

SUSTAINABLE URBAN PLANNING AND DESIGN:
SUSTAINABLE SOLUTIONS FOR RETROFITTING A NEIGHBORHOOD
IN BEIJING, CHINA

A CREATIVE PROJECT
SUBMITTED TO THE GRADUATE SCHOOL
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE
MASTER OF URBAN AND REGIONAL PLANNING

BY
WENTING DU
ADVISOR: MICHAEL BURAYIDI

BALL STATE UNIVERSITY
MUNCIE, INDIANA

JULY 2013

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude and appreciation to Professor Bruce Race. He inspired and enlightened me to understand urban planning and design from a different perspective.

My deepest gratitude and gratitude also goes to Professor Michael Burayidi, who helped me to structure the whole project, and gave me advice on it, and Professor Geralyn Strecker, who helped me with the writing process and improved my writing during this project.

The faculty of the College of Architecture and Planning, showed me a new world, and I benefited so much from that. My fellow classmates, your friendship, enriched my life.

Last but not least, for my family, without your everlasting support and love, I would not have experienced my academic journey at Ball State University.

ABSTRACT

CREATIVE PROJECT: Sustainable Urban Planning and Design: Sustainable Solutions for Retrofitting a Neighborhood in Beijing, China

STUDENT: Wenting Du

DEGREE: Master of Urban and Regional Planning

COLLEGE: Architecture and Planning

DATE: July, 2013

PAGES: 81

Rapid urbanization and population growth in China have remarkably improved people's quality of life. However, these changes have also brought significant negative impacts, which limit further development in China. As the capital of China and one of the world's densest cities, Beijing is facing serious urban environmental issues, especially air pollution.

Working within this dynamic period of urban transformation, this creative project defines current urban air pollution issues, explores driving factors, and proposes solutions through sustainable planning and design concepts. This creative project also meets the challenge of accommodating rapid population growth and development while maintaining balance between the human and natural environments. The key feature of this creative project is to improve the integration of land use, transportation, and renewable resources to achieve a healthy, livable, and

sustainable neighborhood. The site is a typical dense urban residential neighborhood and located beyond the North 4th Ring Road of Beijing. The proposed planning and design also sets an example for other neighborhoods and reflects how to transform all of Beijing into a sustainable and more livable city.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS	1
ABSTRACT.....	2
TABLE OF CONTENTS	4
LIST OF FIGURES	7
LIST OF TABLES.....	10
1.0 Introduction.....	11
1.1 General Introduction	11
1.2 Background	12
1.3 Project Statement	16
1.4 Research Aims	17
1.5 Research Questions	17
2.0 Literature Review	19
2.1 Introduction.....	19
2.2 Air Quality	19
2.3 Energy	21
2.4 Transportation	23

2.5 Land Use	30
3.0 Study Area and Characteristics	32
3.1 Introduction.....	32
3.2 Study Area Description and Analysis	32
3.2.1 Location and Context.....	32
3.2.2 The Study area in Context.....	34
3.2.3 Shijicun Residential Neighborhood Inventories and Population	36
3.2.4 Air Pollution Illustration	37
3.2.5 Existing Land Use and Density.....	38
3.2.6 Gated Communities	41
3.2.7 Street Network	42
3.2.8 Public Transportation	44
3.3 Findings from Study Area Analysis	45
4.0 Site Design.....	46
4.1 Introduction.....	46
4.2 Creative Project Goals and Objectives	46
4.3 Population and Housing Projection	48

4.3.1 Population Projection.....	48
4.3.2 Housing Projection.....	50
4.4 Urban Design Proposal	52
4.4.1 Development Program of the Study Area	53
4.4.2 Proposed Land use	54
4.4.3 Proposed Open Space System.....	57
4.4.4 Proposed Transportation	58
4.4.5 Proposed Shijicun Neighborhood 2025 Plan	62
4.5 Implementation	73
4.6 Conclusion	74
5.0 Conclusion	75
5.1 Summary	75
5.2 Further Research Needed.....	75
BIBLIOGRAPHY	77

LIST OF FIGURES

Figure 1: Maps of China and Beijing.....	12
Figure 2: Urban Expansion in Beijing from 1972 to 2010	13
Figure 3: Population Growth in Beijing from 2000 to 2010.....	15
Figure 4: Six Cities' PM2.5 Levels in January 2013	20
Figure 5: Total Energy Consumption in China by Type in 2009	22
Figure 6: The Fast Growth of Vehicles and Private Automobiles in Beijing.....	24
Figure 7: Cars per Thousand People in 2010.....	24
Figure 8: Bicycle Kingdom - Changan Avenue, Beijing, 1986	26
Figure 9: Bike Lane Now A Parking Lane, Forcing Cyclists Into Street.....	26
Figure 10: Public Transportation Statistics in Beijing in 2010	28
Figure 11: Beijing Subway Map	29
Figure 12: Project Site Location	32
Figure 13: Context Map of Study Area and Shijicun Neighborhood.....	33
Figure 14: 3D Model of Existing Study Area and Shijicun Neighborhood.....	34
Figure 15: 3D Modeling of Existing Shijicun Neighborhood	36
Figure 16: Air Pollution Simulation: A Clear Day Compares to A Smoggy Day	37
Figure 17: Existing Land Use and Open Space	38
Figure 18: 3D Model of Existing Building Use and Density.....	40

Figure 19: Existing Gated Community	41
Figure 20: Existing Street Network	42
Figure 21: Existing Public Transportation	44
Figure 22: Urban Floor Area per capita in Beijing	50
Figure 23: Proposed Land Use.....	52
Figure 24: Proposed Land Use Percentage Chart of the Study Area	54
Figure 25: Proposed Jobs-Housing Balanced Community	56
Figure 26: Proposed Open Space System and Retail Frontage.....	57
Figure 27: Proposed Street Network.....	59
Figure 28: Proposed Non-Motorized System	60
Figure 29: Local Road Street Section	61
Figure 30: Shijicun Neighborhood 2025 Plan	62
Figure 31: Housing Diversity.....	63
Figure 32: High-Rise Building Illustration	64
Figure 33: Passageways Connect with Alleys	65
Figure 34: Green Infrastructure Illustration.....	66
Figure 35: View from Harmony Central Park.....	67
Figure 36: Air Quality-PM 2.5 Estimation	71
Figure 37: Open Space Estimation	71

Figure 38: Annual VMT Estimation	72
Figure 39: Annual Water Consumption Estimation	72
Figure 40: Pervious Surface Percentage Estimation	73

LIST OF TABLES

Table 1: Residential Population of the Study Area in 2012	35
Table 2: Population of Two Universities in 2012.....	35
Table 3: Population Density	49
Table 4: Population Projection.....	50
Table 5: Existing Features Compared to Proposed Features	53
Table 6: Proposed Land Uses Area	54
Table 7: Proposed Open Spaces	54
Table 8: Proposed Shijicun Neighborhood Housing Types and Units.....	64
Table 9: Population, Dwelling Units, and Density Comparison.....	68
Table 10: Air Quality and Sustainability Comparison	68
Table 11: Air Quality-PM2.5 Estimation	69
Table 12: VMT Estimation.....	70

1.0 Introduction

1.1 General Introduction

Rapid urbanization and population growth in China have remarkably improved people's quality of life. However, these changes have also brought significant negative impacts, which limit further development in China. As the capital of China and one of the world's densest cities, Beijing is facing serious urban environmental issues, especially air pollution.

Working within this dynamic period of urban transformation, this creative project defines current urban air pollution issues, explores driving factors, and proposes solutions through sustainable planning and design concepts. This creative project also meets the challenge of accommodating rapid population growth and development while maintaining balance between the human and natural environments. The key feature of this creative project is to improve the integration of land use, transportation, and renewable resources to achieve a healthy, livable, and sustainable neighborhood. The site is a typical dense urban residential neighborhood and located beyond the North 4th Ring Road of Beijing. The proposed planning and design also sets an example for other neighborhoods and reflects how to transform all of Beijing into a sustainable and more livable city.

1.2 Background

China has experienced significant economic growth over the last two decades, bringing undeniable positive effects to people's living standards, plus rapid urbanization and population migration into dense urban areas. However, many environmental issues have come with this expansion, limiting further economic growth.

Beijing is the capital of China and is located in the northeast section of the country, north of the Huabei Plain (figure 1). The region's terrain slopes down from the northwest to the southeast. Beijing has more than 20 million permanent population in its 6,336 square miles (16,410 square kilometers) of city land, with a population density of 1,230 persons/sq. kilometer (Beijing Municipal Bureau of Statistics, 2012).

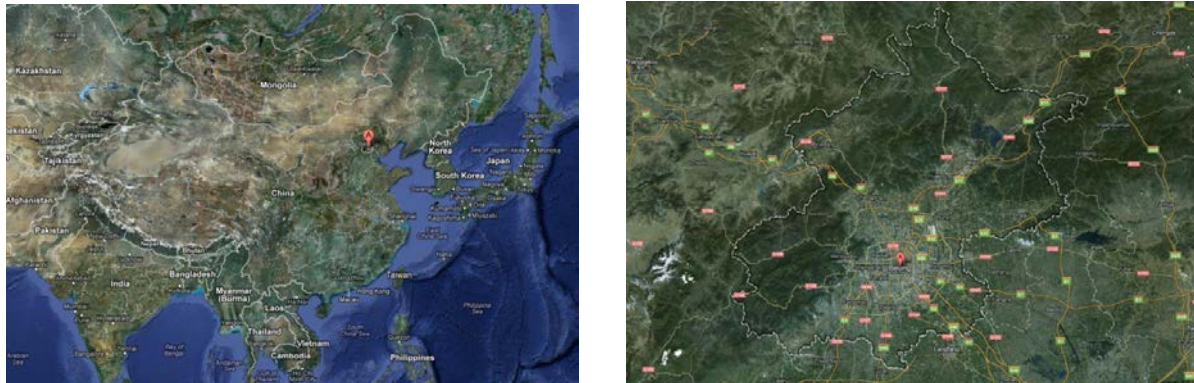


Figure 1: Maps of China and Beijing (Source: Google Maps)

Beijing has undergone significant rapid urban expansion over the past forty years, both in terms of geography and population. Figure 2 highlights the fast urban expansion from 1972 to 2010. As the city continues its expansion, many new neighborhoods are transformed from places that used to be villages outside of the traditional city core into what we today call “residential

neighborhoods,” or “Xiaoqu” in Chinese. Currently, thousands of residential neighborhoods are dispersed throughout the city to accommodate the increasing population. These residential neighborhoods are similar in many aspects, which also means that they are facing similar issues.

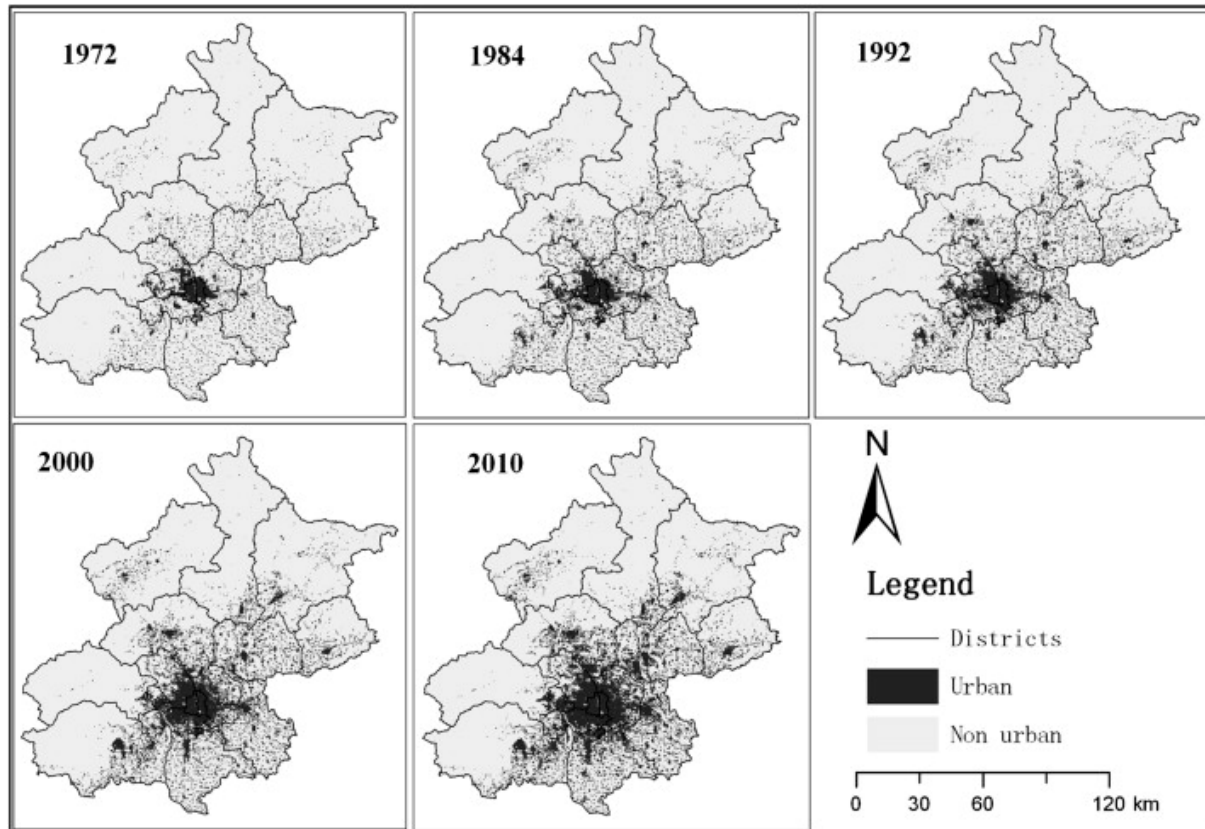


Figure 2: Urban Expansion in Beijing from 1972 to 2010 (Li, Zhou, & Ouyang, 2013)

In Beijing, the air quality level has dramatically worsened, especially in the first three months of 2013, when levels of air pollutants increased by approximately 30% compared to the same period in 2012 (Wong, Two Major Air Pollutants Increase in China, 2013). The deteriorating air quality in Beijing has also resulted in human health issues. According to the 2010 Global Burden of Disease Study (2012), air pollution in China has been linked to 1.2 million premature deaths (Wong, Air Pollution Linked to 1.2 Million Premature Deaths in China,

2013).

Many of China's environmental issues are related to its energy system (Liu & Diamond, 2005). The main reason for regional air pollution in China is coal burning, which contributes three main pollutants to the air: sulphur oxide, nitrogen oxide, and primary particulate matter. Almost 50% of China's coal use is for electricity, with 80% of electricity generation fueled by coal (Center for Climate and Energy Solutions, 2010).

