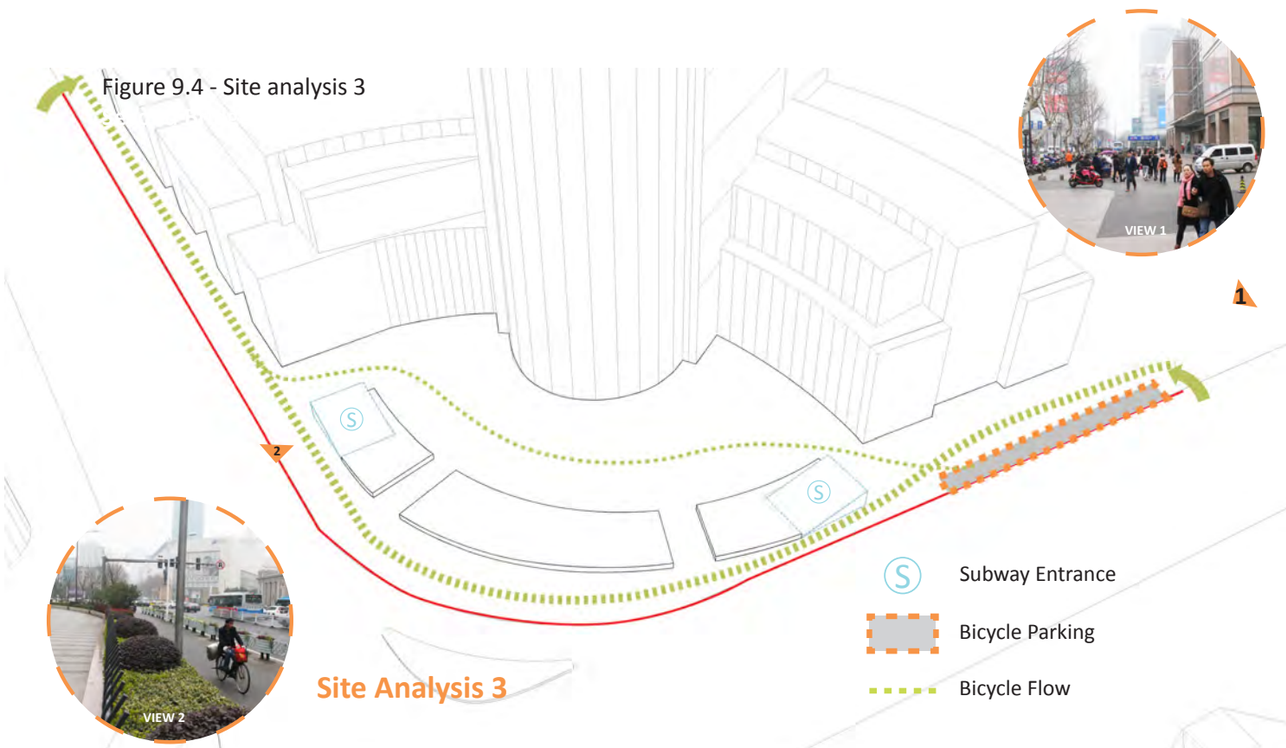


Figure 9.5 - Diagram of thinking process

LEAF PAVILION ROOF

Using ETFE material. Colour is changed with electricity.

BIKE RENTAL

Include: bikes, locks, terminal, screen, benches...

GREEN BELT

Some green belts are designed around leaf structure to create nice micro-climate for people stay in the area.

