Urban regeneration in the future of self-driving: a case study on Beijing's baitasi historic area

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Urban Regeneration in the Future of Self-Driving: A Case Study on Beijing's Baitasi Historic Area

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Abstract*:*

Self-driving vehicles could become both widely available and considerably safer than today's automobiles in the upcoming 15 years. Their ability to provide sharing mobility services could enable cities to recapture most of the street public space once devoted to parking, and to redesign this space for bike lanes, wider sidewalks, transit services, or more public spaces that would make it easier and healthier to live in the city center without owning a car.

Selecting Beijing's Baitasi hutong as a case study, this paper explores a new approach that combines social sciences and computer sciences methodologies to answer a research question around sustainable urban regeneration for the historic area within dense inner-city. The study consists of two parts: 1) Data collection and analysis include: conducting a field audit at the study area collecting street view image data and multi-source information on mobility, living conditions, and social behavior, then running computer-assisted geospatial analysis with data retrieved from image recognition through Baidu APIs and OpenCV using Python language; 2) Proposing an integrated vision of "Streets for People, Hutongs for All" toward a human-centered inclusive urban future in the era of self-driving vehicles, as well as policy recommendations on collaborative creation and governance to ensure the implementation of new design plan. Upon assessing existing mobility and demographic problems within the historic inner-city, the report discussed the potential urban regeneration plan to harness the disruptive self-driving technology.

This study aims to provide reference for small-scale street spatial transformation in residence-oriented historic blocks, and to propose preliminary guidance for key actors regarding the policy decisions, infrastructure investments as well as technology innovations that are necessary to leverage self-driving benefit to create a new urban life that is more inclusive, resilient, and sustainable, thus to help cities to achieve SDG target 11.2 and facilitate implementation of the New Urban Agenda as well.

Keywords: Urban Regeneration, China, Image Recognition, Sustainable Mobility, Public Space

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Introduction

The twenty-first century is in the midst of massive urban expansion and radical growth of the urban population. Globally, another 2.5 billion people will settle in cities by 2050, which means two out of every three people are likely to be living in cities or other urban centers, highlighting the need for more sustainable urban planning and public services (United Nations, 2018). Urbanization represents one of the most severe challenges of our times, mainly because of rising social inequalities, unprecedented demographic shifts, and environmental degradation. Against the backdrop of rapid urbanization, global attention is increasingly drawing to future pathways of sustainable development.

The year 2016 is a remarkable milestone in the history of urban sustainability, because the United Nations Conference on Housing and Sustainable Urban Development (Habitat III) held from 17-20 October in Quito, Ecuador, was the first global summit on urban issues since the adoption of the 2030 Agenda for Sustainable Development Goals (SDG) in 2015, which includes SDG 11 on Sustainable Cities and Human Settlements. Given the long interval between Habitat conferences – the first Habitat conference took place in Vancouver in 1976, and Habitat II gathered in Istanbul 20 years later – Habitat III offered a unique opportunity to shape the urban development landscape for coming decades[i]. Besides, Habitat III established a global platform for world leaders to discuss the critical challenges that cities, towns, and villages are facing in regard to planning and management toward a sustainable future, while shaping the implementation of the SDGs and the Paris Agreement on Climate Change as well[ii].

Moreover, Habitat III successfully delivered its promise with the adoption of the New Urban Agenda (NUA), a non-legally binding framework that will provide an urbanization action blueprint to guide sustainable urban development for 20 years. The NUA represents a shared vision for a better and more sustainable future. "If well-planned and well-managed, urbanization can be a powerful tool for sustainable development for both developing and developed countries[iii]." The first paragraph under the shared vision section is the "right to the city," an overarching term that encompasses political power relationships, land appropriation, and social justice within the context of "global cities" that are undergoing massive urbanization. It represents one of the shared visions, "cities for all", referring to "the equal use and enjoyment of cities and human settlements, seeking to promote inclusivity and ensure that all inhabitants, of present and future generations, without discrimination of any kind, are able to inhabit and produce just, safe, healthy, accessible, affordable, resilient and sustainable cities and human settlements to foster prosperity and quality of life for all" (Habitat III, 2016, p.4, #11).

Over the past decade or so, the right to the city has become one of the more talked-about concepts in urban studies. In policy circles, in the academy, and among activists, it is frequently invoked and championed. Other organizations like UNESCO and Habitat International Coalition (HIC) have also led an effort to conceptualize the right to the city as part of a broader agenda for human rights (Brown & Kristiansen, 2008; Sugranyes &

Mathivet, 2011). Moreover, the “right to the city” could be a new paradigm that provides an alternative framework to rethink cities and urbanization. It envisions the effective fulfilment of all internationally agreed human rights, sustainable development objectives as expressed through the SDGs, and the commitments of the NUA.

Essentially, the concept of “right to the city” emphasizes the need to maximize the engagement of citizens in local governance to avoid further marginalization. Advocates underscore the centrality of thinking about living space and public space within the right to the city concept, and routinely note that urbanization is a fractious process that creates tension among different groups inhabiting cities. The goal is to encourage urban policies that promote justice, sustainability, and inclusion in cities. To reclaim the right to the city, therefore, is in a sense to reclaim some shaping power over the process of urbanization, over how our cities are made and remade, and to do so fundamentally and radically.

Another paragraph under the shared vision is to envisage cities and human settlements that “promote age- and gender-responsive planning and investment for sustainable, safe and accessible urban mobility for all, and resource-efficient transport systems for passengers and freight, effectively linking people, places, goods, services and economic opportunities” (Habitat III, 2016, p.4, #13(f)). Mobility and transportation is at the central part of urban life, and is identified as a significant component of sustainable development by the United Nations (UN). In the 2030 Agenda for SDGs, sustainable transportation is underlined across several SDGs and targets, notably those related to food security, health, energy, infrastructure, economic growth, and cities and human settlements. Closely related SDGs include Goal 3: Good health and well-being, Goal 9: Industry, innovation and infrastructure, and Goal 11: Sustainable cities and communities[iv].

To the implementation of the 2030 Agenda for SDGs, understanding the key trends in urbanization likely to unfold over the coming years is crucial, especially in China, for the scale of China’s urbanization is without precedent in human history. According to the World Urbanization Prospects (WUP), in China, where the total number of cities has reached the first place in the world, the urban population has grown to 837 million in 2018, accounting for 59% of the total population and 20% of the global total, followed by India, with 461 million urban dwellers, and the United States, with 269 million urban dwellers (United Nations, 2018, p.37). Of the world’s 33 megacities—that is, cities with 10 million inhabitants or more—in 2018, 27 are located in the less developed regions or the “global south”, and China alone was home to 6 megacities in 2018. By 2050, China is projected to add 255 million urban dwellers that is equivalent in size to 31% of the urban population in the country in 2018 (United Nations, 2018, p.43).

Besides urbanization, all societies in the world are in the midst of a longevity revolution—some are at its early stages while some are more advanced. According to the 2019 Revision of World Population Prospects, by 2050, 1 in 6 people in the world will be over the age of 65, up from 1 in 11 in 2019 (United Nations, 2019). Traditionally, the UN and most researchers have defined older persons as those aged 60 or 65 years or over. According to another report, World Population Ageing 2019, in China, it will take only two decades (between 2017-2037) for the proportion of the elderly population to double from

10% to 20%, overpassing Japan where it took 23 years. In contrast, it took 61 years in Germany and 64 years in Sweden. Moreover, China's dependency ratio for retirees—those aged 65 or older divided by total working population—as at 2015 was 14%, and the UN estimates this could rise as high as 44% by 2050 (United Nations, 2019).

Unlike many countries where a city typically represents a permanent urban residential settlement, Chinese cities (市, shì) often reflect a political-administrative unit covering an area much larger than the urban area, which typically includes an urbanized core surrounded by extensive rural areas. Within such spatial context, the conflict between the needs for economic development and sustainable urbanization becomes increasingly prominent, and the relationship between urban and rural residents is becoming closer. After decades of rapid urbanization, cities in China have finally started to pay more attention to the existing built-up areas, instead of exploring new territories and expanding. Urban regeneration is playing an increasingly important role in reshaping spatial structures in city-regional levels and urban form at the neighborhood level. Such urban planning strategies imply a paradigm shift in China regarding urban development styles, from aggressive urban expansion to retrofitting the existing built environment adaptation, pursuing more sustainable ways of development.