Transportation also accounts for 26% of China's carbon emission. China used to be the "bicycle kingdom." However, as more people can now afford private automobiles, car ownership has dramatically increased, whereas bicycle usage has decreased. In addition, as automobiles become the "king" of the roads, bike lanes in most areas have been narrowed down to share with automobiles or converted into travel lanes. As a result, bicycle use is no longer convenient or safe and traffic congestion has become part of people's everyday lives in Beijing. According to the Beijing Traffic Management Bureau (2013), the number of vehicles in Beijing reached 5.271 million by the end of March 2013. Therefore, in Beijing, vehicle emissions have become the main cause of local air pollution.

Chinese urban areas also have very long superblocs. These discourage people from biking and walking. As a result, they contribute to air pollution indirectly. The block size in China is much bigger compared to other countries in the world, and the block length is relatively longer as well, which reduces accessibility and connectivity of all different transportation modes.

In Beijing, it is common to see a block length that is more than 1,000 feet beyond the 2nd Ring Road. Additionally, long blocks also reduce street network density, increasing pressure on surrounding roads.

As shown in figure 3, the population in Beijing increased 45% from 2000 to 2010. In 2011, the population reached 20.19 million (Beijing Municipal Bureau of Statistics, 2012). As the population in Beijing and the size of the city continue expanding, residential buildings have been built outside the city. However, most job opportunities still remain in the city, forcing people to commute a long distance every day between home and work.



Figure 3: Population Growth in Beijing from 2000 to 2010 (National Bureau of Statistics of China, 2011)

Although Eco-Cities and Eco-Towns have started to emerge in China, they have failed to live up to expectations. Instead of implementing genuine sustainable solutions, they end up with nothing more than “lots of trees and flowers” (Loew, 2012).

1.3 Project Statement

This creative project addresses current urban environmental issues in Beijing, identifies reasons and proposes solutions from a comprehensive perspective, and illustrates strategies for a sustainable future.

Specifically, the project focuses on retrofitting a neighborhood in Beijing, to be more sustainable by adopting planning and design concepts to mitigate current urban and environmental issues. The dominant idea in this design is to improve the integration of transportation, land use, and renewable resources to achieve a sustainable community. To address population growth and urban environmental issues, this creative project proposes what a sustainable neighborhood should look like in 2025.

Just like thousands of other residential neighborhoods in Beijing, the site suffers air pollution, which covers the whole region. Coal-generated electricity has contributed to low air quality for decades, but recently, emissions from the enormous rise of private automobiles has worsened air pollution throughout the city. Residents' average daily commute time is 52 minutes from home to work (Qian, 2012). Spending about 2 hours per day on transportation has greatly reduced residents' quality of life. Also, the long commute time plays a negative role on the environment, further aggravating air pollution.

Beijing's urban form also contributes to air pollution indirectly. The large blocks add traffic pressure on surrounding roads, worsening congestion and increasing exhaust from idling

engine. Due to the lack of connectivity within blocks, different modes of traffic must take detours to reach their destinations. This has dramatically reduced accessibility throughout the city.

To address air quality, commute times, and block size, this creative project proposes a new retrofit design for a dense urban neighborhood in Beijing.

1.4 Research Aims

The main research aims of the creative project are defined as follows:

1. Define current urban environmental issues.
2. Explore sustainable community concepts.
3. Understand feasibility of a sustainable retrofit in a contemporary neighborhood.

1.5 Research Questions

The main research aims of the creative project are defined as follows:

1. What are current and future sustainability challenges for neighborhoods in Beijing?
2. How to solve those sustainable issues in contemporary neighborhood design?
3. Why do other cities choose certain strategies for retrofitting existing neighborhoods?

This research is presented in five parts: The first part is the introduction. This is followed by literature review, study area and characteristics, site design, and conclusion. In the following chapter, the literature review discusses information from different scholarly sources to address research aims and questions. Next, Chapter 3 presents the study area's context and characteristics, and summarizes findings from the analysis. Then, Chapter 4 sets goals and objectives, projects population and housing in 2025, and proposes sustainable solutions. The last chapter summarizes the creative project and draws final conclusions related to the research and proposed design.

2.0 Literature Review

2.1 Introduction

The literature review explains current air quality facts in China and reveals reasons for air pollution in Beijing on both regional and local scales. Emissions from the energy sector contribute to air pollution on a regional scale, whereas emissions from the traffic sector contribute to air pollution on a local scale. The literature review focuses on research questions and is organized into the following topics: air quality, energy, transportation, and land use.

2.2 Air Quality

The first section of the literature review explains the main criteria to measure air quality in the sector, provides information about annual average pollutant concentrations in China, and describes significant negative human health impacts from air pollution. According to China's Ministry of Environmental Protection (2012), the three main airborne air pollutants in 113 major Chinese cities in 2011 were PM10 inhalable particles (0.041 mg/m³), sulfur dioxide (0.035 mg/m³), and nitrogen dioxide (0.085 mg/m³). The concentration of fine particulate matter (PM) is one measurement of air quality. PM10 represents particles with aerodynamic diameter smaller than 10 microns, whereas PM2.5 represents particles smaller than 2.5 microns. However, in recent years, the new index to measure air quality has been revised from PM10 to PM2.5. According to the World Health Organization (WHO, 2011), PM affects more people than any

other pollutant. PM2.5 is more dangerous than PM10 since when inhaled, these particles may interfere with gas exchange inside the lungs. Air pollution has a significant negative impact on human health. According to WHO (2011), air pollution is a major environmental risk to health and can cause respiratory infection, heart disease, lung cancer, and other diseases. As mentioned in the book *Cities, people, planet: Urban development and climate change* (Girardet, 2008), China has 16 of the world's 20 most polluted cities and the world's highest sulfur dioxide emissions. Of its population, 300,000 people per year are dying prematurely from respiratory disease. Also, air pollution in China has been linked to 1.2 million premature deaths in 2010 (Wong, Air Pollution Linked to 1.2 Million Premature Deaths in China, 2013). Shockingly, this statistic quadrupled in only 2 years, showing the immediate need for sustainable planning to mitigate air pollution in China.

Beijing experienced serious air pollution during the first three months of 2013. Figure 4 shows the PM2.5 levels of Beijing compared to other cities in January 2013.

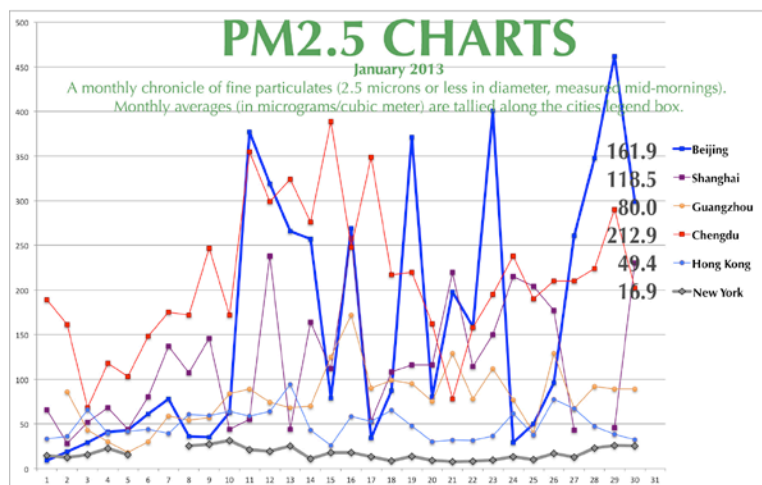


Figure 4: Six Cities' PM2.5 Levels in January 2013 (China Air Daily, 2013)

2.3 Energy

Energy is the biggest contributor of carbon emission across all sectors in China, and many of the country's environmental issues are related to its energy system (Liu & Diamond, 2005). According to the Greenpeace Organization (Greenpeace, 2012), one of the major reasons for air pollution in China is coal burning. As the demand for energy increases, China must build more coal-fired power plants to meet the rising needs. According to the Center for Climate and Energy Solutions (2010), an independent nonprofit organization focusing on challenges of energy and climate change, the new plants in China added 500 million tons of CO₂ in 2006. In addition, China's coal output jumped from 1.3 billion tons in 2000 to 2.23 billion tons in 2005, making China the largest coal producer in the world. Moreover, almost 50% of China's coal use is for electricity, with 80% of electricity generation fueled by coal. In 2011, China consumed nearly 4 billion short tons of coal, which is about half of the world's coal. Compared to 2000, coal consumption in China has tripled (The U.S. Energy Information Administration, 2012). Figure 5 shows total energy consumption in China in 2009.

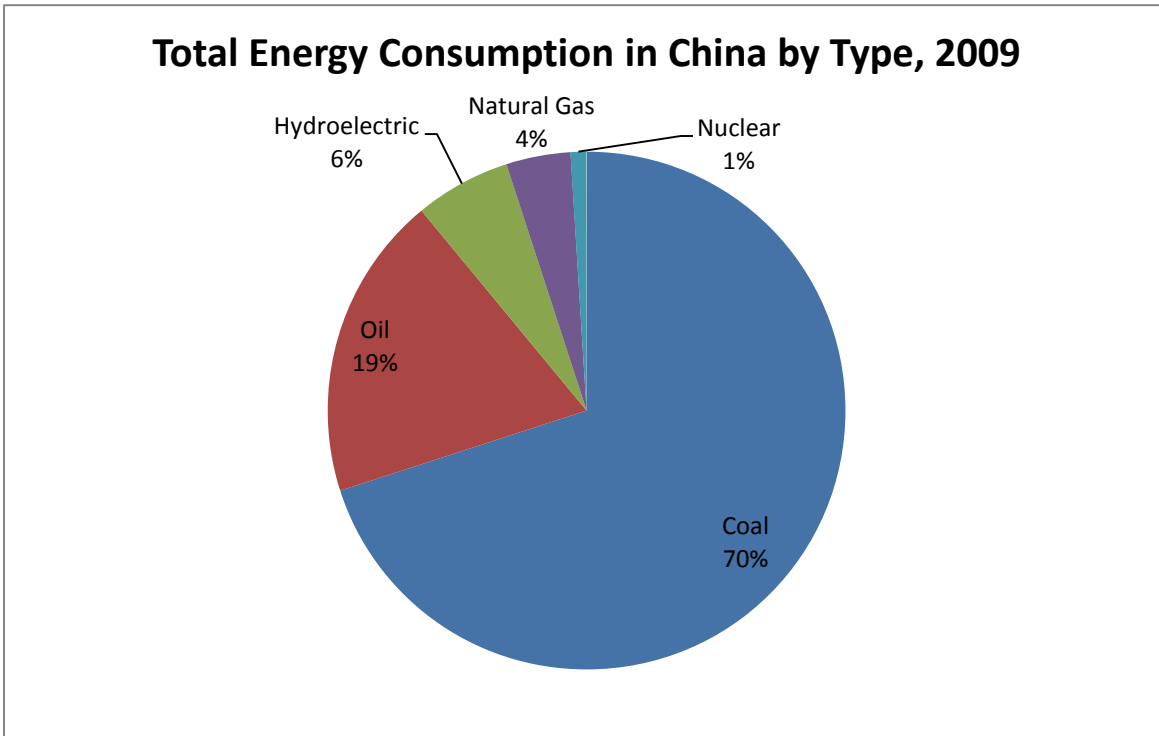


Figure 5: Total Energy Consumption in China by Type in 2009 (The U.S. Energy Information Administration, 2012)

The use of renewable resources can reduce emissions from coal-burned power plants. Electricity generated from renewable energy rather than fossil fuels can dramatically improve air quality and offers significant public health benefits. As described in the Benefits of Renewable Energy Use Fact Sheet (Union of Concerned Scientists, 2013), “Wind, solar, and hydroelectric systems generate electricity with no associated air pollution emissions. While geothermal and biomass energy systems emit some air pollutants, total air emissions are generally much lower than those of coal- and natural gas-fired power plants.” Nevertheless, the renewable energy sources are growing in China, and the national government set a goal to generate at least 15% of total energy output using renewable resources by 2020.

2.4 Transportation

Transportation also accounts for 26% of China's carbon emissions. Additionally, private car ownership has increased dramatically in recent years. According to the Beijing Traffic Management Bureau (2013), the number of vehicles in Beijing reached 5.271 million by the end of March 2013. However, this number was only 1.365 million in 2000 (Beijing Municipal Bureau of Statistics, 2001). These two statistics reveal a 286% vehicle growth from 2000 to 2013 in Beijing. Figure 6 also reveals a fast growth in both private automobiles and total vehicles in Beijing. As the middle-class Chinese fulfill the dream of owning a car, traffic conditions are deteriorating (Loew, 2012). Figure 7 shows cars per thousand people in Beijing compared to other regions in the world in 2010 (Ernst & Young, 2011). Although the number of cars per thousand people is relatively low compared to developed countries, it still causes severe traffic congestion in Beijing, because roads and infrastructure were not designed for such a large number of vehicles. Additionally, population data from the Beijing Municipal Bureau of Statistics and numbers of vehicles from the Beijing Traffic Management Bureau show Beijing had more than 250 cars per thousand people in 2012.