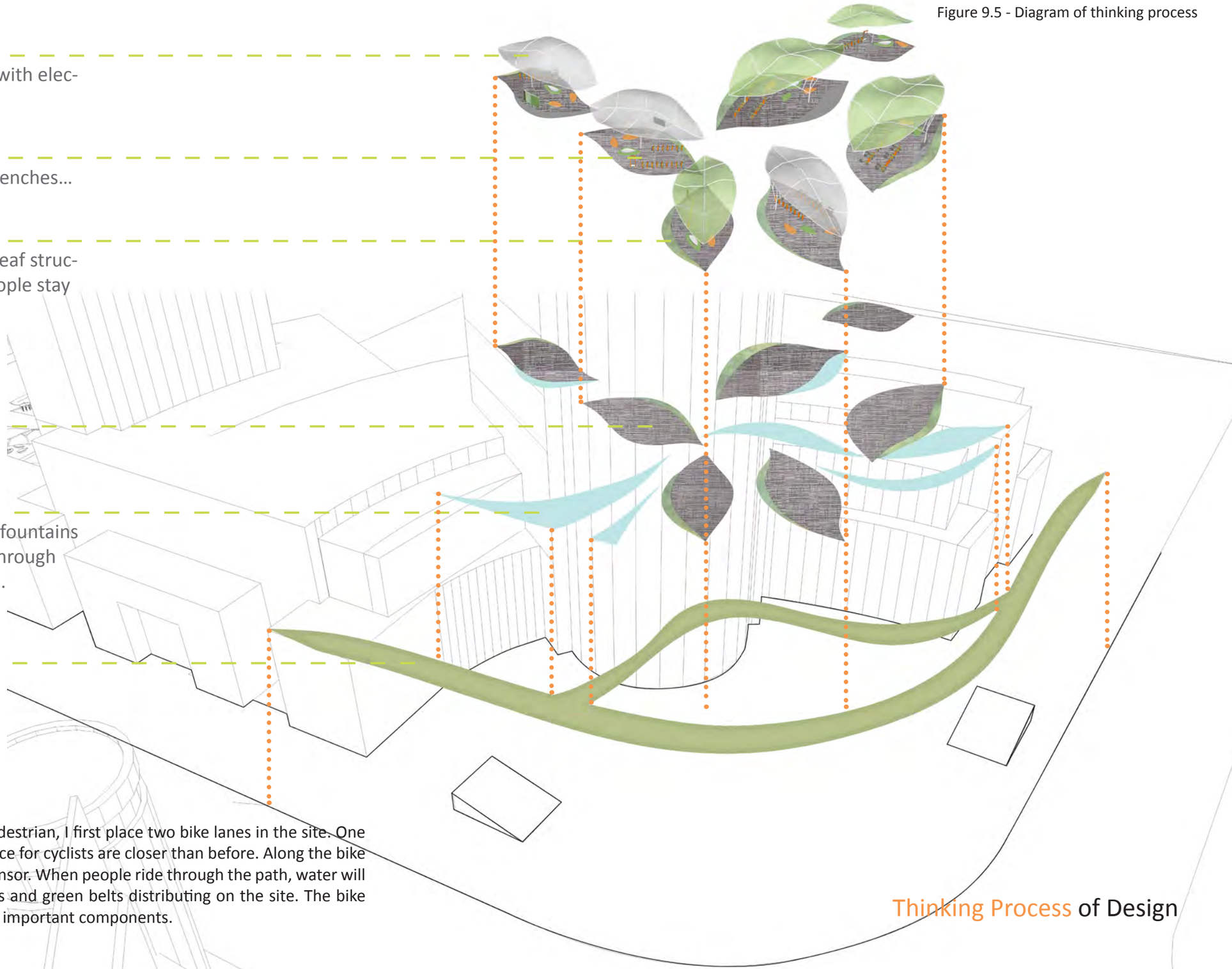
LEAF-SHAPE PAVER

GOUND FOUNTAIN

Along the bike lanes, a series of ground fountains are set with sensor. When people ride through the path, water will come out of ground.

BIKE LANE

Two bike lane are created in the site. One is a rapid lane, another is leisure lane.



To make it a better place for both cyclists and pedestrian, I first place two bike lanes in the site. One is a rapid lane, another is leisure lane. The entrance for cyclists are closer than before. Along the bike lanes, a series of ground fountains are set with sensor. When people ride through the path, water will come out of ground. There are leaf-shape pavers and green belts distributing on the site. The bike rental station under leaf-shape roof are the most important components.