However, driven by demand on land for large-scale redevelopment, especially in central urban areas, blank slate approaches have been adopted in the renewal of old urban fabrics, such as historic inner-city districts and the so-called "urban villages." As a consequence, problems related to gentrification and decrease of affordable housing in central urban areas arose. *Hutong*, as a distinctive architectural and organizational structure in the capital city of Beijing, is in the spotlights of the conflicts between China's historical heritage and its modernization. As one of the first twenty-five historical and cultural preservation zones in the inner-city of Beijing, Baitasi hutong is selected for the case study of this paper due to its complexity and typicality, which makes it a preferred microcosm sample of Chinese urban regeneration. One problem commonly seen in hutong is that the residents usually suffer from poor mobility conditions due to narrow streets and strict regulations from substantial retrofitting. A feasible solution to this problem could be the adoption of self-driving vehicles in order to provide safe, efficient, and convenient transportation services to the residents, which are mostly older people, and recapture the public space that used to be occupied by parking vehicles. Researchers found that older adults are willing to adopt self-driving vehicles as a mode of transportation (Rahman, Deb, Strawderman, Smith, & Burch, 2019).

According to business intelligence, 10 million self-driving cars will be on the road by 2020, with one in four cars being self-driving by 2030 (Garret, 2017). However, it remains debatable that if a self-driving future in which everyone travels in driverless even flying cars is around the corner. Though with less doubt, if we are to meet the SDG 11 on sustainable cities and communities, a more revolutionary (although more low-tech) picture shall unfold, where people are moving freely and swiftly — but not by private car. Reducing our dependence on petrol vehicles is not only better for the planet and public health, it will pave the way for a better chapter for our dense cities. From improving mobility and ensuring citizen participation in how cities are planned, managed, and experienced, to restoring the social fabric that will make our communities more cohesive and resilient, a shift towards car-free, age-friendly, human-centered streets can help our cities not only survive, but thrive.

Though few studies have addressed sustainable urban mobility within the historic inner-city in the era of self-driving, this study aims to fill this gap and shed light on cities with similar mobility challenge in the inner-city urban area. Like most historic cities in the world, Beijing's inner-city has been left deeply wounded by the twentieth century's dual urban legacy: First, the inner-city had been gradually reoriented around private vehicles; second, public spaces and resources had largely been privatized due to the surging population and property price. This dual urban legacy can be observed clearly in Baitasi hutong, where intensive street parking took over sidewalks in the narrow alleys, and different types of additionally built informal housings filled the courtyard and thus forming a typical large miscellaneous hutong neighborhood with disorderly and constrained space.

Therefore, the goal of this study is to examine the relationships between sustainable mobility and public space in a dense urban area, based on which to propose an integrated design plan in the future of self-driving, and policy suggestions accordingly. The main research question is: exploring a sustainable urban mobility solution for the historic hutong area within inner-city, using street view images to propose a data-informed regeneration plan. Furthermore, this paper attempts to fulfill two main research objectives based on the author's three-week in-person field audit that took place in early September 2019: First, collecting street view image data and multi-source information on mobility, living conditions, and social behavior; Second, applying the computer-assisted geospatial analysis on the data retrieved from image recognition to identify the spatial patterns of the existing street environment.

Results from the empirical investigation and computer-assisted research are expected to help identify the prominent mobility and other living problems arising in the process of rapid urbanization based on the unique social context of China, and further provide scientific ground for the new design plan on mobility and space, as well as policy suggestions to optimize the urban regeneration of historic inner-city leveraging a self-driving future. With this being said, a human-centered solution at the community level should be explored to find a way of urbanization and modernization for a populous and high-density neighborhood in hutong. The redesign goal is to support creative urban innovation that contributes to inclusive communities where all people and nature can flourish.

The rest of this paper starts with the detailed field audit including in-person street view image collection and mobility surveys at the selected Baitasi historic hutong, as well as the urbanization history of the capital city and demographic background of the study area; then presents a review of relevant contemporary literature on the development of urban sociology theories around the human-centered concept, the best practices of urban regeneration on historic districts within the inner-city of Beijing, and the emerging street view image data processing used for field audit and space quality analysis; the computer-assisted image recognition analysis using multiple tools and methods is examined in the following section to provide data-informed insights for the new design plan; an integrated human-centered approach of “Streets for People, Hutongs for All” is discussed in the last chapter, followed by policy recommendations based on a collaborative creation and governance model among three key actors including government, private sector, and civil society. The final section provides a concluding discussion on its limitations and specific guidelines on its improvement.

Chapter 1

Currently, China's urbanization has entered a period of rapid growth, with the conflict between the needs for economic development and sustainable environment becomes increasingly prominent. *Hutong*, as a distinctive architectural and organizational structure in China, is in the spotlights of the conflicts between China's historical heritage and its modernization. As one of the first twenty-five historical and cultural preservation zones in the inner-city of Beijing, Baitasi hutong is selected for the case study of this paper due to its complexity and typicality, which makes it a preferred microcosm sample of Chinese urban regeneration. This chapter firstly introduces the planning and executing of the field audit on the study area, adopting an in-person street view image data-collecting method; explains two side projects on traffic situation and toilet distribution; and dives into the urbanization history and demographic dilemma of the area to discuss some of the logical root-and-cause relationships for the social problems and conflicts in modern Beijing.

1.1 Field audit on Baitasi historic hutong area

In September 2018, as part of the master program, I moved to Beijing to study as an exchange student under the School of Public Policy at Tsinghua University, ranked as one of the top two in China (with Peking University). During the fall semester, I have purposely taken classes on a diverse subject from different faculties, including Urban Sociology, Big Data & Urban Planning, New Urban Sciences, Integrated Approaches to Sustainable Development, Governance and Development, as well as Climate Change, trying to understand what are the most prominent urban challenges across China. By the midterm, I realized "urban regeneration" (城市更新) and "old town revival" (老城复兴) were terms that had been frequently mentioned by the academia and central government when discussing about urbanization, and also learned some exciting projects from urban sociology classroom and lectures from the School of Architecture on campus.

In China, the year 2018 is a year of change for the urban planning industry, because in March, the state completed the new plan to reshuffle cabinet-level ministries, which would concentrate the responsibilities scattered across various government departments into two brand new ministries, the Ministry of Natural Resources (MNR) and the Ministry of Ecological Environment (MEE). Additionally, big data bureaus and data centers had been set up as well among various local governments[v]. Later in February 2019, the general office of the MNR issued the "*Technical Outline for Construction of Smart City Spatiotemporal Big Data Platform (2019 Edition)*", a modified version on the 2017 edition, and thus big data has been advanced to an unprecedented level in the urban planning industry[vi].

In regard to the domestic urban planning in China, big data is still a new type of research tool like icing on the cake, which has not reached an indispensable level. However, in many urban planning projects, big data has played a vital role. Especially in the case of limited time, the application of big data often significantly reduced the workload of field audit and investigation, with image recognition often being an essential part of the application (X. Liu et al., 2015). In particular, street view image is the foundation and crucial guarantee for the implementation of self-driving technology. With the continuous advancement of self-driving technology, the coverage of street view image is getting broader, and other image resources with geography coordinates are also increasingly emerging. At the same time, with the continuous evolvement of artificial intelligence (AI) and deep learning, image recognition technology is becoming more mature with higher recognition accuracy. For urban planners, it is now a great time to launch any human-scale research based on street view images.

Therefore, an initial idea to investigate urban regeneration project from a social science perspective, while adopting new methodologies from urban planning sector using street view image data, has come in shape. Moreover, according to a McKinsey report, China is likely to emerge as the world's largest market for self-driving vehicles and mobility services, worth more than US$500 billion by 2030[vii]. Even Alibaba has joined its rival internet giants Baidu and Tencent – which are collectively known as BAT – in the artificial intelligence-driven industry[viii]. Consolidating all those information, I had finalized the research question of this study to be focused on exploring a sustainable urban mobility solution for the historic hutong area within inner-city, using street view image to propose data-informed regeneration plan.

Currently, there are a couple of map firms providing street view dataset on neighborhood environments, including the global technology leader Google (www.google.com). Available from its online maps application is a library of video footage captured by cars driven down the street. The images have been pre-processed to provide panoramic, street-level views of urban streets, in which the user can explore surroundings along the street, pan 360 degrees, rotate the camera vertically 290 degrees, and zoom in and out. Google Street View was initially introduced in 2007 with coverage of a handful of cities but has since extended to new cities at a rapid pace.

Today in China, though Google's product and services are blocked, various Chinese online map providers have introduced Google Street View-like services, including Baidu, Netease, Amap (Gaode), and Tencent. Also, companies such as Tencent even have a multi-year picture recording function to record a time series of variance in street space (Long & Liu, 2017). Among them, Tencent's street view (http://map.qq.com) has the most extensive coverage, according to its website (http://map.qq.com/jiejing/home.html), almost all of the accessible streets in the Baitasi study area are associated with high-quality street view images, and most regional roads and hot spots, like tourist areas, are covered (Figure 1).