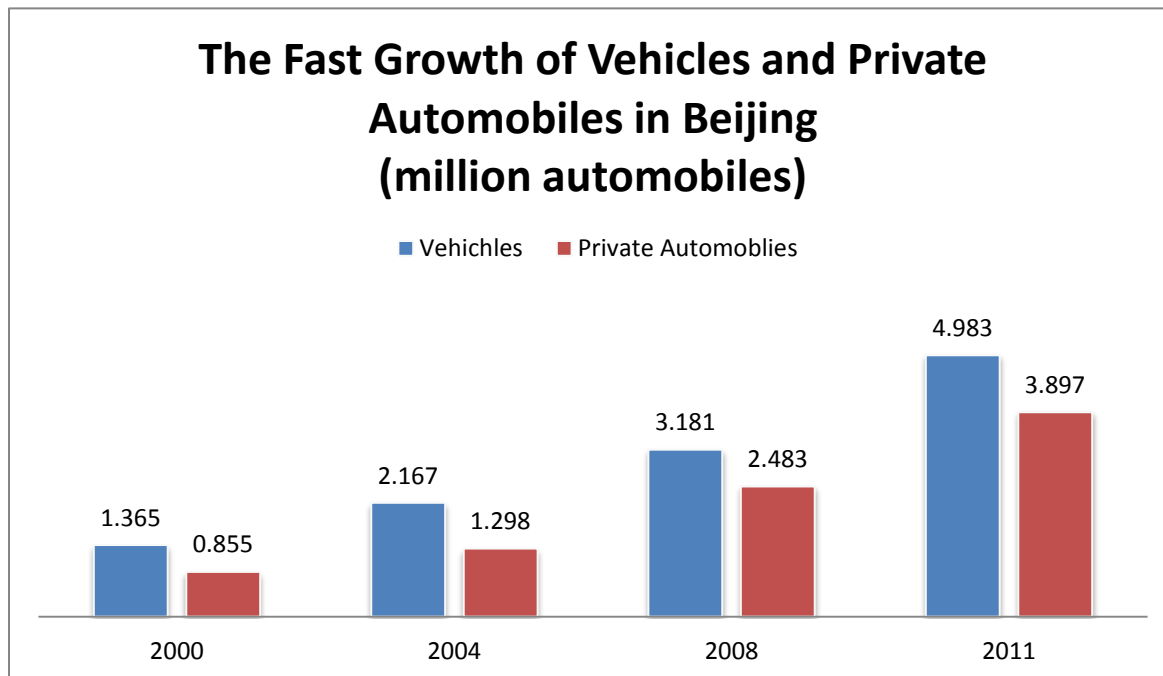


Figure 6: The Fast Growth of Vehicles and Private Automobiles in Beijing (Beijing Municipal Bureau of Statistics, 2001, 2005, 2009, 2012)

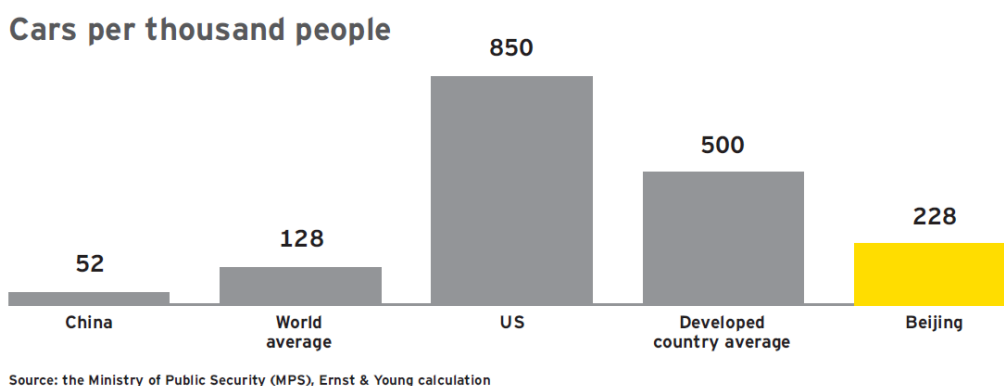


Figure 7: Cars per Thousand People in 2010 (Ernst & Young, 2011)

When most cities in the United States started to improve pedestrian and bicycle modes instead of driving, major cities in China are doing the opposite. Bicycles used to be the dominant transportation mode in China (figure 8), but now they are disappearing. Over the past 20 years, the dominant transportation mode has shifted from bicycle to automobile. Bicycle use accounted

for 62.7% of transportation in the 1980s, but only 18.1% in 2010 (Wang, 2012). In China's major cities today, it is common to see bicycle lanes being converted into travel lanes or shared with automobiles, and sidewalks becoming parking spaces for automobiles. The reason for this rapid change is that China used to be a country with few private automobiles since most people could not afford them. As a result, streets were designed to accommodate pedestrians, bicycles, and public transit instead of private automobiles. However, as the economy continues to skyrocket, more people can now afford private automobiles, and most who own them prefer to drive instead of using other transportation modes. Although streets have been widened to accommodate growing traffic, bicycle lanes and sidewalks have been narrowed down to give more space to automobiles. When automobiles have taken bicycle lanes and sidewalks away from cyclists and pedestrians, traffic becomes more chaotic. As shown in figure 9, it is common to see the following biking and walking conditions in Beijing: Cyclists and pedestrians must use travel lanes mixed with automobiles and drivers veer to avoid them, which dramatically decreases traffic efficiency and increases accidents. This is unsafe for cyclists and pedestrians, and has also taken away their rights of sharing roads.



Figure 8: Bicycle Kingdom - Changan Avenue, Beijing, 1986 (Photos: China's History of Bicycles, 1986)



Figure 9: Bike Lane Now A Parking Lane, Forcing Cyclists Into Street (Li W. , 2012)

During the 2008 Beijing Olympic Games, the municipal authority implemented temporary automobile restrictions based on odd and even-numbered license plates, allowing only half of the automobiles on roads each day. After the Olympic Games, the municipal authority attempted a “drive one day less per week” automobile restriction policy, which restricts 1/5 of automobiles in Beijing from roads inside the 5th Ring Road from 8am-8pm each weekday. This restriction was also based on different last numbers on license plates. Eventually, Beijing municipal authority adopted the “drive one day less per week” automobile restriction in 2011, making it a permanent policy to reduce traffic congestion in the city.

However, these restriction policies may not be an effective and efficient solution. A better solution for the current transportation situation in Beijing should give people more transportation choices, particularly green transportation options. These green transportation options would bring bicycle culture back to cities and leave the original sidewalks to pedestrians. From a long-term perspective, another solution could be adopting integrated transportation planning and educating the general public about how carbon emissions deteriorate the environment and how air pollution jeopardizes human health. This would change people’s attitude about automobile ownership. Additionally, compared to the traffic restraint initiatives, Chinese cities have implemented relatively little in ridesharing, car sharing, and congestion pricing (Cervero, 2006). Carsharing lets people use automobiles on an as-needed basis without responsibilities of ownership.

The Beijing Municipal Government has realized traffic conditions are deteriorating and is investing heavily in public transportation (figure 10). Strategies responding to traffic congestion focus on supply-side, including roads expansion, major investments in the subway system, bus rapid transit, and bus system. Currently, Beijing's subway system has 16 subway lines, 221 stations, and 442 km (275 mile) of tracks in operation (Zheng, 2013). The Beijing Municipal Government subsidizes public transportation operation and offers a flat fare to passengers. Figure 11 shows the intensive subway system in Beijing (The Beijing Mass Transit Railway Operation Corp, 2013). However, the existing network still cannot adequately meet the city's expanding public transportation needs. Government's plans focus on capacity expansions and modernization of infrastructure as the instruments for relieving traffic congestion and spurring economic productivity (Cervero, 2006).

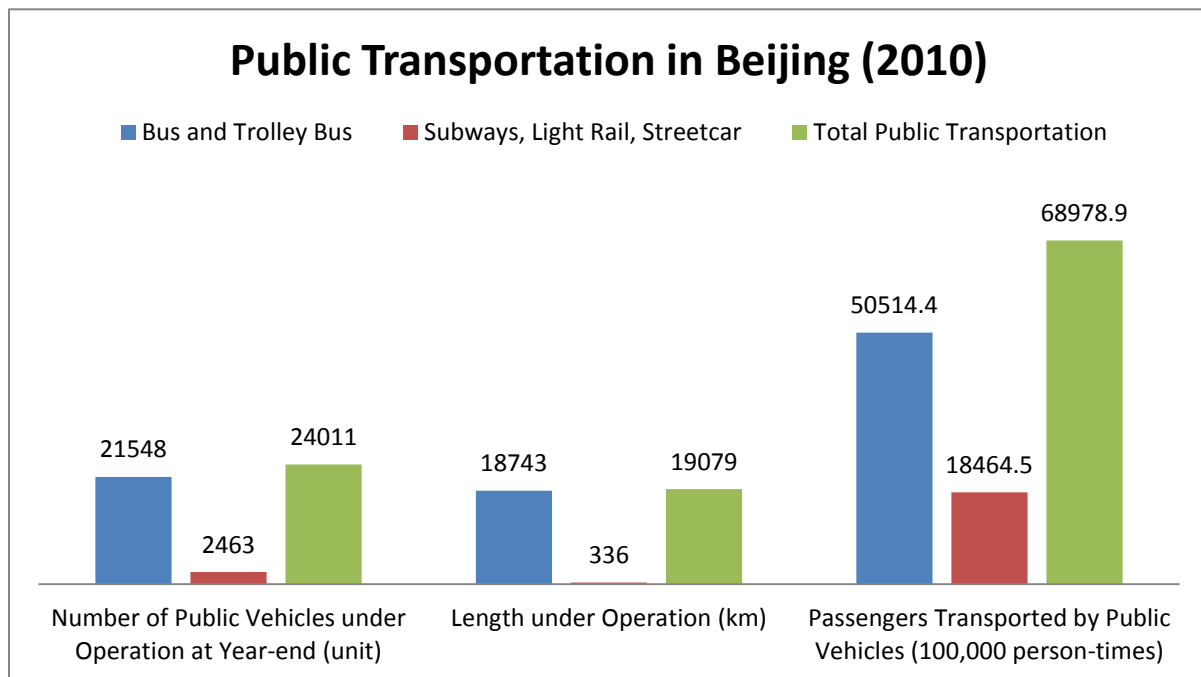


Figure 10: Public Transportation Statistics in Beijing in 2010 (Beijing Municipal Bureau of Statistics, 2011)



Figure 11: Beijing Subway Map (The Beijing Mass Transit Railway Operation Corp, 2013)

Efficient cities require multi-modal transportation systems, which include walking, biking, public transport, automobile travel, delivery services, and telecommunications (Strompen, Litman, & Bongardt, 2012). As Cervero (2006, p. 4) observed, “Balanced transport programs do not ignore the need for road expansion and new construction; rather a diversity of transport initiatives are pursued that promote a wider array of objectives than simply enhanced mobility”

2.5 Land Use

The design of buildings, streets, and other land uses in cities can have significant impacts on air quality. These land uses determine distances and time people need to travel and which transportation mode they may choose. Chinese cities have a strong tradition of strategic and comprehensive land-use planning. However, with rising land-market pressures and real-estate price differentials, spatial mismatch issues and jobs-housing-services imbalances are becoming increasingly critical (Cervero, 2006). As the population in Beijing and the size of the city continue expanding, most job opportunities still remain in certain areas, such as financial districts and high-tech zones, but affordable housing may be far away from them (Loew, 2012). The existing unbalanced land uses are reflected in commute time statistics. According to a 2012 survey released by the Chinese Academy of Sciences, residents in Beijing have an average daily 52-minute commute time from home to work, 14 minutes more than 2011 (Qian, 2012). Spending about 2 hours per day on travel reduces residents' quality of life. Also, the long commute time jeopardizes the environment, aggravating traffic congestion and air pollution.

Additionally, average block size in China is much larger compared to other countries in the world, and the block length is also relatively longer, which further reduces accessibility and connectivity of different transportation modes. Long block length also forces pedestrians to risk climbing guardrails to reach the other side of streets.

A good land use planning strategy such as jobs-housing balance could dramatically

reduce “vehicle kilometers traveled” (VKT) per capita, thus improving safety and reducing emissions from the transportation sector to improve air quality. Jobs-housing balance offers significant opportunities to reduce average journey lengths, rationalize commuting patterns, and improve efficiencies in travel patterns, such as higher rates of bi-directional trip flows (Cervero, 2006).

3.0 Study Area and Characteristics

3.1 Introduction

This chapter examines the conditions in the current study area through a comprehensive analysis, and identifies the existing issues the study area exposes, including air pollution and other problems. Then, at the end of this chapter, the findings summarize existing issues of the study area.

3.2 Study Area Description and Analysis

3.2.1 Location and Context



Figure 12: Project Site Location



Figure 13: Context Map of Study Area and Shijicun Neighborhood

As shown in figures 12 and 13, this creative project explores a 435-acre study area just outside the North 4th Ring Road in Chaoyang district of Beijing, and proposes a demonstration for Shijicun residential neighborhood site design that is located within the study area.

The study area is about 6.25 miles (10 kilometers) north of the geographic center of the city. It is in close proximity to the Olympic Village Area, and the Olympic Park is only 1.9 miles (3.05 kilometers) west of the study area. The study area is surrounded by different subway lines and has easy access to highways. Subway line 5 connects north and south of Beijing and has been operating since 2007. Subway line 10 is the second loop line in Beijing. It sits between the 3rd Ring Road and the 4th Ring Road and opened in 2008. Additionally, Line 15 connects Shunyi District and Beijing. Part of Line 15 is open now, and the whole line is planned to fully operate by 2015.

The 435-acre study area shows a typical combination of neighborhoods in Beijing. Currently, there are thousands of neighborhoods like Shijicun in the city. The study area nestles in a good urban setting and has good connections to the other parts of the city. However, the context map in Figure [14] also shows that the area currently has no hospital, library, or movie theater inside the area.



Figure 14: 3D Model of Existing Study Area and Shijicun Neighborhood

3.2.2 The Study area in Context

The whole study area mainly includes five communities, seventeen different residential neighborhoods, two universities (Beijing Union University and China Women's University), three elementary schools, five kindergartens, three grocery stores, nine convenience stores, one

regional furniture shopping center, and other mixed-use buildings combined with commercial, residential, and office uses (figures 14 & 18). The five communities' population in 2012 was 63,473, including both permanent and floating population. Additionally, the total faculty and student population for the two universities was about 13,900 in 2012. Therefore, the total population of this study area was about 77,373 in 2012. Table 1 and 2 show the current population in the study area, collected from community and university websites.

Community Name	Permanent Population	Floating population	Total Population
Anhuidongli	14,895	7,000	21,895
Yuhuili	7,057	2,168	9,225
Yuhuixili	8,000	3,000	11,000
Shijicun	12,300	NA	12,300
Oulujingdian	4,909	4,144	9,053
Total Population	47,161	16,312	63,473

Table 1: Residential Population of the Study Area in 2012 (Anhuidongli Community, 2012); (Yuhuili Community, 2012); (Yuhuixili Community, 2012); (Shijicun Community, 2012); (Oulujingdian Community, 2012)

Institution Name	Faculty Population	Student Population
Beijing Union University	482	8,900
China Women's University	456	5,000
Total Population	938	13,900

Table 2: Population of Two Universities in 2012 (Beijin Union University, 2012); (China Women's University, 2012)

This 435-acre study area in China has a similar population as a medium city in the United States. However, because of limited land and services, residents' quality of life is lower than that of a typical neighborhood in the United States. For example, the dense urban setting of the study area creates smaller open and living spaces for a large population. Access to healthcare,

entertainment, and public service is also lower.

3.2.3 Shijicun Residential Neighborhood Inventories and Population



Figure 15: 3D Modeling of Existing Shijicun Neighborhood

The Shijicun neighborhood was built in 1996, and residents started living there in 1997. Within the study area, Shijicun is a 17.2-acre residential neighborhood, including 19 residential buildings from mid-rise to high-rise and an elementary school. The mid-rise buildings usually are 5 to 6 stories, whereas the high-rise buildings are 12 to 24 stories. The current neighborhood has approximately 1,388 households and approximately 3,401 residents. This number was computed by multiplying the number of residencies by the average Beijing household size of 2.45 people (National Bureau of Statistics of China, 2011). The Fangcaodi Elementary School, which is

located in the southeast of Shijicun neighborhood, currently has about 800 students.