Proposed Design Components

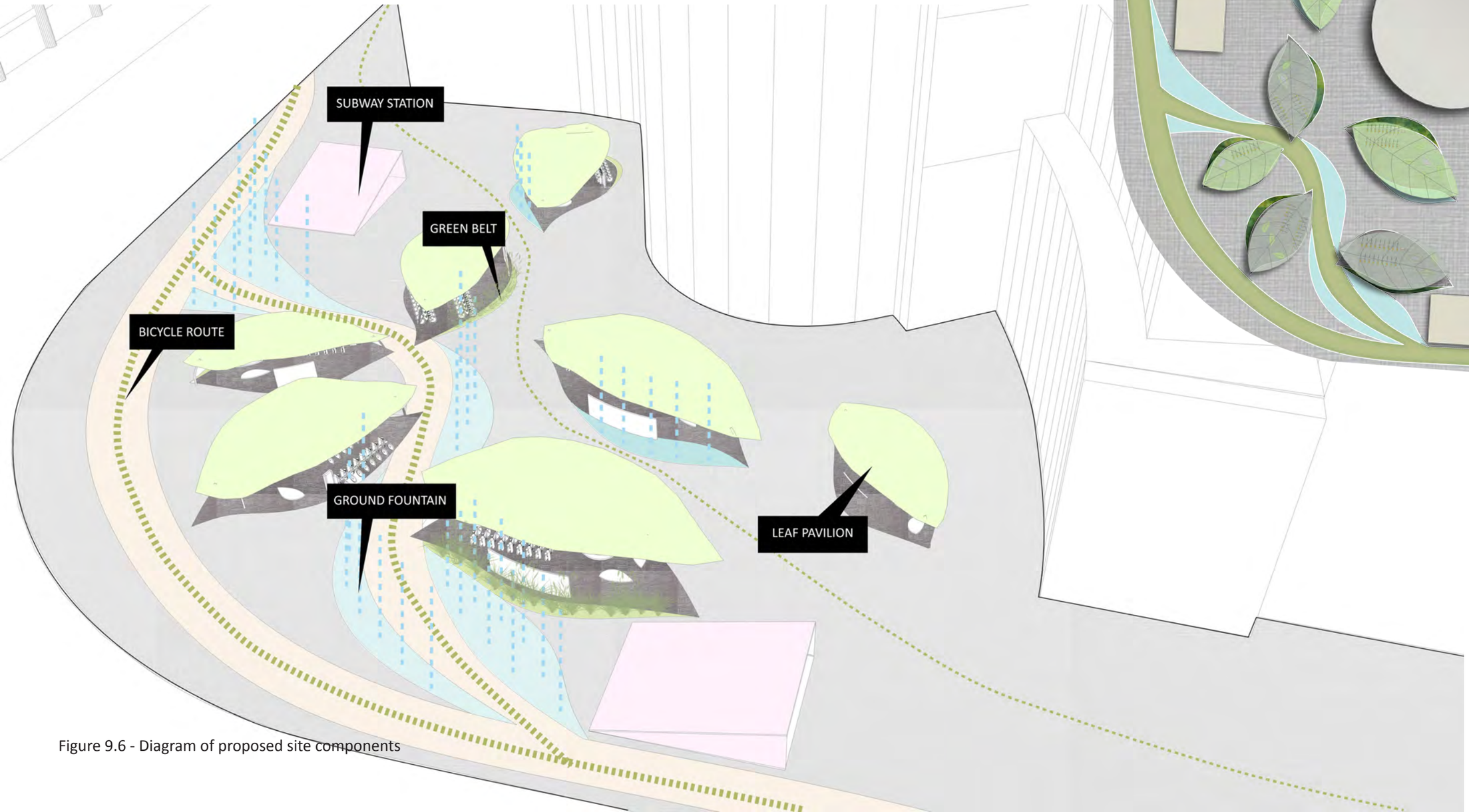


Figure 9.6 - Diagram of proposed site components

Figure 9.7 - Diagram of site plan

Proposed Plan

Leaf Structure Components

In each bike station, there are benches for cyclists and pedestrian to have rest; screen showing cycling information and environmental protection advertisement; terminal, locks and bikes.

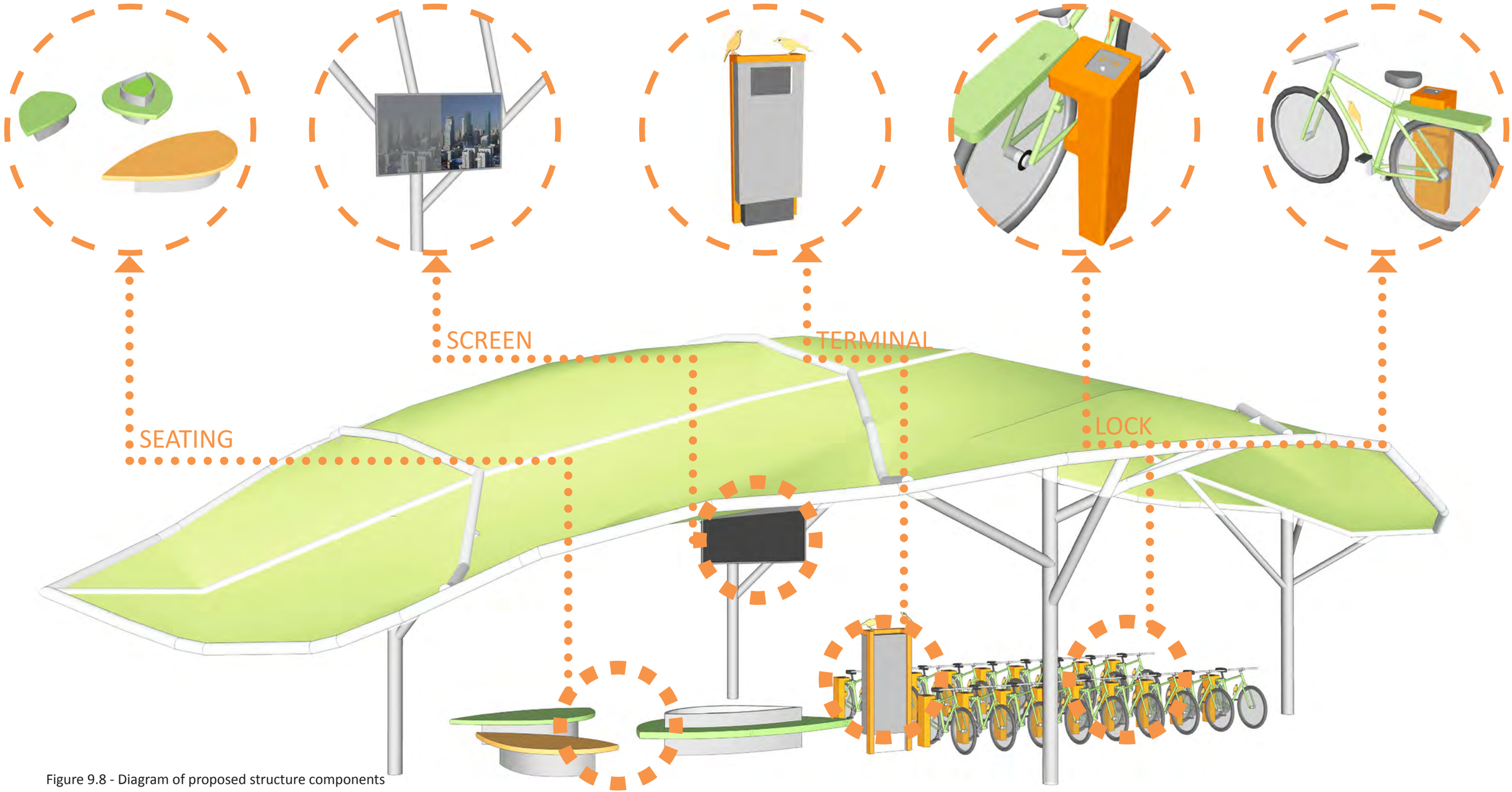
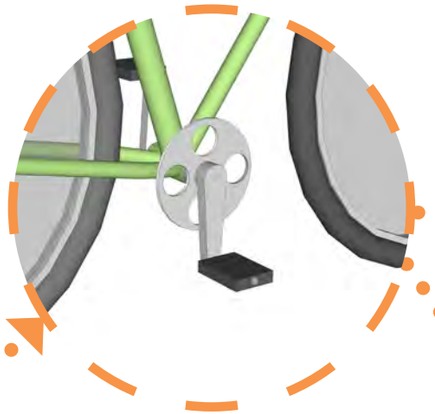