Figure 1: Tencent map of Baitasi study area (blue streets represent street images are available, accessed November 7, 2019)

Upon arriving Beijing in September 2019 for a three-week in-person field audit, I had learned about one of the Beijing City Lab (BCL) latest projects, which was to create a virtual reality map of the campus of Tsinghua University, with images captured by a 360 degrees panoramic view car driving recorder mounted to a bicycle biking down the street. Established in October 2013 by Dr. Ying Long and his collaborators, the BCL is an "academic network dedicated to quantitative urban studies and focuses on employing interdisciplinary methods to quantify urban dynamics, generating new insights for urban planning and governance, and ultimately producing the science of cities required for sustainable urban development" (https://www.beijingcitylab.com/). The idea of the undergoing project was built on earlier studies using videotaped images, but leveraging map company's industrial-scale collection of street view images. Inspired by this idea, I decided to use a similar approach to collect first-hand street view image data.

The whole process of street view data collection was divided into two major stages: planning and executing. The planning stage started with me spending long hours walking in the study area to design the optimal route for biking in order to avoid repeating streets and taking the same images. Some narrow alleys were not shown on the map, or dead ends, or blocked somehow, then would be marked on the printed map to take into consideration. In the meantime, I needed to prepare the equipment kit that includes a Huawei P30 pro is selected for its high-quality camera, an aluminum bicycle phone holder, and a shared bicycle. Moreover, the final plan was to download a timer application on the phone and set it to automatically take a photo by an interval of five seconds, put the smartphone in the holder installed to the bicycle handle, and then I would bike down the streets in hutong at a steady speed while taking quality street view photos.

Moving on to the executing phase, since it was my initial experience with such type of task, a pilot test was conducted first, and not surprisingly, several issues had then arose. Firstly, the phone holder could not mount to the bike handle tightly due to the size mismatch. Then when biking in the hutong, sometimes too much traffic and I was forced to stop or detour, which resulted in invalid photos. After finishing the data-collecting and exporting all the photos to a computer, I found out there were no GPS information captured for each photo, the reason for which could be the timer application did not work well with the latest android system on the phone. Eventually, I had to adjust the original plan and managed to manually take photos with the smartphone every 20 steps (15 meters) at the same height and angle while walking down the streets in two hours. After exporting all the geotagged photos, I had a visual check on all images and deleted bad ones that did not meet requirements. The final dataset was 543 valid street view images in total, with all necessary GPS location information for the later spatial analysis.

1.2 Experimental side projects on traffic and toilet

During the field audit, I was living at a rental room in the nearby hutong, and thus able to walk around taking photos, talk to residents, explore and observe deep into the study area. The first impression was that the intertwined narrow alleys were surprisingly full of parking vehicles that entailed astonishing driving skills. To prevent unauthorized parking on the side of the narrow street or private spot, residents used paper notices, potted plants, bicycle parking, and other objects, which also resulted in a reduction of movement space. Hence, to get a snapshot of the traffic volumes and modal split in the study area, a small observation survey was conducted on a random weekday (Friday, September 6, 2019). Traffic volume was measured by me walking the streets repeatedly during rush hours around morning, noon, and late afternoon, counting every person and moving vehicle encountered. Final results are calculated and documented in the table below.

Time	Car	Tricycle & E-tricycle	Motorcycle & E-motorcycle		Bicycle	e-scooter	wheel chair	Walking		
			Residents	Food delivery				Adult	Kid	Dog
08:00-09:00	11	73	144	26	183	2	4	327	18	5
12:00-13:00	8	30	108	18	59	0	2	157	33	0
18:00-19:00	7	46	241	36	204	1	3	329	49	2

Table 1: Observed transport modes during rush hours on a random weekday in the Baitasi study area

Based on the results, most of the vehicles on the streets are motorcycles and electrical motorcycles, which is the most efficient and affordable way for local residents to move around, and could carry passenger either kid or spouse or food basket in the back. There are still a lot of people choosing bicycles in the morning and late afternoon, to commute from their home in hutong most likely to the nearest subway or bus station, thanks to the mature sharing bike services in the city. In general, there is heavy dependency on bicycles either motorized or normal for daily commutes and high levels of walking within the hutong.

The electric tricycles are also omnipresent on the streets for all last-mile shipments with each driver delivering an average of 300-360 kg of goods every day. Without a doubt, online-shopping for all kinds of goods and food has been surging in China and with it the demand in Courier, Express and Parcel (CEP) deliveries, causing major environmental problems and big challenges for the last-mile delivery. Coming in different configurations and technical characteristics – closed and open cabin, heavy and light cargo vans with closed boxes or stacking surface – three-wheelers became the solution of choice in goods and service delivery in Chinese cities over the past decade.

In recent years, there is an emerging new type of three-or-four-wheeled vehicle called elderly mobility scooters (老年代步车) or elderly e-cars (老年电动车), which are designed specifically for the seniors and people with limited mobility (figure 2) at an affordable price. They are extremely popular and attractive to elder residents in hutong for the cheap, mobile, easy-to-operate, and neither driver license nor plate required which is a huge advantage given how strict the license market is. According to the conversations with local seniors, such elderly e-car is their favorite means of transportation that has significantly improved their mobility outside of the hutongs even in the rainy days. They all shared their positive feedbacks on how convenient these elderly e-car were, yet did not realize how much threats and problems posed by them.

According to the data from the traffic management department of China in 2018, over the past five years, as many as 830,000 traffic accidents caused by low-speed electric vehicles have caused 18,000 deaths and 186,000 injuries. The average number of accidents and deaths have increased each year at 23.3% and 30.9%, respectively[ix]. low-speed electric vehicles include a large number of three-wheeled and four-wheeled elderly mobility scooters, which are categorized and managed under low-speed electric vehicles within current transportation systems. In July 2018, Beijing has banned the sales of all kinds of unqualified electric vehicles, especially these cheap elderly e-cars which have low quality, poor safety and protection. The thickness of the vehicle body does not exceed 2 mm, but the speed could exceed national standards of 20km per hour to the highest 60km per hour[x]. In addition, many drivers never attended formal driving trainings and do not follow traffic rules on the road. However, for residents in hutong, it’s not always the high price tag keeping them from buying the dream cars, it’s the license plate they need to have a conventional gasoline car.

Figure 2: Electric tricycles: package delivery (upper row), Elderly E-cars (lower row)

Since 2011, the Beijing government has used a lottery for license to restrict the number of cars registered each year, to tackle traffic congestion and air pollution in the capital city. The annual new vehicle quota, which was 240,000 in 2013, fell to 100,000 in 2018 and 2019. Among this total quota, 38,000 of those license plates will be issued to individual buyers of gasoline-fueled cars while 54,000 for electric vehicles. Despite increasingly quota for electric vehicles, some applicants joined the lottery in 2018 must line up to 8 years to receive an electric vehicle license plate[xi]. It aims to cap the number of locally registered vehicles at below 6.3 million by the end of 2020—in a city of 22 million people. However, according to the data from Beijing Traffic Management Bureau, the current number of locally registered vehicles has already hit 6.084 million by the end of 2018[xii].

What's more, the municipal government restricts each licensed gasoline-fueled car from running on the road one day a week, according to the last digit of its license-plate number. Many residents used to simply register their car outside the city to avoid the years long waits, but officials are closing that loophole. Starting in November 2019, cars without a local license will be allowed only 12 permits to drive within the city per year, with each permit valid for just seven days[xiii]. Those restrictions are a big reason car-sharing and ride-hailing companies such as Didi Chuxing and Shouqi Limousine & Chauffeur have gained millions of customers in recent years, with Beijing leading in the number of active users. Besides Beijing, seven other cities including Shanghai and Shenzhen have adopted similar policies restricting car ownership.

Despite traffic and parking issue, another direct impression was the extreme poor living conditions and constrained space within the courtyard. According to the Beijing Statistical Year Book 2018, Beijing's per capita floor space of urban households is 32.56 square meters[xiv], yet it is only 23.37 square meters per household in the Baitasi hutong[xv]. Some locals even claimed it is less than 3 square meters per capita living space for some household. For example, one resident, Mrs. Zhang, is sharing an 8 square meters room with her husband, her son, and daughter in law, far behind the city's average level.

In order to meet the needs of living area, different types of additionally built illegal housings filled the courtyard and thus forming a typical large miscellaneous courtyard with disorderly and constrained space. Some residents have built illegal informal constructions occupying public space to be their kitchen or storage, and even moved rarely used furniture to the shared space of the neighborhood, some of which later became a public belonging. They did so for there was limited space indoor, but also because they believed the shared space is part of their home as well. In their mind, the whole hutong is their home. As a result, the shrinking public space led to even narrower alley, which made it impossible for trash trucks to get in and collect trash.