3.2.4 Air Pollution Illustration

As in other parts of the city, the study area is exposed to unhealthy air most of the time. With no strong winds, heavy grey smog covers the whole place, keeping the blue sky far away and creating low visibility. The air pollution also has long-term health impacts. Figure 16 simulates a scenario of the study area under air pollution.



Figure 16: Air Pollution Simulation: A Clear Day Compares to A Smoggy Day

3.2.5 Existing Land Use and Density



Figure 17: Existing Land Use and Open Space

From the land use map in figure 17, we can see that multi-family residential is the primary use in the area. Most mixed-use buildings consist of ground-level retail and upper-level residential uses. Other mixed-use buildings, especially those located at the street corners, are retail combined with office mixed-use. A regional furniture shopping center located at the North 4th Ring Road makes the study area a shopping destination in the city. Most retail and commercial uses spread along major north-south direction streets, with fewer of them in the west-east direction. Jobs and housing are unbalanced, with fewer job opportunities provided in this study area compared to the number of residents. Therefore, residents must commute from home to work at other locations in the city. These commute trips aggravate air pollution and consume valuable time.

Institutional use in the study area consists of universities, elementary schools, and kindergartens. The college students from two universities have dramatically increased the local young population, making the area more vibrant. Elementary schools and kindergartens are interspersed in each community, providing the basic level of education for children in this area. However, due to differences in educational standards in each school, students may choose to attend a school with higher education standards that is far from where they live.

The smaller open spaces are usually located in the center of neighborhoods. They are literally only open to residents who live in the neighborhood. The larger open space next to Xiaoying North Road and Dingcheng Road is a parcel waiting for new development. Huawei Garden is the largest open space in this study area, providing easy access for residents. However, the existing open spaces are inadequate, and most are exclusive. Additionally, the whole area lacks an open space system to provide recreational opportunities, including biking and walking trails.



Figure 18: 3D Model of Existing Building Use and Density

The study area needs high-density development to support the large population. As this area continues evolving to accommodate a growing population, the density of the study area will increase. Figure 18 reveals that older buildings built before 2000 have a relatively lower density than newer buildings built in the last 10 years. Although universities have a relatively lower density, their dorms are very crowded. In Beijing's universities, a small dorm room usually accommodates 4 to 6 students.

3.2.6 Gated Communities



Figure 19: Existing Gated Community

China has a long history of gated communities. In contemporary residential neighborhood development, the gated community has become a standard pattern. Gated communities are fashionable because they provide safety, prestige, privacy, and exclusivity. However, gated communities can have a negative impact on urban form and development (Yao & Wei, 2012). Highly uniform patterns of residential neighborhoods create less community character and identity. Gated communities also emphasize separation between socio-economic groups.

Figure 19 shows that the gates of each residential and university neighborhood are typically placed along main streets to allow vehicles and residents to enter and exit with ease. Some neighborhoods have pedestrian-only gates to provide convenience for residents. Each

neighborhood has its own realm, and is always surrounded by perimeter walls or fences and guarded gates. Basically, every residential neighborhood is only open to its own residents. Each neighborhood occupies a large tract of land, because the government commonly sells entire blocks to developers. The largest residential neighborhood block in the study area is more than 1,000 feet in length, whereas Shijicun's average block length is about 800 feet.

The gated communities with huge blocks reduce accessibility and connectivity of different transportation modes, increasing walking and biking distance to destinations. Additionally, they also reduce street network density, adding pressure on surrounding roads.

3.2.7 Street Network



Figure 20: Existing Street Network

As shown in figure 20, the study area is surrounded by the North 4th Ring Road on the

south, Beiyuan Road on the west, Xiaoying North Road on the north, and Dingcheng Road on the east. The 4th Ring Road is an urban expressway, which is approximately 5 miles (8 kilometers) long and shaped in a rectangle around the city. The 4th Ring Road was fully opened in 2001 with 4 traffic lanes and an emergency lane in each direction. Additionally, the 4th Ring Road has a side feeder road with additional 3 traffic lanes in each direction to allow traffic to enter and exit.

Beiyuan Road is a north-south arterial road with 3 traffic lanes in each direction.

Roads colored in red on the map are secondary roads. They collect traffic from each neighborhood and connect to the arterial road and the expressway. Typically, they have 2 traffic lanes in each direction. They used to be narrower than what they look like today, but the city has widened them to accommodate growing traffic as the whole area has been developed and private automobile ownership has increased. The roads colored in purple are narrower than the secondary roads. Collector roads have one traffic lane and one parking lane in each direction. Finally, the most dense street network on the map is the residential road. These roads mainly serve local neighborhoods, connecting to different buildings and parking lots.

The study area has a good connectivity with other parts of the city, but superblocs, gated communities, and private residential roads have dramatically reduced connectivity within the study area. This does not encourage people to bike and walk. Therefore, the accessibility and connectivity within the study area needs more systematic planning.

3.2.8 Public Transportation



Figure 21: Existing Public Transportation

The bus is the primary public transportation mode in this area. Figure 21 illustrates all different bus routes, directions, stops, and 5-minute walking radius from bus stops. The bus system covers the whole area, especially residential areas, and transports residents to other parts of the city. Apart from the intense bus system, Subway Line 5 station is located southwest of the study area. Residents can take a bus and transfer to the subway.

Sidewalks and bicycle lanes are combined with different levels of streets, since walking and biking used to be the dominant transportation modes in Beijing. However, as the number of private automobiles increases, the existing parking spaces cannot handle them, so drivers find other spaces for parking. Sometimes, they occupy sidewalks and bike lanes.

3.3 Findings from Study Area Analysis

The comprehensive analysis in the previous section identified the following issues:

- Unbalanced jobs-housing land use increases commute distance, exacerbating air pollution.
- Superblocks, gated communities, and private residential roads have dramatically reduced connectivity within the study area, discouraging people from biking and walking.
- The existing large population continues to grow.
- Although the study area is surrounded by many open spaces, they are quite far away to be accessible to residents who use non-motorized transportation modes.
- Pedestrian and cyclist rights have been taken away, and the automobile is dominant on roads.

In the next chapter, a proposed site design will be outlined for addressing these issues.

4.0 Site Design

4.1 Introduction

This chapter starts with project goals and objectives. Through setting goals and objectives, this section demonstrates how to mitigate air pollution and achieve a sustainable future. The section on population and housing projections gives a rationale for the site design, which is based on the most intensive scenario of population growth. Next, the urban design proposal section illustrates details of what the study area and Shijicun neighborhood within this study area would look like in 2025. Next, proposed land use plan and transportation plan are described at the community scale, and building types, sustainability solutions, and other features are demonstrated at the neighborhood scale. Then, the section on implementation describes how to adopt the proposal.

4.2 Creative Project Goals and Objectives

The comprehensive and sustainable design concepts of this creative project are to create jobs-housing balance, pedestrian and cyclist-oriented development, and achieve sustainability at the community and neighborhood levels.

Three main goals and objectives are proposed to reduce air pollution through energy, transportation, and land use solutions:

- Encourage the use of renewable resources on site, and improve green infrastructure

and open space. This will be accomplished by:

- a. Using solar panels to minimize carbon emissions;
 - b. Installing green infrastructure such as green roofs, raingardens, and permeable surfaces to improve urban environment; and
 - c. Creating an open space system to improve environmental quality by filtering air.
- Improve the multi-modal transportation system, create green transportation systems, and bring bicycle culture back to the people. This will be accomplished by:
 - a. Decreasing transportation-related emissions through a multi-modal transportation system;
 - b. Increasing biking and walking connectivity to destinations; and
 - c. Encouraging carshare and bikeshare.
- Create jobs-housing balanced communities through:
 - a. A decrease in per capita Vehicle Miles Traveled (VMT), and
 - b. Increase in local job opportunities.

In addition to the main goals, the following secondary goals focus on social, economic, and environmental issues to help the study area achieve a sustainable future:

- Accommodate rapid population growth and development;

- Enhance community identity by building connections between residents through community engagement and urban agriculture;
- Reunite neighborhoods through an open space system;
- Create centers and nodes and let the study area evolve into a vibrant community;
- Bring nature back to the dense urban setting;
- Create economic opportunities for neighborhoods;
- Provide affordable housing to attract a diverse mix of people; and
- Link residents to amenities through non-motorized connections.

4.3 Population and Housing Projection

In order to plan effectively for the site, it is important to know the size of the population that will reside in the study area in the plan period. Thus, there is a need for projecting the population to 2025.

4.3.1 Population Projection

The population in Beijing increased 45% from 2000 to 2010. In 2010, the average population density in Beijing was 1,196 persons per square kilometer (3,097 persons per square miles).

There are several scenarios regarding the future population of Beijing. By the year 2025, the population in Beijing may achieve a static level, or it may still keep growing, or even

decline because of the escalating cost of living and poor air quality in the city. However, the creative project is assuming the most intensive scenario, which is that the population would continue to grow. As Beijing Academy of Social Sciences reported, the population of Beijing is expected to hit 26 million by 2020 (Lin, 2011). The creative project therefore shows how to accommodate this large population in a sustainable way, while also improving residents' quality of life.

According to the projection of 26 million population by the Beijing Academy of Social Sciences, the population in Beijing would grow by 32.5% from 2010 to 2020 if the existing population growth trends continue. If we assume that the study area would have the same growth rate, by 2025 the permanent population of the study area would be 68,902 (a 46.1% growth rate from 2012 to 2025), and the permanent population of Shijucun Neighborhood would be 4,969. Moreover, the total population in the study area would be 113,041, including the floating population. Table 3 shows the population density in 2012 and 2025. Table 4 shows the total projected population for 2025.

Population Density	Population Density in 2012 (persons/acre)	Population Density Projection in 2025 (persons/acre)
Shijicun Residential Neighborhood	198	289
The Study area	178	260

Table 3: Population Density

	Existing Population in 2012	Projected Population in 2025
Shijicun Residential Neighborhood	3,401	4,969
The Study area	77,373	113,041

Table 4: Population Projection

4.3.2 Housing Projection

In addition to population projection, it is also important to understand the future density for the site. This is because the housing projection gives a rationale about the density of new construction buildings, and whether the existing and new constructed housing will be able to accommodate population growth in 2025.

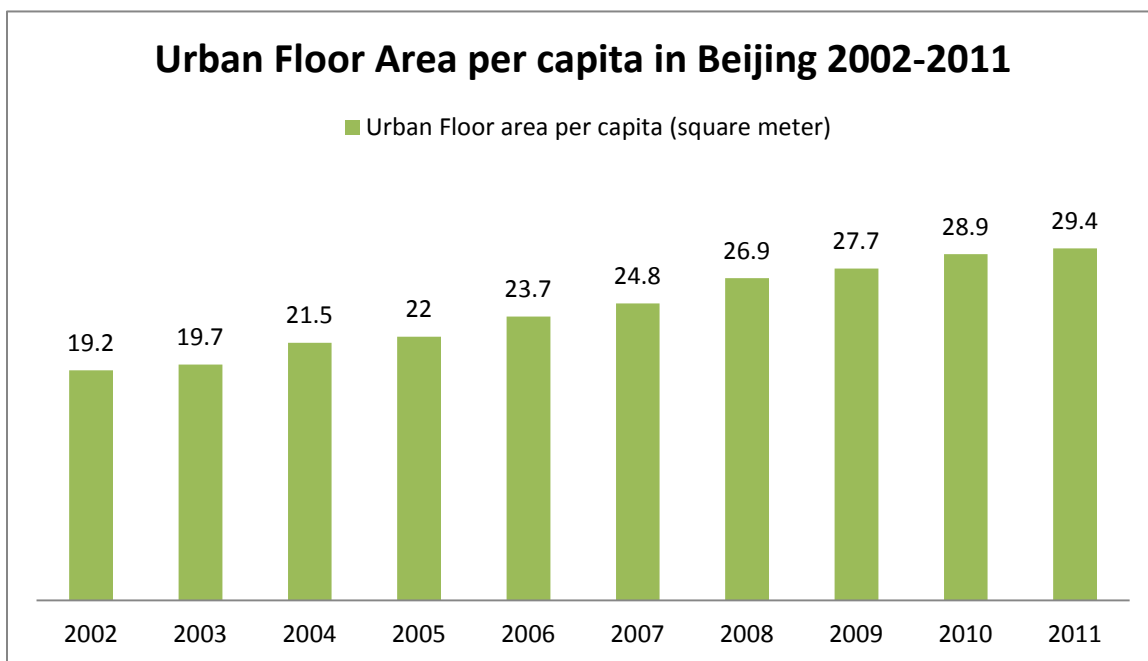


Figure 22: Urban Floor Area per capita in Beijing (Beijing Municipal Bureau of Statistics, 2012)

The urban floor area per capita in Beijing increased 53% from 19.2 square meters in 2002 to 29.4 square meters in 2011 (figure 22), (Beijing Municipal Bureau of Statistics, 2012).

According to research from the McKinsey Global Institute (2011), urbanization will create an average of 17 million new urban residents each year until 2025, and a near 50% increase in per capita floor space from 2008 to 2025. Therefore, the floor space per capita is expected to be 40.4 square meters (434.9 square feet) in 2025.

Additionally, the number of households in China will approximately double by 2025, due to a global trend toward smaller household sizes driven by demographic shifts and altered behavior (McKinsey Global Institute, 2011). The average household size in Beijing in 2010 is 2.45 persons, but the average household size in 2025 is estimated to be 2.2 persons. The population in Shijicun Neighborhood is projected to be 4,969 persons in 2025. Given a projected household size of 2.2, about 2,259 housing units will be needed to accommodate the new population. Therefore, Shijicun Neighborhood will need about 2,259 total housing units in 2025.

These calculations play a foundational role in the design, since they project what the density might be and how many units will be needed to accommodate the population growth.