Figure 9.8 - Diagram of proposed structure components

Proposed Design to Improve People's Ecological Awareness

I not only would like to propose an enjoyable space for cyclists and pedestrian, but also to create a place, in where people can experience the different when more and more people rent bikes during a day. Thus, they can notice the relation between cycling and environmental protection. My strategy is to collect electricity to change the space.

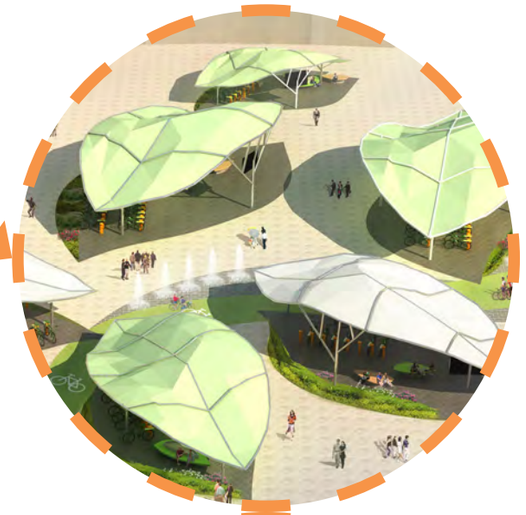


When people ride a bike, they generate electricity by riding. The electricity is collected by the battery on bike.

Bike is returned.

When bike is locked, electricity transfers from battery to the locker.

The electricity generated by each cyclist, will help to change the colour of shelter from grey to green. It can also used for lighting. People in the plaza can see the difference when more and more people cycle.



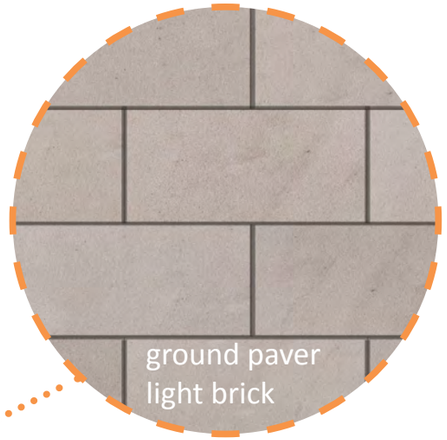
The data will show on the screen distributing in the city. People will see the data and understand cycle is truly help to reduce air pollution, as well as a healthy life style.

The counter on each bike record and calculate data when people bike.

When bike is locked, riding data transfers from counter to bike station terminal.

Figure 9.9 - Diagram of how to improve people's ecological awareness

For the choices of materials, first, I use four different materials for the ground, which are light paver for main ground paver; dark brick for leaf-shape paver; another dark brick for ground fountain paver; and green asphalt for bicycle lane. The material of leaf pavilion roof is ETFT. This kind of film is firm, tenacious and transparent. People can see the colour of roof turn gray to green, when the LED lights under the film change their colour. Other materials, such as, ground fountain, various vegetation, and wood bench are chosen to create a good environment and micro-climate.