Figure 3: Informal constructions and furniture taken public spaces on rooftop, inside the yard, and by the street

Another fact of the constrained indoor space is no toilet or shower facilities. Most of the residents use the nearby public toilets in the neighborhood, which have been retrofitted to a high standard of quality over the last decade. In order to map all of the public toilets in the study area, another side project was carried out through testing a new application called Cat's Eye (猫眼象限). It is China's first application that combines intelligent technologies with investigation devices developed by UrbanXYZ (http://www.urbanxyz.com/) in May 2018. It "was designed as an integrated system which can improve investigation efficiency and enhance the rationality and accuracy of schemes with advanced technical means of deep learning and so on" (T. Wang, Mao, & Cui, 2019). As an investigation tool for medium- and small-scale urban planning and design practice and research, Cat's Eye is ideal for users to collect information of spatial settings and facility conditions only by taking photos. The application is available in forms of both applet and PC terminal, processing with the information of photo-taken locations to realize spatial recording and mapping and smart management of survey photos.

By using its lightweight and user-friendly WeChat interface, I set up an experimental project to take photos of all the 36 public toilets at the Baitasi study area and received data of six indicators: number of pedestrian, number of vehicles, visible vegetation ratio, built-up area ratio, road area ratio, and sky area ratio. After finishing adding all the photos, three indicators could be visualized on the map with labels, simple, intuitive, but in Chinese only (figure 4). Adopting open-source datasets and algorithms of image segmentation and target detection, Cat's Eye can recognize required information from site photos in seconds. The complete dataset includes the time and location of each photo and the index of six indicators, which could be exported into either .json or .csv format and used for spatial analysis later. In addition to the functions above, its full-featured PC terminal is claimed to support upload, image recognition, and data analysis of video files. Unfortunately, by the time of writing this paper, the PC terminal was still under testing and not published for public use yet.

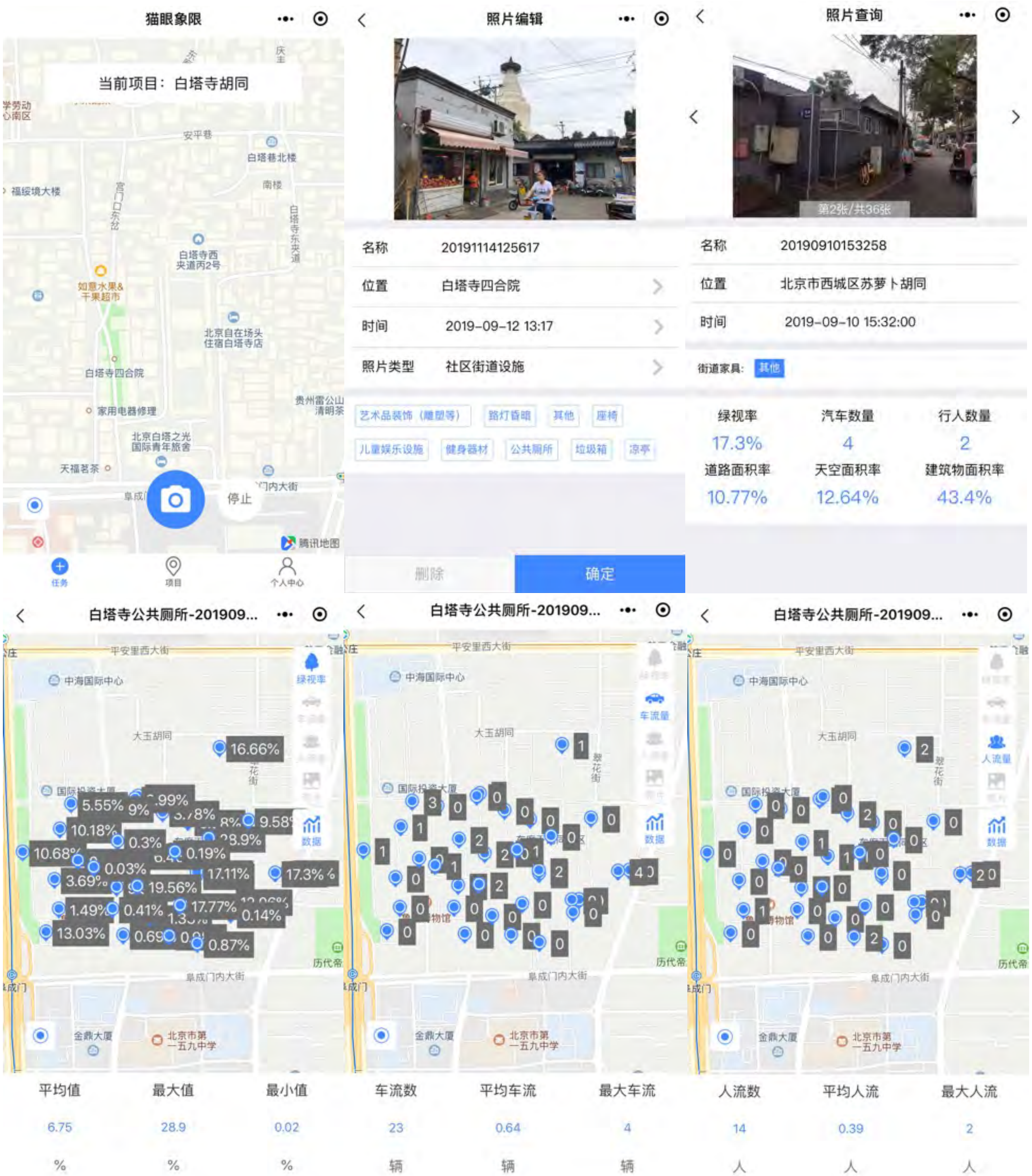

Figure 4: Interface of Cat's Eye applet within WeChat mini-program
Upper row from left to right: creating a task, adding photo types, six indicators of each photo.
Lower row from left to right: visible vegetation ratio, number of vehicles, number of pedestrian.

1.3 History background of Baitasi study area

Beijing is one of the oldest cities in the world. As the last of the Four Great Ancient Capitals of China (Xi'an, Luoyang, Nanjing, Beijing) [1], Beijing has been the political center of the country for most of the past eight centuries. With mountains surrounding the inland city on three sides, Beijing was strategically poised and developed to be the residence of the emperor and thus was the perfect location for the imperial capital, with a series of fortification systems which includes watch towers, city walls, city gates, and a moat system. The last city wall was constructed between 1400 and 1553, surrounding the Inner City (内城 neicheng) in the north and the Outer City (外城 waicheng) in the south.