4.4 Urban Design Proposal

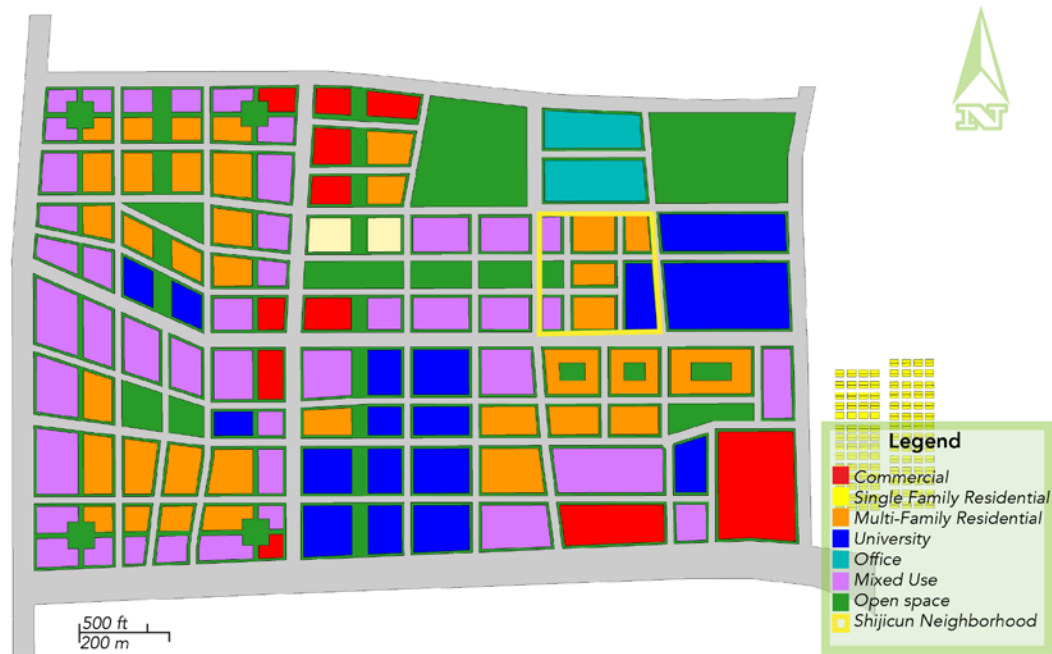


Figure 23: Proposed Land Use

This creative project integrates three features to mitigate air pollution and retrofit the neighborhood into a sustainable place: land uses, transportation, and open space proposals. Combined these key features will achieve a healthy, livable and sustainable community. The urban design proposal includes two parts. The first part focuses on land use, open space, and transportation proposals at the community scale. The second part visually focuses on building types, density, and sustainable solutions at the neighborhood scale. The design illustrates a 2025 plan for this study area (figure 23), to help it to evolve to accommodate the continuing population growth and development. Table 5 compares existing features to proposed features of the study area.

Categories	Existing Features	Proposed Features
Land Use	<ul style="list-style-type: none"> • Unbalanced jobs-housing mix • Superblocks • Gated communities 	<ul style="list-style-type: none"> • Balanced jobs-housing mix • Reduced block size • Open communities
Transportation	<ul style="list-style-type: none"> • The private residential roads do not encourage biking and walking • Primacy of private automobile use 	<ul style="list-style-type: none"> • Balanced and systematic street network • Multi-modal transportation system
Open Space	<ul style="list-style-type: none"> • Exclusive open space • Lack of open space system 	<ul style="list-style-type: none"> • An open space system that connects each neighborhood and encourages walking and biking

Table 5: Existing Features Compared to Proposed Features

4.4.1 Development Program of the Study Area

The proposed land use of the study area includes: multi-family residential, mixed-use, commercial, office, institution, open space, and infrastructure. Table 6 and figure 24 summarize the proposed land uses in the study area. A diversity of open spaces are offered in the study area, including urban agriculture, nature reserve, central park, community park, and greenway. Table 7 summarizes the size of each type of open space.

Land Use	Total S.F.	Acre
Residential	2,511,517	57.7
Mixed-Use	3,284,161	75.4
Commercial	1,184,141	27.2
Office	410,709	9.4
Institution	2,108,532	48.4
Open Space	2,659,620	61.1
Infrastructure	7,375,745	92(Pavement)+62(Sidewalks)

Table 6: Proposed Land Uses Area

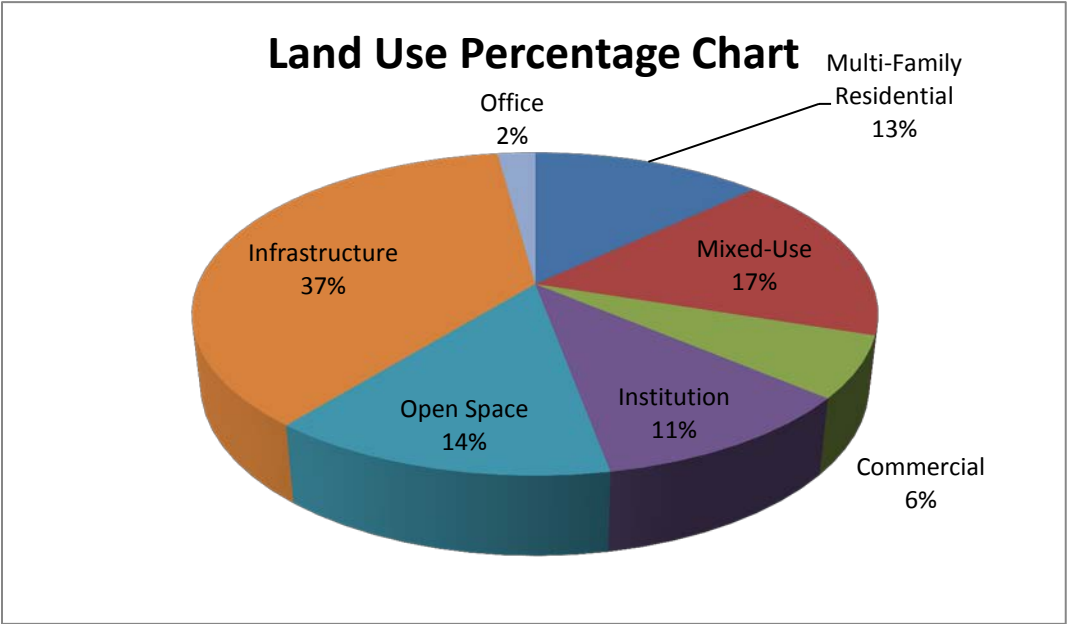


Figure 24: Proposed Land Use Percentage Chart of the Study Area

Open Space Types	Size (Square Foot)
Urban Agriculture	619,846
Nature Reserve	559,205
Central Park	234,970
Community Park	362,579
Greenway	883,020

Table 7: Proposed Open Spaces

4.4.2 Proposed Land use

By better addressing population needs for trips, the proposed land use plan aims to provide amenities and access by propinquity to reduce commute trips and enhance the urban environment, thereby improving air quality. In addition, the land use plan also dismantles the gated community pattern to provide an inviting atmosphere between neighborhoods and different land uses, and provides social opportunities to previously isolated neighbors.

4.4.2.1 Jobs-Housing Balance

The land use map in figure 23 illustrates a solution for balancing all different land uses, especially jobs and housing, to reduce residents' commute from home to work, thus dramatically improving air quality. All mixed-uses are located on the periphery of each community or district. They are located near major streets to provide easy access for both local residents and people from outside. These mixed-uses basically include: office and retail, office and residential, and retail and residential. Multi-family residential is mainly located near local streets to offer a quiet environment for residents to relax. Retail and commercial are interspersed along streets, bringing restaurants, shops, banks, and other amenities close to residents. Elementary schools and kindergartens are still located within individual communities. Public Parks and open spaces invite residents to enjoy nature.

The design for jobs-housing balance land uses could increase employment opportunities on site, but also provide opportunities within walking distance for local residents. Additionally, a jobs-housing balance land use can dramatically reduce commute trips and times. Reducing pollution from vehicle exhaust would also improve air quality. Figure 25 illustrates that within a 10-minute walk radius from home, residents could easily choose non-motorized transportation modes to most jobs, public parks, shops, schools, and other amenities.

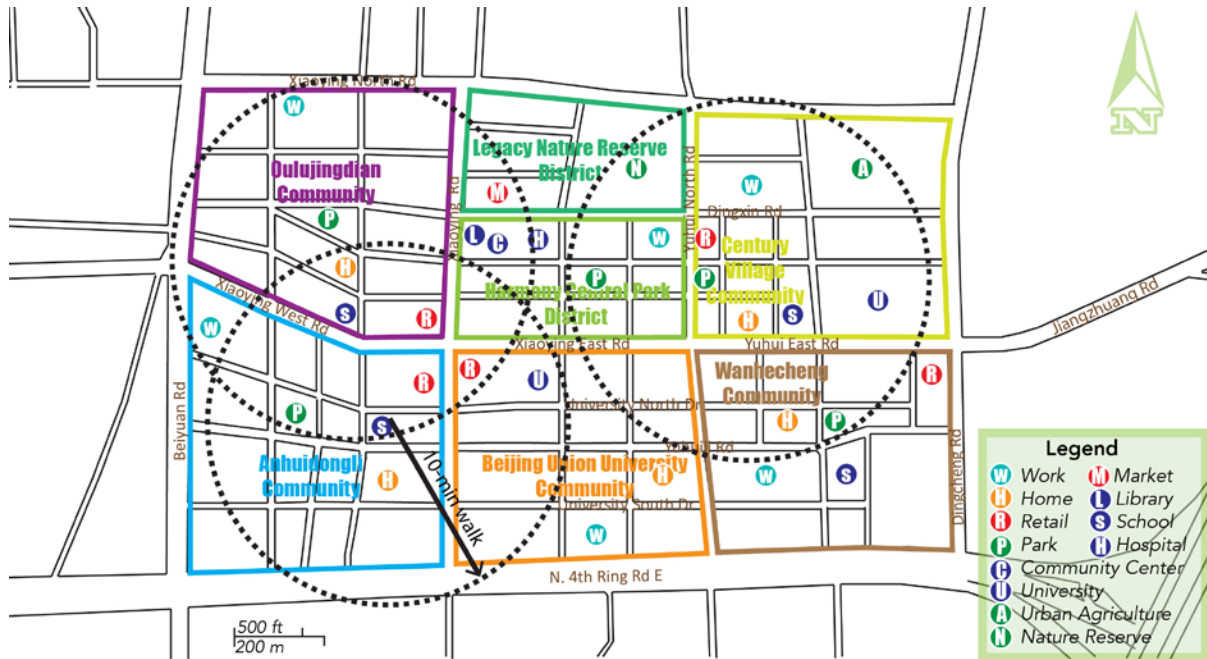


Figure 25: Proposed Jobs-Housing Balanced Community

4.4.2.2 Center of the Study area

Among seven communities and districts, the Harmony Central Park District is designed to be the center of the study area, creating a sense of place and enhancing the area. This proposed district has a large central park, but also a community center, library, and hospital, which are currently missing in the area. This district also helps the study area to sharpen and improve its community identity. Inviting public spaces encourage residents to engage in community events and meet their neighbors. Also, this linear park preserves valuable open space for people to enjoy nature 24/7, even in the dense urban setting.

4.4.3 Proposed Open Space System

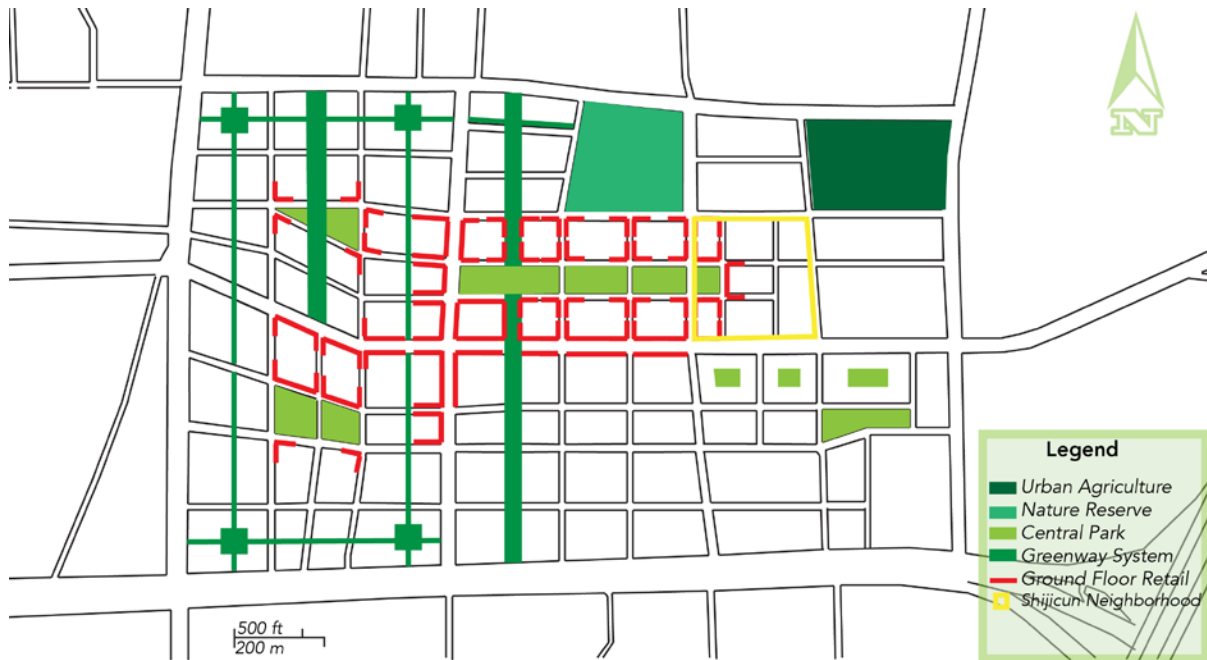


Figure 26: Proposed Open Space System and Retail Frontage

The current dense urban setting distances people and nature. As shown in figure 26, the proposed open space system is combined with greenways, central parks, nature reserve, and urban agriculture. The purposes of this open space design are to filter the air and noise of the area, bringing nature back to people, creating a healthy urban environment, and providing recreational and community engagement opportunities. Additionally, this open space system serves as green infrastructure to improve the sustainability of the area.

The linear design of the greenway system serves as a buffer between different land uses, provides recreational opportunities such as trails on site, and links neighborhoods and amenities.

In addition to the greenway space system, the current urban park in the north portion of

the study area would be redeveloped as an urban nature reserve. As trees and plants mature, more wildlife will be attracted to this urban nature reserve, which would also serve as a learning center for children, college students, and local residents. When people understand nature, they will protect it.

Urban agriculture provides safe food options, but also acts as a major social hub. It plays an important role in building connections between people. Students from schools and universities could participate in urban agriculture together with residents. People can learn about where and how vegetables and fruits grow. This locally grown produce also provides a safe, nutrition food source for local residents.

4.4.4 Proposed Transportation

As a major cause of air pollution in cities, transportation is the key to improve local air quality. Therefore, the creative project proposes improving transportation networks that de-emphasize automobiles and encourage people to walk, bicycle, and use public transit modes.