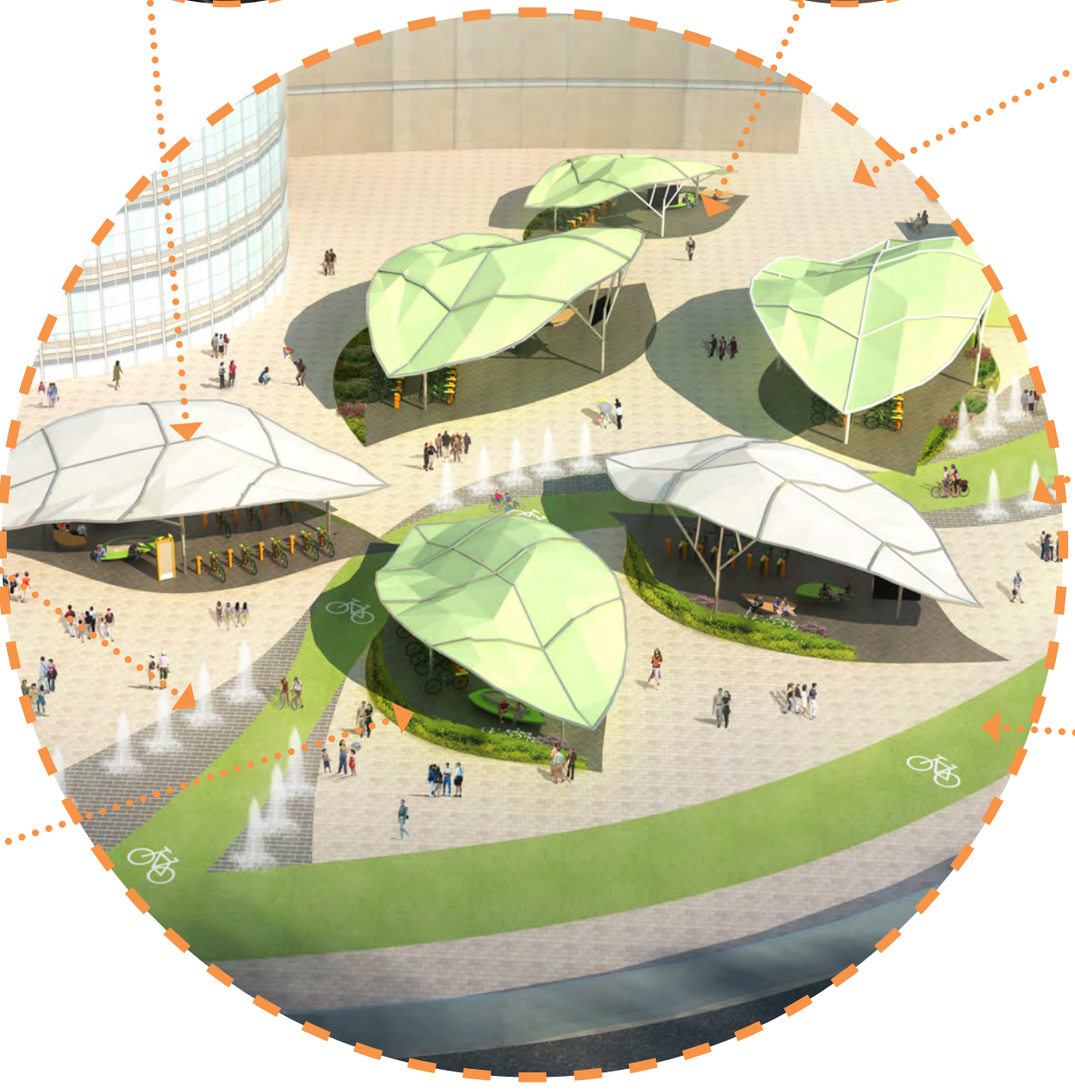


Figure 9.10 - Choices of materials

Choices of MATERIALS

ROSE
(rose chinensis)

SNOWROSE
(serissa)

HOLLY
(Ilex)*

HYDRANGEA
(hydrangea macrophylla)

GARDENIA
(gardenia jasminoides)*

MALUS
(malus spatabilis)

BANANA SHRUB
(michelia figo)*

RED BARKED
(swide alba)

RHODODENDRON
(rhododendron aboreum)*

CAMELLIA
(camellia sasanqua)

BROADLEAF LADY PALM
(rhapis excelsa)
*

GARDEN CROTON
(codiaeum variegatum)
*

PAPERPLANT
(fatsia japonic)
*

CHINESE MAHOINA
(mahonia fortunei)