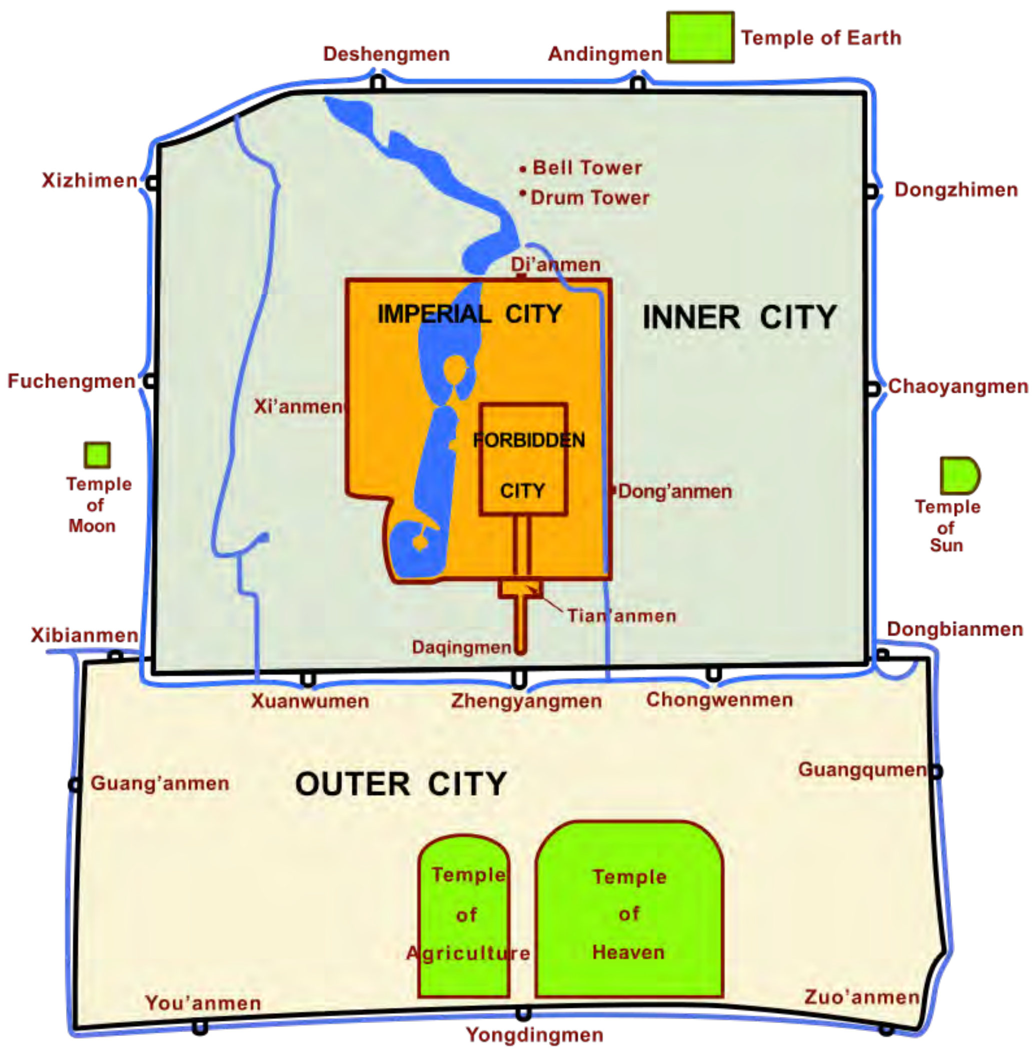

Figure 5: Map of Beijing city wall
(Source: https://en.wikipedia.org/wiki/Imperial_City,_Beijing, accessed on November 20, 2019)

[1] 中国四大古都：西安，洛阳，南京，北京

Nonetheless, the ancient fortifications were deemed by the central authorities as a barrier to the development of the modem Beijing. The Outer City wall was entirely gone by the year 1950, since when there has been a broad debate about how to preserve Beijing as a great historical and cultural city. The debate mainly focused on the practical problems of reconciling preservation with urban development, for instance, whether or not to tear down historic buildings that might block transportation. Still, the Inner City wall has been torn down bit by bit in the process of rapid urbanization and the construction of the metro line. In 1979, the city stopped dismantling the city wall and named the remains “cultural heritage”. No more than the Deshengmen Watchtower, Zhengyangmen Gatetower, a section of northern moat, and a section of south city wall near the Beijing railway station was left intact. The ancient city walls, the typically linear spatial elements of Beijing that represent the transformation of urban form over the past 800 years, now only exists in the memory of the older generation (J. Wang, 2011).

Since the 1990s, the construction of circular ring roads became the new major element that define the spatial distribution of Beijing's urban form. The Second Ring Road (二环，erhuan), first projected in the 1960s and eventually completed in 1992-at the era of China's Economic Reform, was the first road system that is comprised of elevated highways with no traffic lights. Despite its intention to create rapid transportation paths around the periphery of the city, this ring-structure following the old city wall serves as a new center for the city; it is notorious for its traffic jams, pollution, and drastically degenerated urban environment - a “wall” that cuts off two sides of the city and its associated urbanity. In modern Beijing, the Second Ring Road is the dividing line between two different types of urban fabrics: the historic net of narrow and dense hutongs in its geometric center, and the vast dimension super blocks built over the last 50 years (Liang, 2014).

Compared to other major cities in China, such as Guangzhou or Shanghai, whose commercial economies were much more highly developed in the early decades of the century, Beijing lacks a densely built up urban center. The principal building form throughout the neighborhoods surrounding the imperial palace is still the single-story courtyard house of the aristocracy, although now subdivided and filled in to accommodate virtually everyone but the aristocracy. These intensely crowded buildings, often separated only by narrow hutong (lanes), are disparagingly referred to as “courtyardless” courtyard houses (WU, 2011). Nowadays, siheyuan (四合院), the city's traditional courtyard housing style, and hutongs, the narrow alleys between siheyuan, are major tourist attractions and are common within the urban center of Beijing.

The administration area of the Beijing municipal government is 16,807km2, composed of two city districts, four suburb districts and two outer suburbs, as well as eight rural counties. Traditionally, the two city districts (Xicheng and Dongcheng) plus parts of four suburban districts (Haidian, Shijingshan, Fengtai and Chaoyang) are viewed as the central city, the area of which is about 300 km2. According to the Beijing Statistical Year Book of 2018, the permanent population of Beijing was 21.707 million by 2017, including 18.766 million urban population. In the two city districts, the population density is the highest, with 24,144 people/km2 in the Xicheng district, and 20,330 people/km2 in the

Dongcheng district. In the four suburban districts, the population density is lower but on average it reaches 7675.25 people/ km2.

Unlike redevelopment in the more commercially oriented cities of China's southeast coast, where low-rise inner-city housing is rapidly being replaced by medium and high-rise buildings, the symbolic quality of Beijing as an imperial center is still highly valued, and current planning efforts are aimed at rebuilding the urban core in a form which is congruous with its historic roots. According to the latest Beijing Master Plan for 2016-2035, "Beijing's urban strategic positioning is to become the national political center, cultural center, international exchange center, as well as science and technology innovation center." The Plan contains eight chapters in total and one of which is about how to strengthen the preservation of historical and cultural sites in this ancient capital city that has witnessed over thousand-year of history.

In 2002, Beijing Municipal government approved the *Conservation Plan for Twenty-Five Beijing Old City Historical and Cultural Conservation Areas* drafted by the Beijing Planning Committee, which had finalized "the twenty-five Beijing Old City historical and cultural conservation areas cover a total land area of 1,038 ha., and take up approximately 17 percent of the land area in the Old City". Two years later, a second list of fifteen historical and cultural conservation areas were confirmed. With the third list of three more areas published in 2013, there are totally forty-three historical and cultural conservation areas in Beijing city[xvi].

On the first list of twenty-five historical and cultural conservation areas, fourteen are distributed within the old Imperial City area, which are important components of the traditional landscape of the old Imperial City. Another seven zones are distributed outside the Imperial City but within the Inner City, including the Nanluoguxiang district which were built during the Yuan Dynasty and constitute Beijing's best-preserved traditional residential area and hutong system. The Shichahai area is a zone that blends aquatic scenes, palaces of princes, and Buddhist temples with Beijing's folk culture. The Guozijian area is centered on important cultural relics and temple buildings and set off by neighborhoods consisting of traditional courtyards. Fuchengmennei has always been a major communications artery and is lined with many temples and monasteries including Baitasi. Four more such zones are spread out in the Outer City.

Master plans have usually helped rationalize and guide the allocation of necessary resources, though they failed to provide humane and livable environments. Alternatively, the idea of "projects and not plans" emerged in urban planning, with substantial success in Europe and elsewhere, embracing the idea that various well-made and locally defined building projects, with some coordination, was a better solution than grand schemes and master plans (WU, 2011). With societal advancements, people have realized that standard large-scale demolition and construction of Beijing's urban center is no longer viable. Instead, small-scale, organic renovation models are attracting more considerable attention and practice.

Baitasi (白塔寺, the White Pagoda Temple, figure 6) is one of the first twenty-five historical and cultural preservation zones. It covers about 40ha, as shown in the red box in figure 8. To its south, across Fuchengmennei street lies Beijing’s Financial Street in Xicheng district. To its north across Shoubi street lies the Xizhimen business district and to its west across the west second ring are the Fuchengmen commercial area and the Sanlihe administrative district. Also, the popular Xidan and Xisi shopping districts border the temple to its east.

Figure 6: Baitasi, the White Pagoda Temple

Within the territory of the Baitasi study area, in addition to the net of historic hutongs, there are other types of conservation elements, including relic sites like Luxun Museum and the Temple, several courtyards labeled for conservation, and old trees, as highlighted in figure 9. It remains a peaceful cultural oasis for the public in the heart of new Beijing, located in an old low-rise residential district, one of the last remaining traditional residential areas in the capital city.