4.4.4.1 Street Network

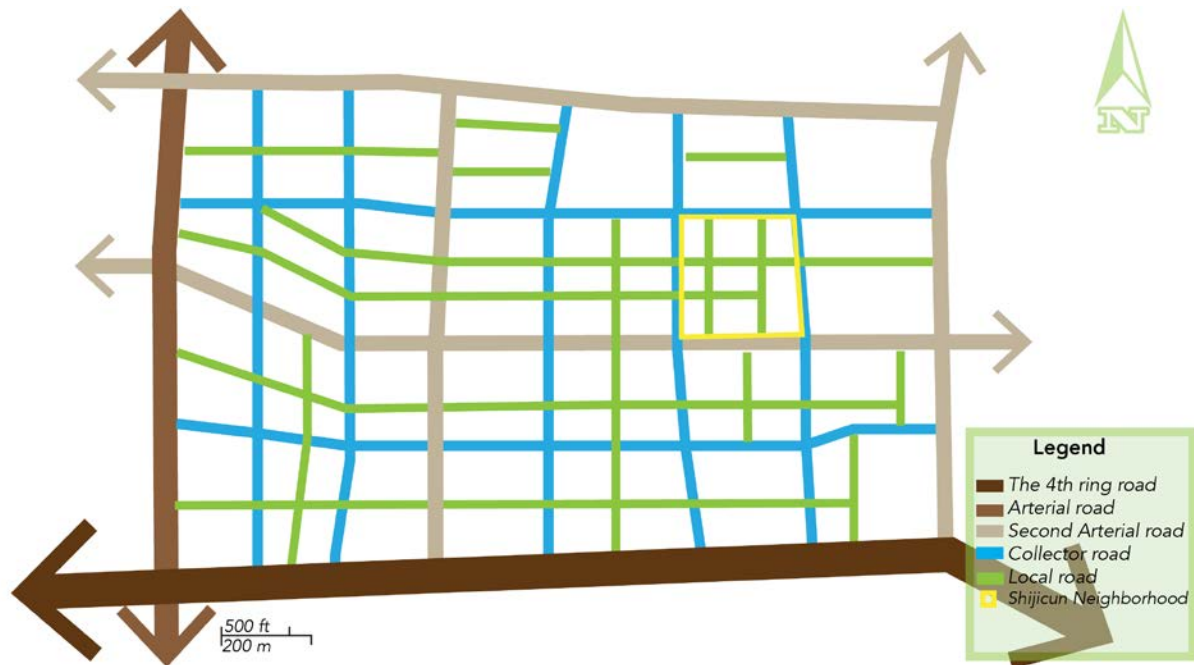


Figure 27: Proposed Street Network

Compared to the existing street network, the proposed circulation is more balanced and systematic. Figure 27 shows a hierarchy street network system to address connectivity. In addition to serving automobiles, this street network focuses on bringing bicycle culture back to people. All of these streets are reserved for cyclists and pedestrians and provide a safe environment for these two non-motorized transportation modes. The new connections create more nodes around the study area.

4.4.4.2 Multi-Modal Transportation

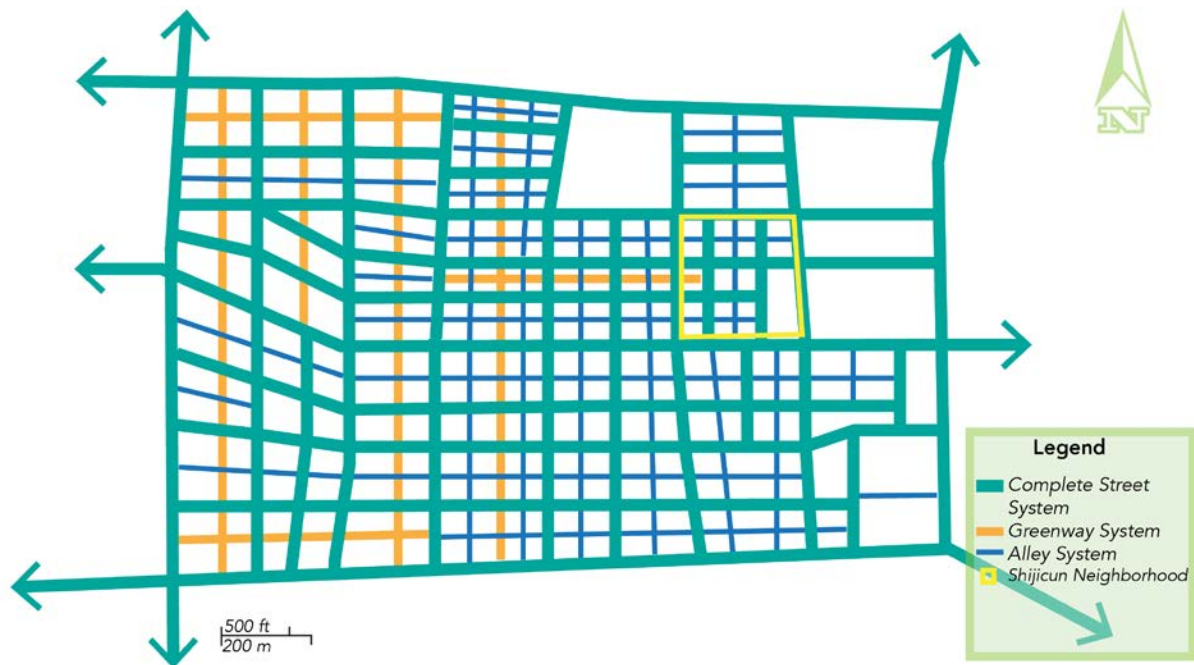


Figure 28: Proposed Non-Motorized System

Figure 28 represents a dense non-motorized grid. The Complete Street System has separated bike lanes, tree-lined sidewalks, and landscape medians. The Greenway System provides trails for people to reach multiple destinations. The Alley System serves as the shortcut between buildings. All of these would dramatically enhance walkability. Figure 29 illustrates a local road street section of Complete Street System.



Figure 29: Local Road Street Section

In addition to this non-motorized grid, carshare such as “Zipcar” and bikeshare are offered in the study area to encourage people to be less dependent on private-owned automobiles. Public transit is also improved with the installation of GPS, buses will be more efficient, so people can track them on-line to know when the next bus will come.

Reducing reliance on private automobiles and emphasizing more multi-modal transportation will dramatically improve air quality and enhance the overall quality of life for local residents.

4.4.5 Proposed Shijicun Neighborhood 2025 Plan



Figure 30: Shijicun Neighborhood 2025 Plan

The Shijicun Neighborhood 2025 Plan (figure 30) represents a typical residential neighborhood retrofitted to respond to environmental issues and population growth in Beijing. The existing Shijicun Neighborhood will be around 30 years old by 2025. Part of the older buildings will need to be retrofitted to serve as affordable housing. Retrofitting will also improve sustainability and energy performance. To accommodate the growing population, some older buildings must be demolished to clear land for new higher-density construction. The new construction also focuses on sustainability and energy performance. The following sections explain the design concepts and sustainable solutions.



Figure 31: Housing Diversity

4.4.5.1 Design Description

As shown in figure 31, dark yellow buildings have been retained and retrofitted with green infrastructure to provide affordable housing for low-income residents. These older buildings also remind residents about the history of this neighborhood. White buildings are higher-density new construction to accommodate population growth on the limited land. As shown in table 8, different unit sizes are provided for diverse populations. As illustrated in figure 32, high-rise buildings are combined with bases and towers. Bases provide retail and affordable housing, and towers provide up-scale housing. About 2,259 units are available to house the expected population growth in 2025.

Housing Types	Size of Unit (square foot)	Proposed New Construction Number of Units	Retained Buildings Number of Units	Total Number of Units
Affordable Housing	700	358	165	523
	900	543	196	739
Up-Scale Housing	1,200	563	NA	563
	2,000	434	NA	434
				2,259

Table 8: Proposed Shijicun Neighborhood Housing Types and Units

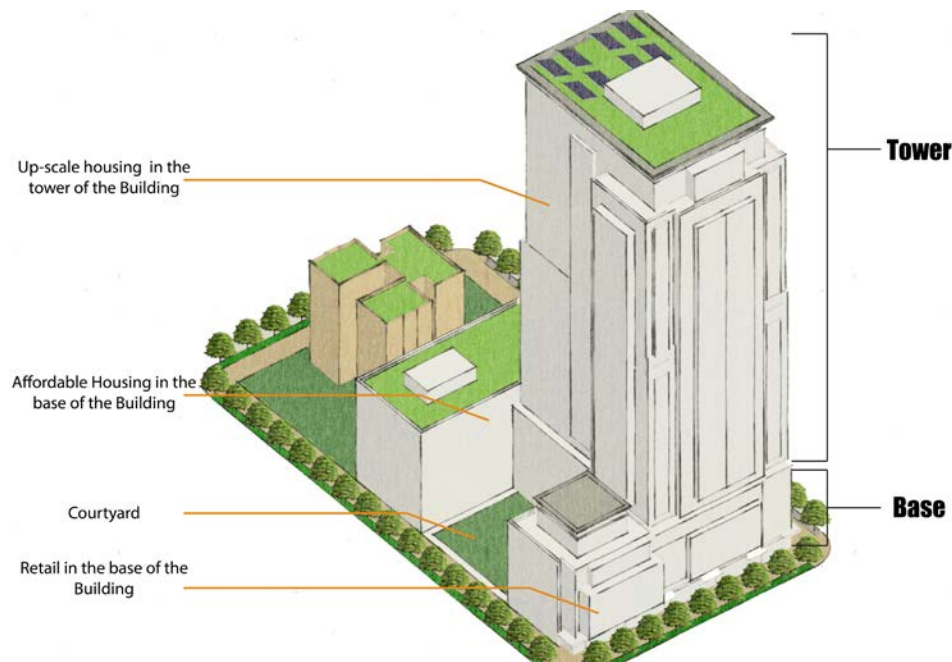


Figure 32: High-rise Building Illustration

Two buildings on the west of the neighborhood are retail and residential mixed-uses. Grocery store, cafes/restaurants, pharmacy, post office, banks, and other amenities are located in the lower three floors, whereas the rest of the buildings are residential. Residents can easily obtain what they need in the neighborhood.

A small block of open space is attached to the central park, enhancing the connection between the neighborhood and the whole area. Every high-density building has a small courtyard

to provide open space. The exposed portion of the base roof provides a secondary open space in the dense urban environment.

Although high-rise buildings have bases to maximize footprints, they do not disconnect the alley system. As shown in figure 33, passageways allow people to pass through bases.

Underground parking saves more desirable space for other uses.



Figure 33: Passageways Connect with Alleys

4.4.5.2 Sustainability

Solar panels are installed on rooftops to maximize the provision of renewable resources and reduce coal-generated energy use. Together with green roofs, this makes efficient use of all spaces in the dense urban setting (figure 34).

As shown in figure 34, green infrastructure such as green roofs, rain gardens, bio-swale medians, and pervious pavements are installed to manage rainwater. The rainwater collection

system catches rainwater from roofs, helping avoid wasting fresh water. The collected rainwater can be used for garden irrigation. This green infrastructure provides stormwater management, which is especially important in the dense urban setting.

These sustainable solutions help to improve air quality and sustainability in this neighborhood.

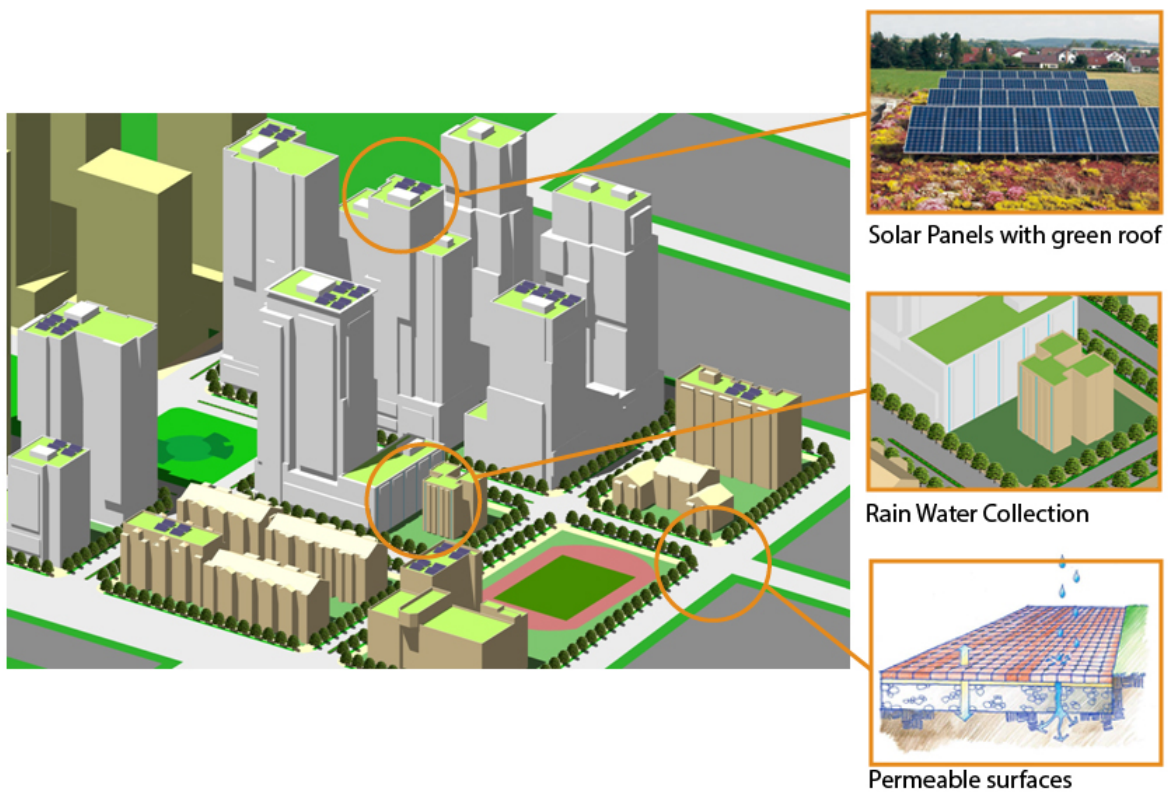


Figure 34: Green Infrastructure Illustration



Figure 35: View from Harmony Central Park

4.4.5.3 Baseline, Business As Usual, and Proposed Plan Scenarios

Three scenarios are compared in this section. Baseline shows the scenario Shijicun Neighborhood experienced in 2012. Business as usual illustrates what the impacts of the same amount of population growth without a sustainability plan. This includes air quality, vehicle mileage travelled, open space, and other impacts by year 2025. Shijicun 2025 plan shows the scenario with the adoption of sustainable planning and design.

Table 9 compares population, dwelling units, and density of Shijicun Neighborhood between baseline, business as usual, and Shijicun 2025 Plan.