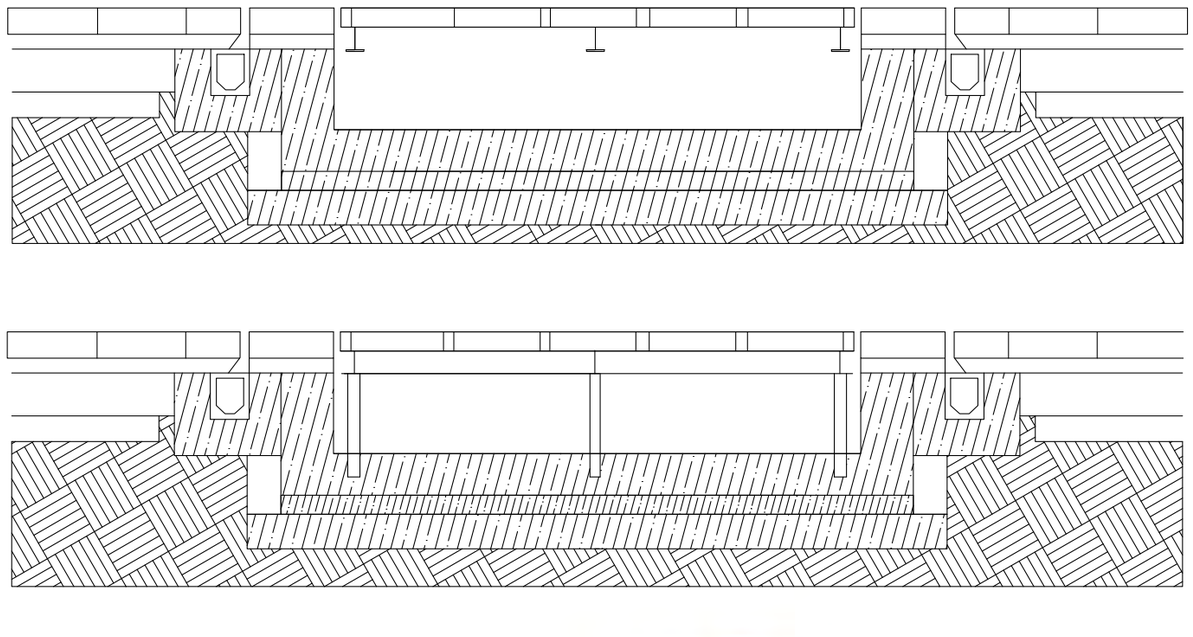
CHULAN - TREE
(aglaia odorata)
*

I choose some vegetation for the proposal design, according to the climate in Nanjing. Besides, I take smog into take into consideration. So, I choose some broad leaved plants, which can absorb air pollution.