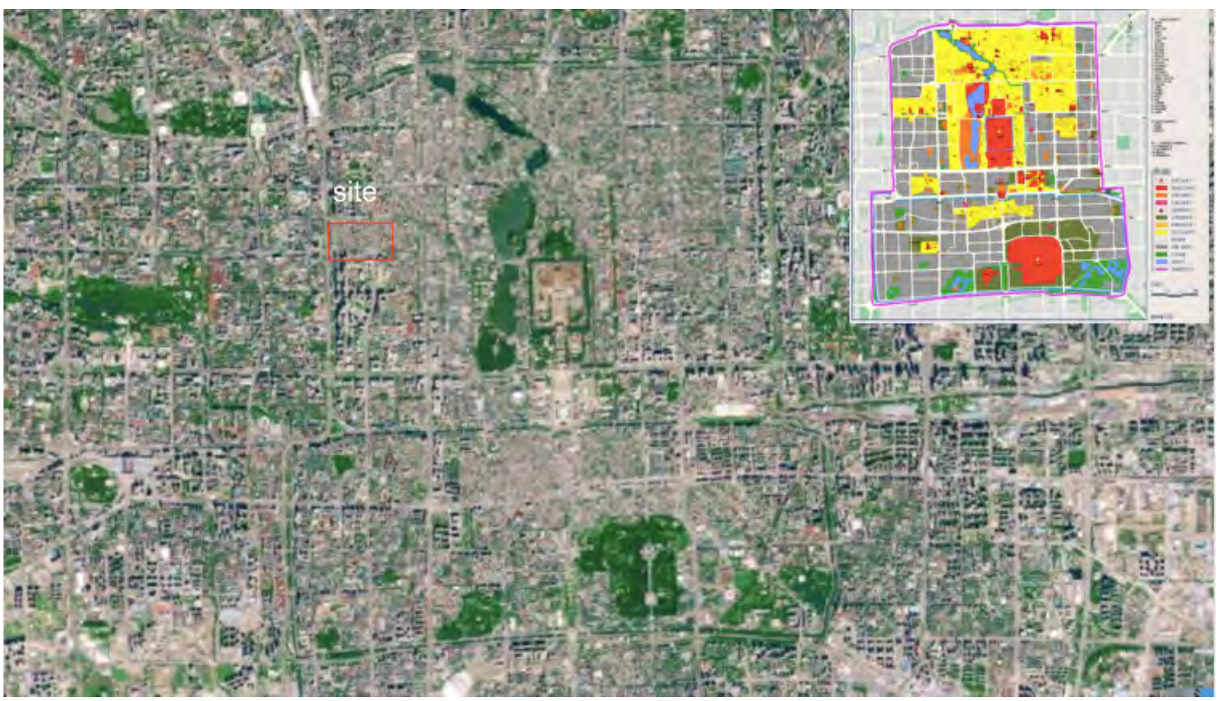

Figure 7: Location of the studying area: Baitasi hutong. (Source: Beijing City Lab)

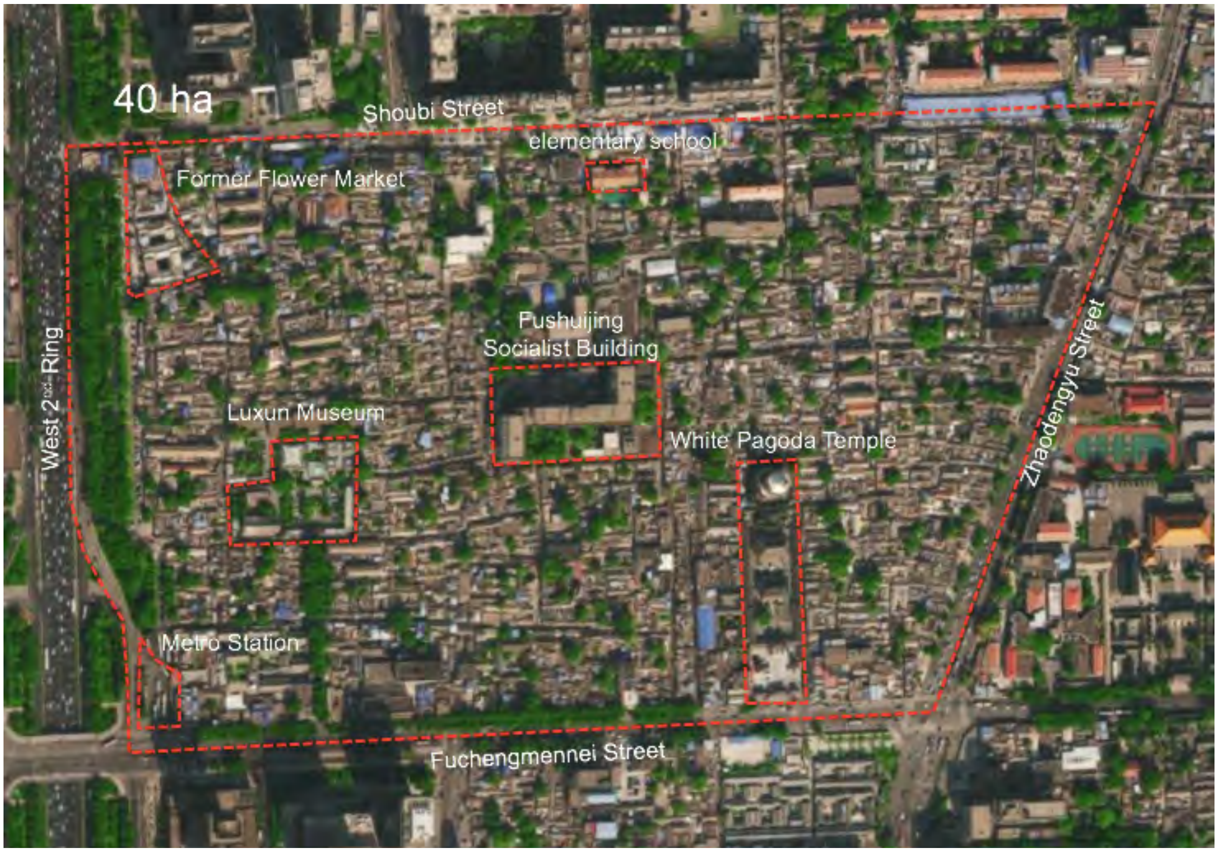

Figure 8: Satellite imagery of the studying area. (Source: Beijing City Lab)

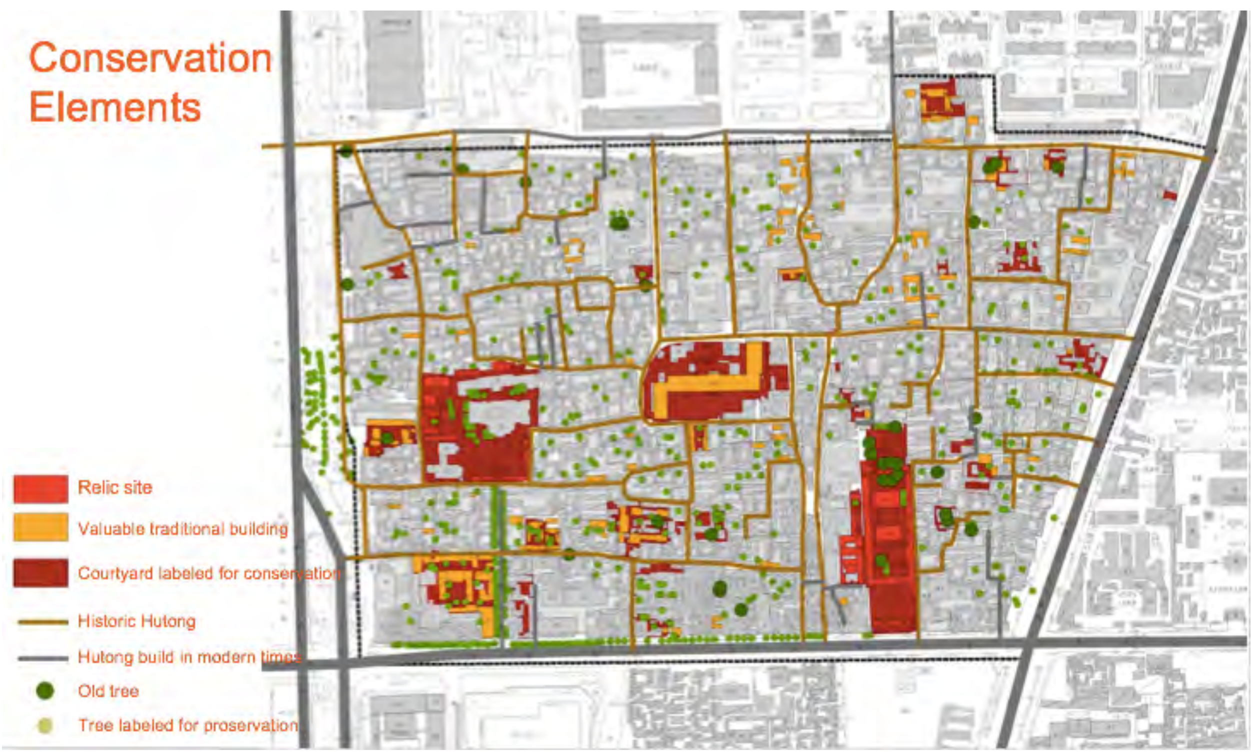

Figure 9: Conservation elements within the studying area. (Source: Beijing City Lab)