	Population	Dwelling Units	Density (Dwelling Unit/Acre)
Baseline in 2012	3,401	1,388	81
BAU in 2025	4,969	2,259	131
Shijicun 2025 Plan	4,969	2,259	131

Table 9: Population, Dwelling Units, and Density Comparison

	Air Quality-PM2.5 (Pound/Year)	Open Space (S.F.)	VMT (Mile/Year)	Water Consumption (Gal/Year)	Pervious Surface Percentage
Baseline in 2012	1,303	54,406	15,093,112	34,149,951	12%
BAU in 2025	1,928	54,406	24,564,366	49,894,474	3%
Shijicun 2025 Plan	996	178,293	15,794,928	31,704,265	88%

Table 10: Air Quality and Sustainability Comparison

Table 10 compares air quality-PM2.5, open space, vehicle miles traveled, water consumption, and pervious surface between baseline, business as usual, and Shijicun 2025 Plan.

Table 10 indicates Shijicun 2025 Plan has significantly improved environmental performance.

Estimated environmental improvements include:

- **Air Quality-PM2.5:** The methodology to estimate PM2.5 basically includes calculations of PM2.5 from vehicle mileage traveled (VMT) and coal-generated electricity. The calculation of PM2.5 from VMT uses US Environmental Protection Agency (EPA) data because the relationship between PM2.5 and VMT is unavailable in China. The US EPA estimates that the average PM2.5 emission from passenger cars per mile driven is 0.0041 gram (Office of Transportation and Air Quality, 2008). The calculation of PM2.5 from

coal-generated electricity combines data from both China and United States. According to the Beijing Municipal Bureau of Statistics (2012), residential electricity consumption per capita in Beijing in 2011 was 727.2kwh. Also, about 80% of the country's electricity is generated by coal-fueled power plants (Center for Climate and Energy Solutions, 2010). Generating 1 MWh by coal emits about 0.59 lbs PM2.5 (Geothermal Energy Association, 2013). As shown in table 11, PM2.5 in 2025 with business as usual would be 1,928 pounds per year for the whole population of Shijicun Neighborhood. The Shijicun 2025 Plan will achieve a 24% reduction of PM2.5 over 2012 baseline levels. Table 11 shows detailed data of PM2.5 from vehicle mileage traveled and coal-generated electricity.

	Population	PM2.5 from VMT (Pound/Year)	PM2.5 from Coal-Generated Electricity (Pound/Year)	Total PM2.5 (Pound/Year)
Baseline in 2012	3,401	136	1,167	1,303
BAU in 2025	4,969	222	1,706	1,928
Shijicun 2025 Plan	4,969	143	853	996

Table 11: Air Quality-PM2.5 Estimation

- Vehicle Mileage Traveled (VMT): A survey showed that the average VMT in Beijing in 2008 was 10,874 Miles (Huo, Zhang, He, Yao, & Wange, 2012). With fewer miles travelled and more efficient cars, the Shijicun 2025 Plan will achieve a 36% reduction of VMT over 2012 baseline levels. Table 12 shows detailed numbers of VMT and comparisons of baseline levels.

	Dwelling Units	Annual VMT (Mile/Dwelling Unit)	VMT (Mile/Year)	VMT Change
Baseline in 2012	1,388	10,874	15,093,112	-
BAU in 2025	2,259	10,874	24,564,366	62% increase over baseline
Shijicun 2025 Plan	2,259	6,992	15,794,928	36% reduction over baseline

Table 12: VMT Estimation

- **Water Consumption:** In 2003, Beijing's residential water use was about 104.14 L/person/day (27.51 gallon/ person/day) (Zhang, Deng, Yue, & Cui, 2007). The baseline data of water consumption is based on historic data from that survey.

The Shijicun 2025 Plan would significantly improve air sustainability. It would reduce PM2.5 by 24% compared to baseline, 48% compared to business as usual, dramatically improving air quality (figure 36). Open space would increase 327% by providing community parks, courtyards, base roofs, and green alleys (figure 37). An efficient multi-modal transportation system and jobs-housing balance help to achieve VMT reduction of 36% compared to business as usual (figure 38). Collecting rainwater would save 11% of water, and using water-efficient appliances and a wastewater recycling system would save another 15% (figure 39). The Shijicun 2025 Plan increases pervious surface 88% with the installation of green roofs, bio-swale medians, and pervious pavement (figure 40).