Figure 9.11 - Series of images highlighting the plant species

Choices of Vegetation

Proposed Detail Drawing



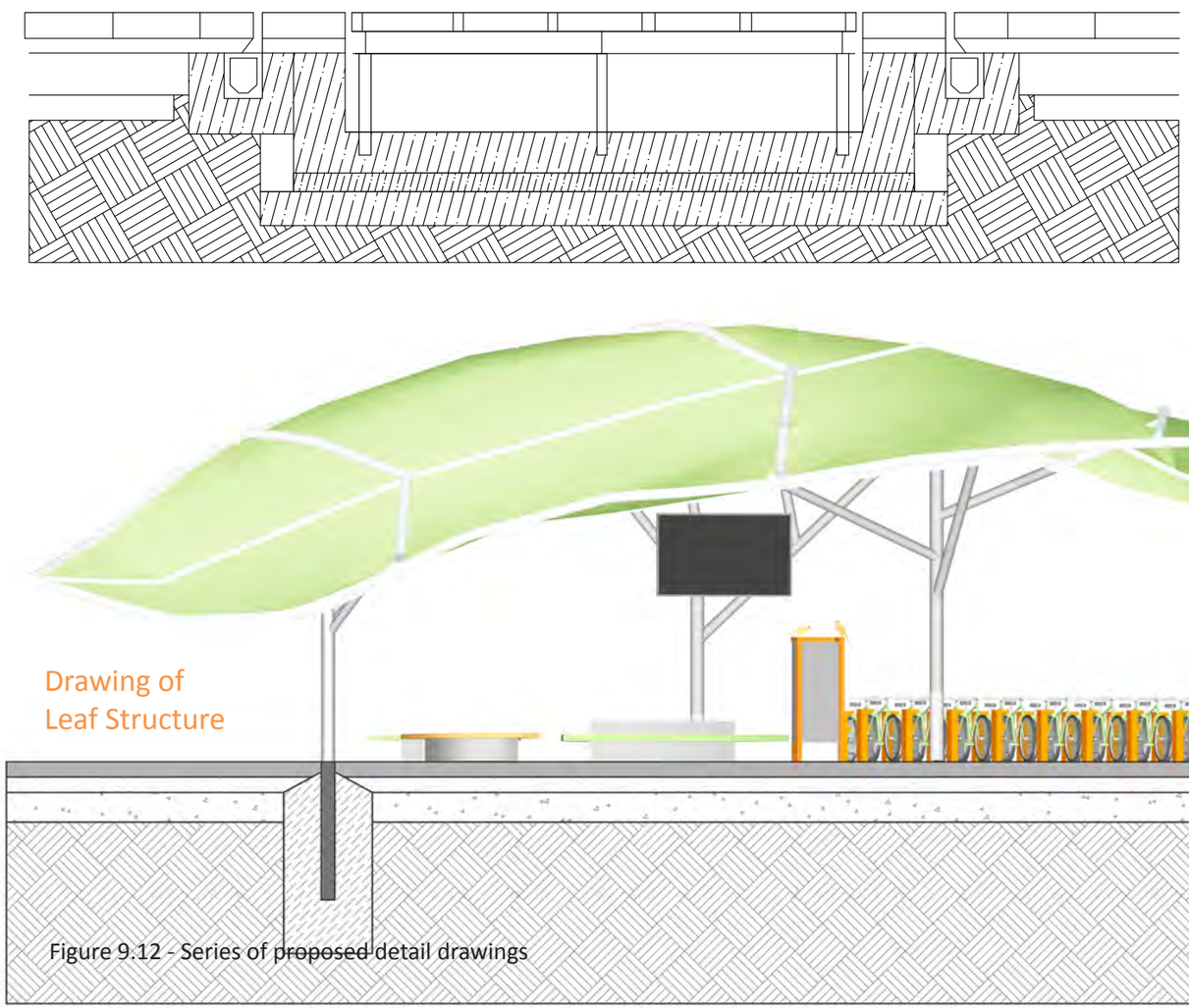
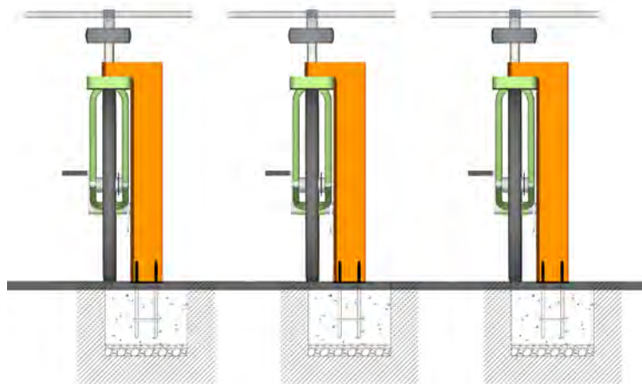
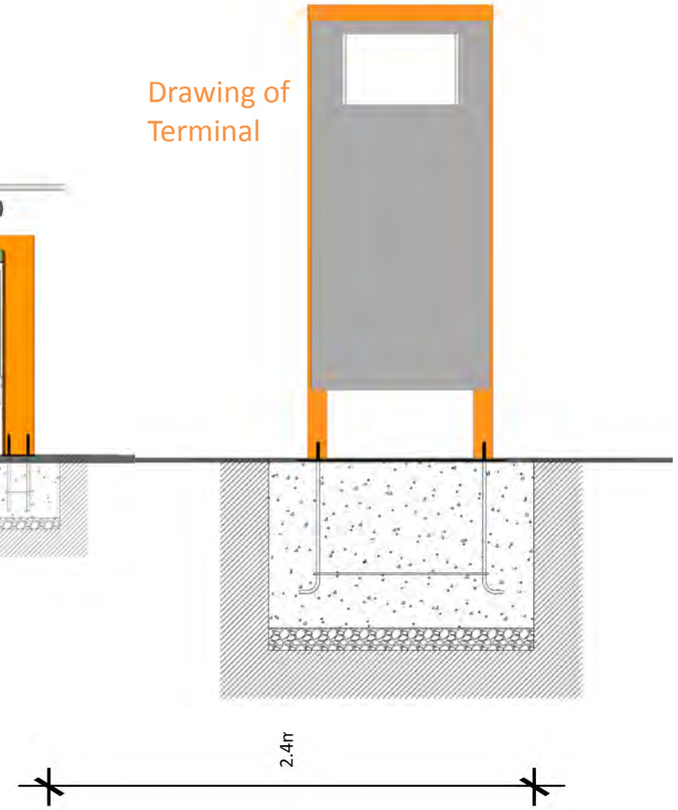