1.4 Baitasi Remade project and its demographic dilemma

The “Baitasi Remade” project (白塔寺再生计划), carried out by Beijing Huarong Jinying Investment & Development Company since 2015, was designed to establish a new model for the hutong residents with the joint force of public participation, proactive enterprises, and government leadership. The project “hopes to establish a sustainable population, revitalize the physical spaces, upgrade to basic energy sources, and re-engineer the public environment, thus fostering a cultural revitalization of the region as a whole.” While maintaining the unique character of Hutong neighborhoods and the residential functions of traditional courtyards, “Baitasi Remade” is expected to “inject new elements of design as well as cultural and creative models to create a new cultural district comprehensively integrating tradition, innovation, and style.”[xvii]

Located at Gongmenkou East Alley n.81, Baitasi Community Living Room (白塔寺街区会客厅) is a meaningful part of the Remade project. It is an open space for community residents to hang out, share cooking skills, and discuss community issues, the very first collaborative community of its own in Beijing, according to the founder. Since the establishment in September 2017, the Living Room has received over 15,000 visitors and facilitated the launching of six thematic clubs that has organized over 300 events, including various activities, lectures, exhibitions, books reading, calligraphy, household, and senior home care services[xviii]. Such events have attracted not only the residents but also the tourists, business owners, non-governmental organizations, service agencies, and media, to participate and contribute their ideas as well. The living room has significantly smoothed and strengthened the communications between residents, boosted the growth of community clubs, and explored a new approach of community governance with residents playing the leading role. Over the field trip, I have visited the Living Room several times to participate events, talk with residents and community workers, including Mr. Zhang, who joined the team over a year ago as the head in charge of all sorts of events, and thus very familiar and affectionate with the area.

Figure 10: Baitasi Community Living Room

Another significant pillar of the Remade project is the collaboration with Beijing Design Week, an annual leading design platform of China, which has set up one of its sub venues in the Baitasi area since 2015. In 2018, the theme of Neighborhood Warming Initiatives (暖城行动) was raised for the first time that aims to rebuild the community into a caring and warm harbor, through jointly creating shared space, cultures, services, and organizations with the idea of design thinking. This year, the concept continued to serve the multi-purposes as to: restore hutong culture through several forms, such as micro-renewal of hutong, cultural memory digging, and residents' participation in innovative neighborhood management; maintain the continuation of the lifestyle of historic cultural district while promoting the industrial development of creative design; meet the needs of contemporary urban lifestyles and create a warm neighborhood[xix].

Figure 11: Baitasi posters for Beijing Design Week from 2015-2019 (source: Baitasi Remade website)

Because the last few days of my field trip overlapped with the opening of Beijing Design Week 2019 (September 23-30)[xx], and I had the fortunate to attend inspirational lectures and exhibitions, talk to experts and architects who have been working on relative projects. One architect named Lu Ping, was grew up in Beijing and decided to come back upon receiving his master degree in Architecture from Harvard University. He joined a design studio and think tank called Urbanus (http://www.urbanus.com.cn/), one of the most influential architecture practices in China, and has participated in a series of design projects focusing on China's urban realities and emerging urban problems. One of the projects is a renovation solution of a two-in-one courtyard located at No.72 Dongjiadao, also served as the Exhibition Center for the Baitasi Area Urban Renewal. To preserve the historical cultural value of the site, Lu Ping and the design team restore the poor original house by elevating its structure to a higher standard of traditional courtyard house. Then by introducing contemporary architectural elements to the traditional setting, it helps to glorify the old structure, and sets a good example of the new in the old.

Such concept of integrating the new in the old is the design logic among most of the urban renovation projects. In regards of the hutongs regeneration processes, the primary problem to be solved is the insufficiency of original conditions, and architects take two opposite positions: some of them try to transform the area by densifying it, some reduce the volume to restore the ancient balance between built and voids. While in Lu Ping's opinion, neither might be good enough. "I have heard that despite architect designer had renovated a small house into modern apartment with efficient storage space and various functional areas, in a few months, it was turned back to the messy situation as before without proper maintenance. Why? Because those senior residents' years-long behaviors and lifestyles could not be changed overnight. This is of course very frustrating to find out, yet worth all our architects to bear in mind that who are the people living in the space is central for the design, rather than award-winning design plan."

In fact, very few of Beijing's old town regeneration projects are as multi-faceted as Baitasi Remade, where options are being explored to provide an alternative path for urban regeneration and community revival. It is impressive that Baitasi, while not championing either in historical value or social significance in Beijing, has been hosting such complexity and typicality, that itself has become a de facto contemporary source of great architectural questions and debates. It all dated back in the 1990s, when Baitasi was listed as one of the typical old districts in Beijing waiting to be regenerated, not typical for any of the known genres of old districts, but has evolved as a microcosm sample of China's urban regeneration, producing dilemmas that gradually made it an exciting space for urban experimentation.

The *World Architecture* (WA) journal from Tsinghua University has a whole issue of July 2019 designated to Baitasi, discussing the fascinating dilemmas to reveal the architectural and anthropological potential of the two-decade-long Baitasi regeneration project. As described in its prologue, there has been the dilemmas of regenerative mechanism, architectural ideology, and demographics. To be specific, Baitasi's unique demographics consist of 90% newcomers, also called "pseudo-original inhabitants," (伪原住民) mainly lodgers and renters settled in over the last 20-30 years. "The co-existing of peoples of drastically different professional and educational backgrounds, the scattered distributions across the age spectrum, and the multiplicity of culture and lifestyles, has only made it even harder to give Baitasi a clear demographic definition."(ZHANG, n.d.)

So, who are those "pseudo-original inhabitants" exactly? They are the peasant workers (农民工) mostly from the countryside who came to Beijing to work in the service sector as the economy was rocket booming over the last decades. During the field audit, I have talked to a restaurant owner, Mr. Wang, who moved to Beijing from his hometown in Anhui twelve years ago, along with his relatives. He started by selling breakfast from a street cart, then in three years he saved some money and rented a spacious room facing the three-way intersection at Baitasi hutong to open a restaurant for breakfast, quick lunch and dinner, named Old Beijing Home Cooking (老北京家常菜). Over the years, he has brought his family members over to help with the business, including his wife, brother in law, and his father, while his mother is staying at hometown taking care of two children at high school.

"I miss my kids," said Mr. Wang, "I wanted to bring them here with us, but I can't because they could not go to the public school here without a Beijing hukou, and I could not afford to send them to a private school either." Introduced in 1958, known as the hukou (户口), China's residence permits has long been the central institutional mechanism defining the city-countryside relationship and shaping essential elements of the country's unprecedented urbanization (Cheng & Selden, 1994). Since the economic reforms launched in December 1978, Deng Xiaoping and fellow reformers retained this system but gradually loosened the migration restrictions, enabling Chinese peasants to migrate into the cities and towns, a "floating population (流动人口)" estimated to number more than 244 million by 2017, with over 65% are born after 1980[xxi]. Millions of migrants, mostly young and eager to leave their villages, were willing to engage in construction, shipping and delivering, export-oriented manufacturing, entertainment, household service, and other jobs that urban youths despised.

However, without an urban hukou, those migrants have to tackle with the restricted access to specific jobs, food, housing, healthcare, and education in their new home city. It has been tough for youths with rural hukou to obtain education beyond middle school graduation, the end of nine-year compulsory education, unless they pay high fees. Some send their children to nearby migrant-run schools of uncertain quality, but many send their children back to their villages of origin, like Mr. Wang, to be supervised there by grandparents, called the "left-behind children (留守儿童)," estimated to number nearly 70 million[xxii]. Moreover, the conversion of an individual's hukou from rural to urban has been a notoriously problematic process. Large cities such as Shanghai and Beijing follow a strict point-based system that only those who exceed specific point could settle down. It is almost impossible for migrants like Mr. Wang and his family to achieve that point due to no stable job with paid social insurance record nor high education or skills. That is why Mr. Wang only planned to stay and make money until his children are out of college, then he could go back to his hometown and enjoy retiring life with local social welfare.

Based on the above conversation and research, two major demographic dilemmas among the Baitasi area could be concluded: One is between the originals and newcomers; another is between the seniors and the rest. According to a survey, there are nearly 130,000 senior residents, which accounts for 25% of the total population[xxiii]. Many complaints from the originals were that they felt less happy and secure than decades ago. The quiet, peaceful, and harmonious life in hutong has long gone since the newcomers settled in and overcrowded the streets. Because newcomers came in the city to make money and then build houses back in their hometowns, they did not treat their rental room in the hutong as a home and thus did not take good care of it. For instance, they did not clean toilet shared among a couple of households, they felt free to spit and litter on the street, and they biked or drove motorbike very fast in the narrow alleys. According to Mr. Zhang, head of Living Room, senior Pekingese inherited the politeness and humbleness from elder generations living close to the Imperial City, for they never knew the background of any random people they encountered. So they became very prudent and referred to each other as nín (您) regardless of age, a very polite and respectful way to say 'you' in mandarin, which is still commonly used and uniquely featured in today's Beijing dialect. However, he stressed that the newcomers did not have this habit of being polite nor humble; coming from rural areas and most likely lower education level, newcomers could not fit in the hutong culture, and they did not seem to care about that either.