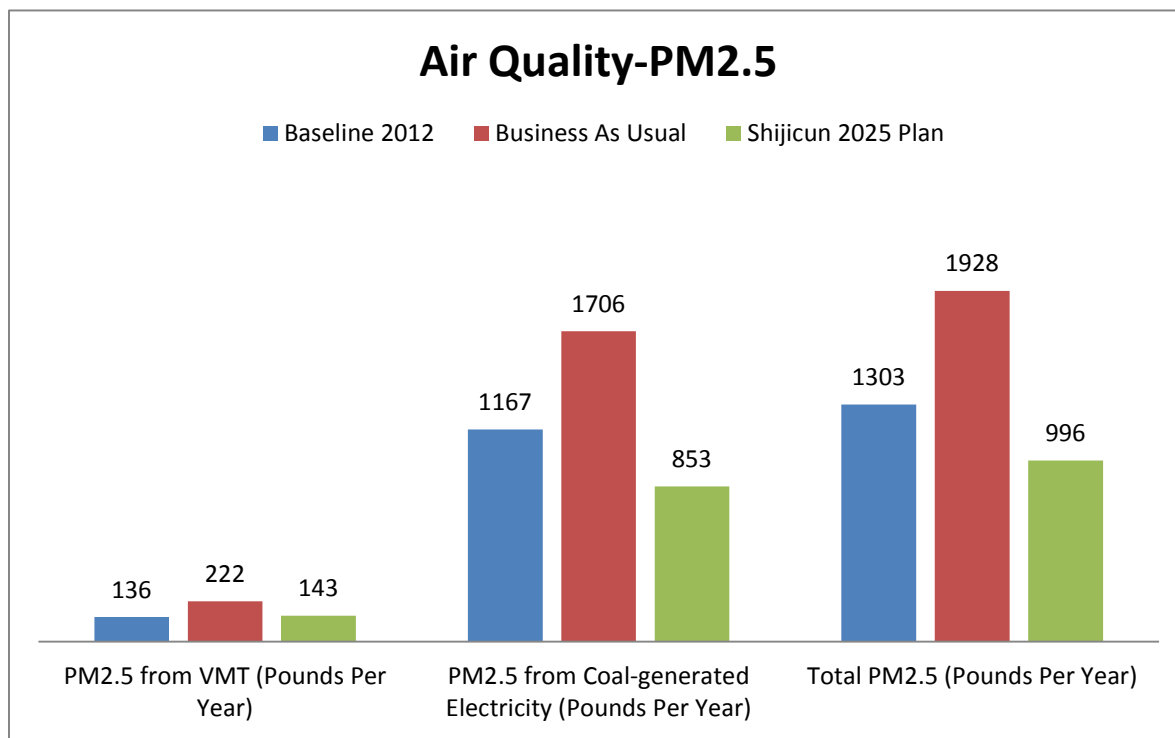


Figure 36: Air Quality-PM 2.5 Estimation

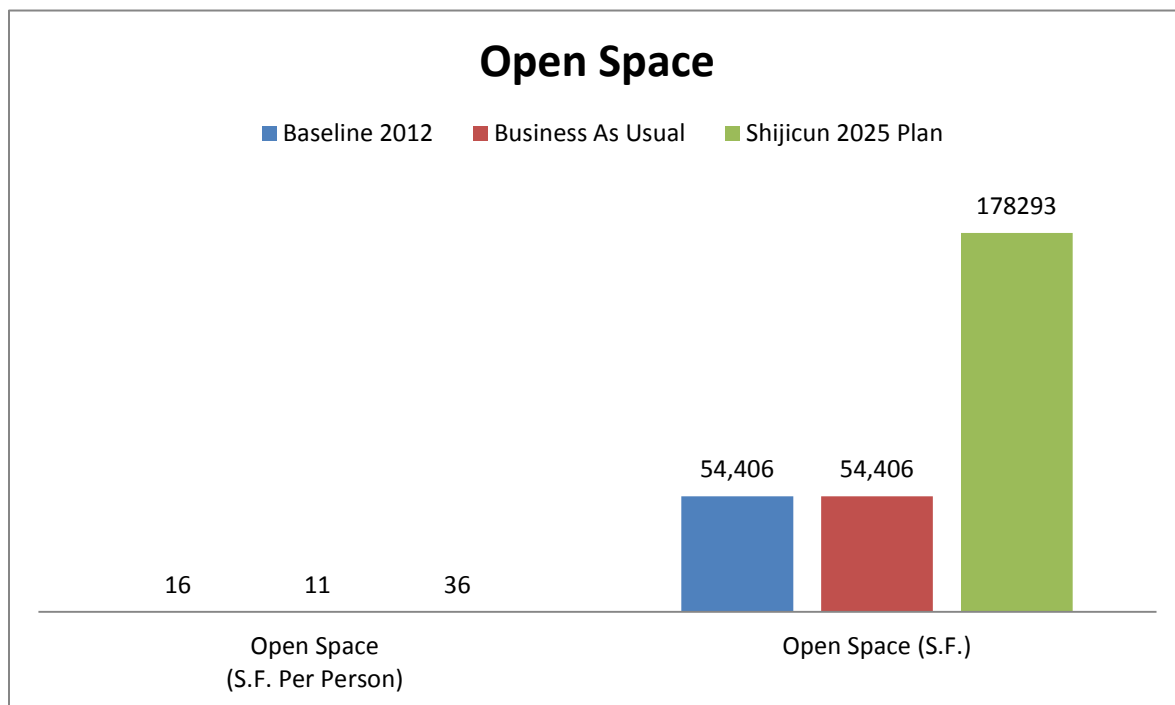


Figure 37: Open Space Estimation

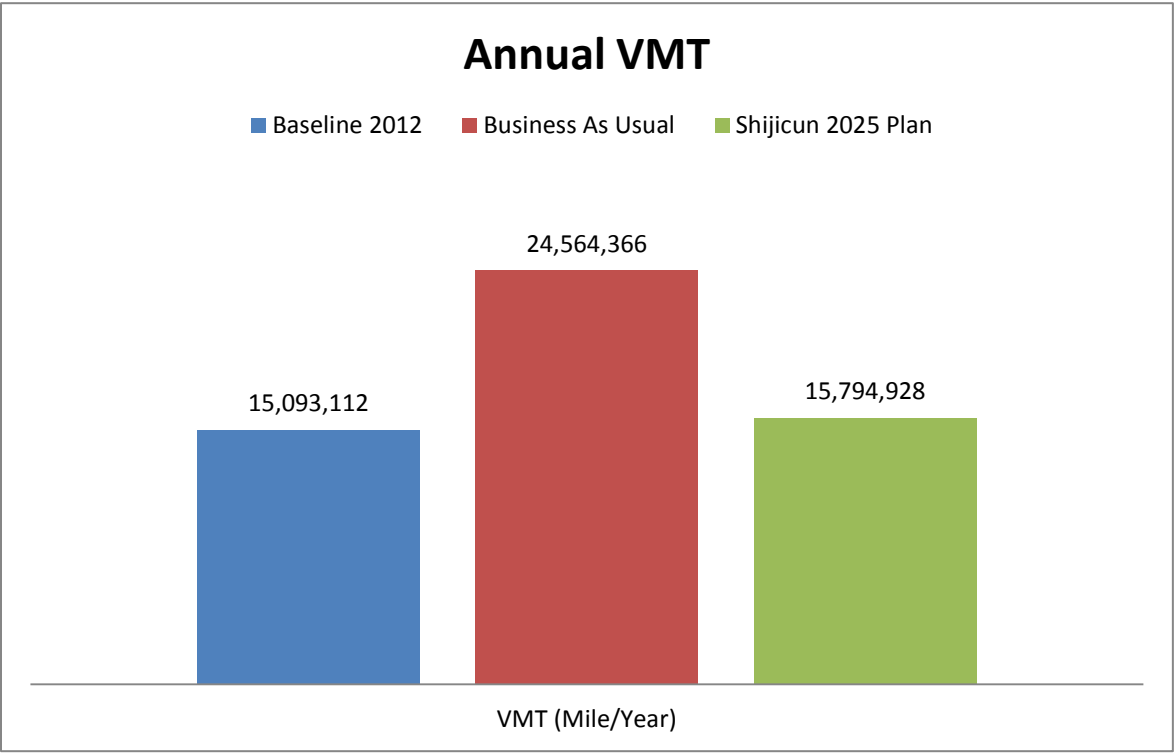


Figure 38: Annual VMT Estimation

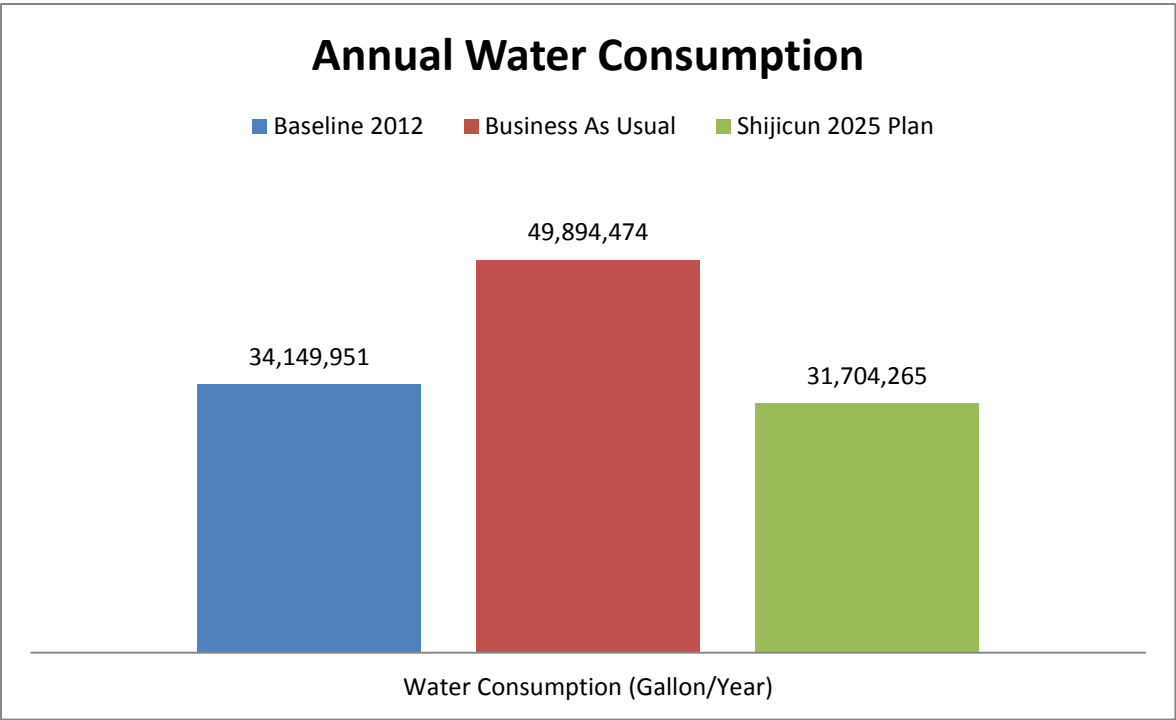


Figure 39: Annual Water Consumption Estimation

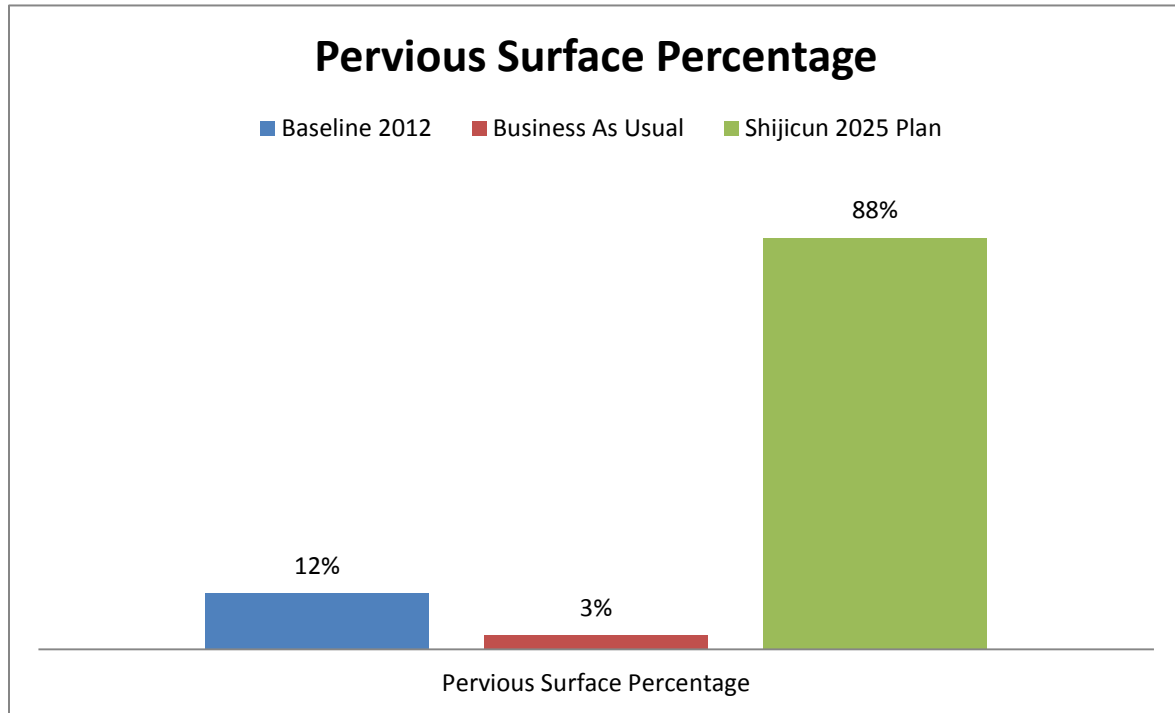


Figure 40: Pervious Surface Percentage Estimation

4.5 Implementation

Although this creative project has developed a sustainable neighborhood plan, implementing it is the key to achieve this long-term vision. This will require jurisdictions, citizens, and non-governmental organizations to collaboratively participate in the planning process. In addition, as part of implementation, education is essential to improve the general public's perception of the environment and sustainability. Different organizations must cooperate to improve the general public's attitudes toward sustainability. From kindergarten education to public service advertising, intentionally letting environmental protection become a part of people's daily life.

The following shows a brief description of the implementation:

- a. **Municipal Government:** The Beijing Municipal Government must play a key role in the plan implementation. The government has already realized growing problems and should govern air quality regulations and enforcement. They also should adopt good design and management to improve urban environmental infrastructure. Also, they should encourage people to live near jobs by subsidizing housing.
- b. **Non-Governmental Organizations (NGOs):** NGOs are also involved in plan implementation. They work to promote adoption of the plan and directly help residents understand these sustainable solutions. NGOs will develop activities in the communities to show the plan and explain solutions to the residents.
- c. **Local Institutions and Neighborhoods:** A volunteer program should be organized to help residents shape the community identity. Students and residents can both participate in the volunteer program, working together to mitigate urban environmental issues.

4.6 Conclusion

By addressing the urban design proposal at two different scales, a vision for mitigating air pollution and achieving a sustainable future has been shown in the 2025 Plan. Also, the implementation of the 2025 Plan should involve several stakeholders.

5.0 Conclusion

5.1 Summary

The harmony between human and nature is one of the most precious elements in Chinese traditional culture. However, erratic urban development is unbalanced today. China must recognize this and make a change.

This creative project presents opportunities for retrofitting a neighborhood in Beijing to be sustainable. By addressing issues of low air quality, unbalanced jobs-housing land use, lack of renewable resources and green infrastructure, population and private-automobile growth, and superblock urban patterns, Shijicun neighborhood can achieve a sustainable future. Through illustrations of community-scale land use and transportation planning, and neighborhood-scale building density, types, and green infrastructures, this creative project proposes the development of a sustainable community. Further, this neighborhood proposal offers a sustainable model for Beijing and other rapidly expanding Chinese cities. When implemented, this community and neighborhood plan could be the prototype from which lessons can be learned to retrofit other neighborhoods in Beijing.

5.2 Further Research Needed

This creative project only briefly illustrated the sustainable solutions, and further work should include more detailed calculations of carbon emissions savings and detailed analysis of

how the rainwater collection system works. Those are the opportunities for further research.

The implementation section only briefly described three layers of stakeholders, and more detailed research could be conducted with more time. Further research will focus on involving other stakeholders in the implementation.

BIBLIOGRAPHY

- Anhuidongli Community. (2012). *Community Introduction*. Retrieved March 15, 2013, from Anhuidongli Community: <http://www.dtanhuidongli.com/sqjs/>
- Beijing Municipal Bureau of Statistics. (2001). *Beijing Statistical Yearbook 2000*. Beijing: China Statistics Press.
- Beijing Municipal Bureau of Statistics. (2005). *Beijing Statistical Yearbook 2004*. Beijing: China Statistics Press.
- Beijing Municipal Bureau of Statistics. (2009). *Beijing Statistical Yearbook 2008*. Beijing: China Statistics Press.
- Beijing Municipal Bureau of Statistics. (2011). *Beijing Statistical Yearbook 2010*. Beijing: China Statistics Press.
- Beijing Municipal Bureau of Statistics. (2012). *Beijing Statistical Yearbook 2011*. Beijing: China Statistics Press.
- Beijing Traffic Management Bureau. (2013, April 5). *Beijing Traffic Management Bureau*. Retrieved April 5, 2013, from Beijing Traffic Management Bureau: <http://www.bjjtgl.gov.cn/publish/portal0/>
- Beijin Union University. (2012). Retrieved March 2013, from Beijin Union University: <http://www.buu.edu.cn>
- Center for Climate and Energy Solutions. (2010). *Coal and Climate Change Facts*. Retrieved February 2, 2013, from Center for Climate and Energy Solutions: <http://www.c2es.org/science-impacts/basics/fact-sheets/coal-facts>
- Cervero, R. (2006). Balanced transport and sustainable urbanism: Enhancing mobility and accessibility through institutional, demand management, and land-use initiatives. Retrieved March 12, 2013, from Escholarship: <http://www.escholarship.org/uc/item/6mv8d15f>
- China Air Daily. (2013). *Monthly Charts of PM2.5 Levels From China Air Daily*. Retrieved June 16, 2013, from China Air Daily: <http://chinaairdaily.com/PM25/>

- China Women's University. (2012). *University Introduction*. Retrieved March 2013, from China Women's University: <http://www.cwu.edu.cn/cwu/mainstation1/xygk/?flag=4>
- Ernst & Young. (2011). *Impact of Beijing's license quota system on the Chinese automotive industry*. EYGM Limited: [http://www.ey.com/Publication/vwLUAssets/Auto_Beijing/\\$FILE/Auto_Beijing.pdf](http://www.ey.com/Publication/vwLUAssets/Auto_Beijing/$FILE/Auto_Beijing.pdf)
- Geothermal Energy Association. (2013, May). *Promoting Geothermal Energy: Air Emissions Comparison and Externality Analysis*. Retrieved June 24, 2013, from Geothermal Energy Association: http://geo-energy.org/reports/Air%20Emissions%20Comparison%20and%20Externality%20Analysis_Publication%20May%202013.pdf
- Girardet, H. (2008). *Cities, People, Plant: Urban Development and Climate Change*. Chichester: John Wiley & Sons Ltd.
- Greenpeace. (2012). *Air Pollution in China*. Retrieved March 15, 2013, from Greenpeace East Asia: <http://www.greenpeace.org/eastasia/campaigns/air-pollution/problems/china/>
- Huo, H., Zhang, Q., He, K., Yao, Z., & Wange, & M. (2012). Vehicle-use intensity in China: Current status and future trend. *Energy Policy*, 43(6), 16.
- Li, W. (2012, April 12). *自行车王国陷入困境 自行车出行环境“恶劣”* (*The Bicycle Kingdom is in a dilemma, cycling is in adverse circumstances*). Retrieved May 12, 2013, from [www.ce.cn](http://luxury.ce.cn/html/2012/today_0412/52300.html): http://luxury.ce.cn/html/2012/today_0412/52300.html
- Li, X., Zhou, W., & Ouyang, Z. (2013). Forty years of urban expansion in Beijing: What is the relative importance of physical, socioeconomic, and neighborhood factors? *Applied Geography*, 38, 1–10.
- Lin, Y. (2011, June 1). *Experts Make Huge Revisions to Beijing Population Projections*. Retrieved March 12, 2013, from Caixin Online: <http://english.caixin.com/2011-06-01/100265200.html>
- Liu, J., & Diamond, J. (2005). China's environment in a globalizing world. *Nature*, 435(7046): 1179-1186.
- Loew, S. (2012). *Urban Design Practice*. London: RIBA Publishing.

- McKinsey Global Institute. (2011). *Urban world: Mapping the economic power of cities*. McKinsey Global Institute.
- Ministry of Environmental Protection of China. (2012). *2011 Report on the State of the Environment of China*. Beijing: Ministry of Environmental Protection of China.
- National Bureau of Statistics of China. (2011). *China Statistical Yearbook*. Beijing: China Statistics Press.
- Office of Transportation and Air Quality. (2008, October). *Average Annual Emissions and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Trucks*. Retrieved June 24, 2013, from The US Environmental Protection Agency: <http://www.epa.gov/otaq/consumer/420f08024.pdf>
- Oulujingdian Community. (2012). *Community Introduction*. Retrieved March 15, 2013, from Oulujingdian Community: <http://www.dtoulujingdian.com/sqgk/>
- Photos: China's History of Bicycles*. (1986). Retrieved May 12, 2013, from The Urban Country: <http://www.theurbancountry.com/2013/02/photos-chinas-history-of-bicycles.html>
- Qian, L. (2012, November 2). *Beijing tops other cities in commuting time*. Retrieved May 1, 2013, from People's Daily Online: <http://english.people.com.cn/90882/8002034.html>
- Shijicun Community. (2012). *Community Introduction*. Retrieved March 15, 2013, from Shijicun Community: <http://www.dtsjcsq.com/sqjj/>
- Strompen, F., Litman, T., & Bongardt, D. (2012, August 4). *Reducing Carbon Emissions through Transport Demand Management Strategies*. Retrieved May 1, 2013, from Transport Demand Management: http://tdm-beijing.org/index.php?option=com_flexicontent&view=category&cid=12&Itemid=9
- The Beijing Mass Transit Railway Operation Corp. (2013, May 3). *Beijing Subway Map*. Retrieved May 12, 2013, from Beijing Subway: <http://www.bjsubway.com/node/3158/>
- The U.S. Energy Information Administration. (2012, September 4). Retrieved May 10, 2013, from China-Analysis-U.S. Energy Information Administration (EIA): <http://www.eia.gov/countries/cab.cfm?fips=CH>

- Union of Concerned Scientists. (2013, April 8). *Benefits of Renewable Energy Use*. Retrieved May 10, 2013, from Union of Concerned Scientists: http://www.ucsusa.org/clean_energy/our-energy-choices/renewable-energy/public-benefits-of-renewable.html#
- Wang, Q. (2012, May). *A Shrinking Path for Bicycles: A Historical Review of Bicycle Use in Beijing*. Retrieved May 15, 2013, from https://circle.ubc.ca/bitstream/handle/2429/42523/SCARP_2012_gradproject_Wang.pdf?sequence=1
- Wong, E. (2013, April 2). *Air Pollution Linked to 1.2 Million Premature Deaths in China*. Retrieved April 23, 2013, from *The New York Times*: <http://www.nytimes.com/2013/04/02/world/asia/air-pollution-linked-to-1-2-million-deaths-in-china.html>
- Wong, E. (2013, April 4). *Two Major Air Pollutants Increase in China*. Retrieved April 23, 2013, from *The New York Times*: http://www.nytimes.com/2013/04/04/world/asia/two-major-air-pollutants-increase-in-china.html?_r=0
- World Health Organization. (2011, September). *Air quality and health*. Retrieved February 2, 2013, from World Health Organization: <http://www.who.int/mediacentre/factsheets/fs313/en/>
- Yao, Q., & Wei, W. (2012). Gated Community: The past and present in China. *World Academy of Science, Engineering and Technology*, 71(115), 691-693.
- Yuhuili Community. (2012). *Community Introduction*. Retrieved March 2013, from Yuhuili Community: <http://www.yhlsq.com/jianjie/>
- Yuhuixili Community. (2012). *Community Introduction*. Retrieved March 15, 2013, from Yuhuixili Community: <http://www.yhxlq.com/sqdj/20110803/139253.shtml>
- Zhang, S., Deng, L., Yue, P., & Cui, H. (2007). *Study on Water Tariff Reform and Income Impacts in China's Metropolitan Areas: The Case of Beijing*. Retrieved June 1, 2013, from The World Bank: <http://siteresources.worldbank.org/INTEAPREGTOPENVIRONMENT/Resources/ReportWaterpricingBeijingENFinal.pdf>

Zheng, X. (2013, January 4). *Capital's subway system branches out*. Retrieved May 10, 2013,
from China Daily:
http://www.chinadaily.com.cn/cndy/2013-01/04/content_16078926.htm