Figure 9.12 - Series of proposed detail drawings

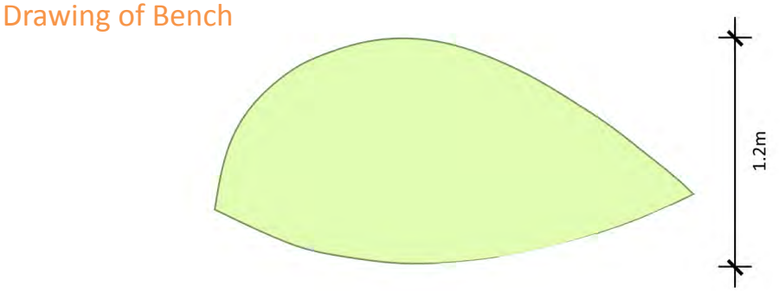
Drawing of Lock



Drawing of Terminal



Drawing of Bench



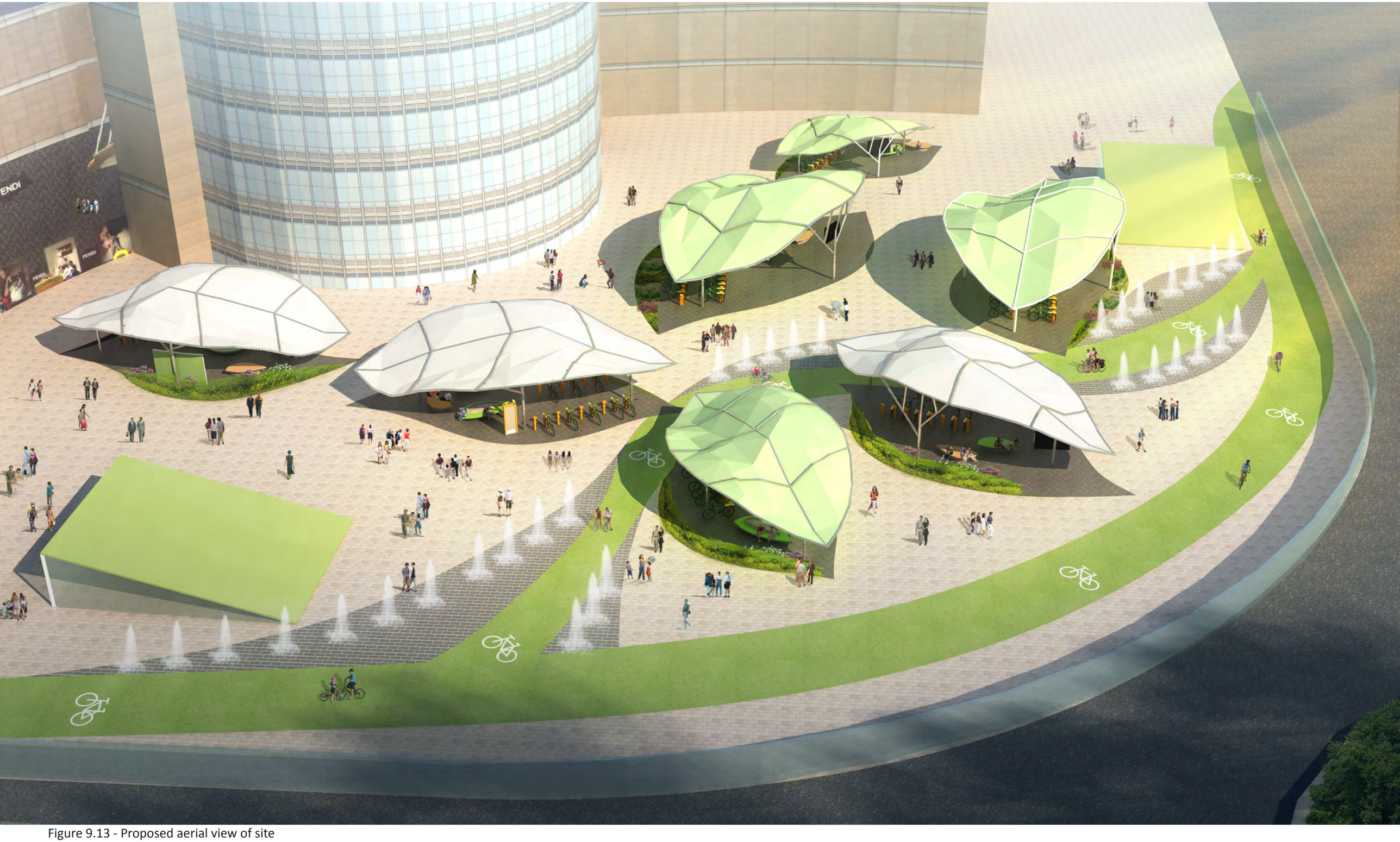


Figure 9.13 - Proposed aerial view of site

Figure 9.14 - View of site during day

Figure 9.15 - View of site during night

ten. CONCLUSION

I have gained extensive knowledge of urban bicycle systems from my practicum. Based on my personal interests and concerns, I used my practicum to analyze how landscape architecture can be employed to improve the environment. I particularly focused this environmental problem on the terrible smog caused by air pollution in China. Extensive research led me to determine the main cause of smog in China, an efficient way to improve the problem, and how to implement the solution through landscape architecture. Meanwhile, I would like to make use of the proposal design to improve Chinese people's awareness of environmental protection.

To achieve the above goal, I decided to design a bicycle infrastructure for Nanjing, China. To have a safe, functional, convenient, efficient, interesting and enjoyable bicycle infrastructure, I propose to design the following components: bicycle routes network, cycling corridors, parking spots, rental stations, bollards, fences, signs, bicycle location maps, traffic lights, racks, and bicycle design. Moreover, to better promote the bicycle network, a branding is created and two optional logos are designed. I propose to combine the branding into all designs. Therefore, people can realize they are protecting the environment when they are riding.

In China the government has realized the importance of urban bicycle infrastructure and many cities begin to construct a bicycle rental infrastructure. In my practicum, I believe a safe, functional, convenient, efficient, interesting and enjoyable bicycle infrastructure is proposed. I hope this proposal could be helpful to the bicycle infrastructure construction in China. As I mentioned, I also would like to improve Chinese people's environmental awareness through the proposal. It is difficult to assess how well the design works to reach this goal. I appeal to landscape architects, especially those who are in China, to take this factor into consideration when they are designing.

Figure 9.16 - My father is riding his favorite bike.

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IMAGE

*ALL PHOTOGRAPHS AND DIAGRAMS ARE CREATED BY THE AUTHOR UNLESS OTHERWISE NOTED.

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