Such conflict between public and private resources, however, is not limited to the hutong community only, and should not be simply attributed to the bad habit due to low literacy level. It is one of the distinctive characteristics that deeply rooted in Chinese society and culture. Fei Xiaotong, a pioneering Chinese researcher and professor of sociology and anthropology, has defined it as the problem of selfishness, which is “really more common than the problem of ignorance or illness in China,” is essentially the problem that “how to draw the line between the group and the individual, between others and ourselves.” To understand this problem, we have to take into consideration the pattern of the entire social structure. Fei's core thesis is that Chinese society is organized over the principles -- different from those prevailing in the West – through the concept of chaxugeju (差序格局), means “differential mode of association.” Within the chaxugeju, extending out from the self are the social spheres formed by one's relationships, basically through kinship, which includes relations between parents and children and among siblings born of the same parents (Fei, Hamilton, & Wang, 1992).

After the three-week intensive field audit at the Baitasi study area, it is clear to me that, only with such empirical investigation deep into the daily life in hutong, can I identify and tackle the prominent social problems arising in the process of rapid urbanization based on the unique social context of China. China’s more than 1.3 billion population is in the midst of an urbanization experiment of the largest scale in human history, which has brought with it incredible transformations in urban lifestyles. Quality of urban life has become a commodity or privilege to some extent of those with money, property, or power, yet a luxury dream for those without any. The negative impact is growing social gap, individualistic isolation, anxiety, depression, and other pressing issues, among urban dwellers across increasingly divided, fragmented, and conflict-prone cities. As an old saying in China goes, “neighbor should watch over and help with each other” (守望相助，邻里与共), a human-centered solution at the community level should be explored to find a way of urbanization and modernization for a populous and high-density society.

Chapter 2

The same physical environment can be experienced in a number of different ways. That is, reality has a subjective side; we attach our own personal perception of our experience. The city has a different symbolism, and emotional impact on different people, and hence has been studied by researchers from many fields while diverse points of view can be discerned within any field. Researchers have studied many features of urban life, utilizing a variety of approaches, and stressing different elements. In order to answer the research questions of this study and lay the groundwork for the later analysis and discussion, this chapter presents a literature review to examine briefly: the theoretical developments of urban sociology on the human-centered concept; three case studies on the urban regeneration projects at Beijing; and various studies of new research methods and investigation tools leveraging street view image data.

2.1 Urban sociology theories on the human-centered concept

Theoretical developments in the field of urban sociology usually have been driven by the recognition of significant changes in how the social, economic, and political life of contemporary society is organized, which means that whatever insights we gain from different theoretical approaches are historically situated.

In early twentieth century Chicago, Robert Park, Ernest Burgess, Louis Wirth, and W.I.Thomas shifted their attention to trying to understand the emergent social processes found in the newly "large, dense, and heterogeneous" modern city (Wirth, 1938). Urban ecology, once the most influential theoretical school in urban sociology, emerged in the 1920s when the "Chicago School" of urban sociology pioneered the use of ecological theory and terms to illustrate the structure and function of cities (Hawley, 1944). Urban ecology then developed into a bona fide sub-discipline of ecology in the following decades of the twentieth century from intellectual seeds planted in the late 1940s and early 1950s in Europe, North America, and Asia (Sukopp, 1998). The "Chicago School" emphasized the importance of "social integration" at a historical moment characterized by economic growth and crisis, social transformation, and massive immigration. Most fundamentally, these Chicago sociologists were concerned with what they called "social organization, " a state of social equilibrium, which they feared would be threatened by the conditions of urban living. In this period of mass immigration, rapid industrialization and urbanization, their research sought to explain how urban dwellers created—or failed to create—various forms of social organization and its correlates: social integration, social order, social control (Park, 1915; Wirth, 1938).

By the late 1970s, a paradigm shift to a "new urban sociology, " which was heavily influenced by Marxist political economy and critical geography, emerged in response to the rioting, deindustrialization, and fiscal crisis surfacing in U.S. and European cities post the second world war (D. Harvey, 2009; Walton, 1981). The theoretical problem is still too often studied as a battle between Chicago and Marxist paradigms even though it may be that the main difference between the two is ethical and political rather than methodological and theoretical (McQuarrie & Marwell, 2009). New urban sociologists argued that capitalism expressed itself spatially and that this geographical expression had a determining effect on the organization of urban life. An implication of this view was that the "Chicago School" focused on social integration and social order analytically masked fundamental conflicts in cities, conflicts that had emerged with full force, and could no longer be explained by social disorganization alone (Zukin, 1980). The three most influential scholars of the "New Marxist School, " Henri Lefebvre, David Harvey, and Manuel Castells, further indicated that the fundamental conflicts among interests of different groups of people were neglected in the development and governance of capitalist cities.

As Henri Lefebvre wrote in his seminal essay on *The Right to the City (Le Droit à la Ville)* in 1967, the idea of the right to the city does not necessarily arise out of various intellectual fascinations and trends, but primarily from the streets, the neighborhoods, as a cry for help by oppressed peoples in desperate times (Purcell, 2002). Moreover, Lefebvre also remarked that the relation between the urban and the rural was radically transformed, that the traditional peasantry was disappearing and that the rural was being urbanized, in a way that offered a new consumerist approach to the relation to nature and a capitalist approach to the supply of agricultural commodities to urban markets, as opposed to self-sustaining peasants' agriculture (D. Harvey, 2012). Furthermore, he presciently detected that this process was "going global, " and that under such situations the question of the right to the city had to give way to the right to urban life, which later synthesized into the more general question of the right to the production of space (*La production de l'espace)*, analyzing in-depth how the best quality space in the city was occupied by the few groups of significant capital, while the mass people and the working class were excluded (Lefebvre, 1974).

Being one of the most important interpreters of Marxism in France, the French philosopher Henri Lefebvre (1901-1991) lived the "adventure of the century. " His contribution, which includes over 60 books and numerous other publications, spans much of 20th-century and covers a wide range of subjects, including philosophy, literature, sociology, political theory, linguistics, and urban studies. During the 1970s and 1980s, Lefebvre's work, which had been rejected by the initiator of structuralist urban sociology (the early Manuel Castells), provided a key impetus for the neo-classical urban Marxism developed by David Harvey from the United States. Since the late 1980s, and the publication of Edward Soja's "*Postmodern Geographies: The Reassertion of Space in Critical Social Theory* (1989), " Lefebvre has mostly been interpreted as a pioneer of poststructuralist and postcolonial courses in urban studies. In both cases, Lefebvre's writings on cities, urbanization, and space have thus been a principal source for the "spatial turn" in the social sciences, which informs all contributions in this symposium (Kipfer & Milgrom, 2002).

Besides, several American modern scholars have already suggested the concept of human-centered cities. Henry Churchill, an architect who has devoted years to study and practice in the areas of housing and city planning, clarified in his famous book *The City is the People* that people are the center of all urban planning and construction. With his eye on the ideal of complete urban redevelopment, he was more interested in whole communities than in single buildings, and more interested in people than in the physical urban settings, and presented the trend towards better use of land and creation of values in health, comfort, good living (Churchill, 1945). Lewis Mumford, famous for his study of urban culture and architecture, first mentioned "human environment" and expressed his caring about the people living in the city among his books. Like in the final section of *The City in History, Its Origins, Its Transformations, and Its Prospects*, he depicted his anxiety and discouragement over the advance of urbanism devouringly encompassing all peripheral districts, turning men into machines. However, in the shadows, he saw glimmers of hope, that the "One World Man" could be the goal of the future city: "that of creating a visible regional and civic structure designed to make man at home with his deeper self and his larger world" (Mumford, 1961). Jane Jacobs, the legendary author of *The Death and Life of Great American Cities*, a book that has transformed the disciplines of urban planning and city architecture, criticized that the planning community has deviated from the human-centered path for a while, and thus caused numerous mistakes in urban planning and construction (Jacobs, 1992).

Entering the twenty-first century, against the background of both the global financial crisis and intensifying social movements, urban planning researchers Neil Brenner, Peter Marcuse, and Margit Mayer have edited a collection of essays in *Cities for People, Not for Profit: Critical Urban Theory and the Right to the City*, that contributes useful studies for efforts to cut back profit-based forms of urbanization, and to promote human-centered, radically democratic and sustainable forms of urbanization instead. Emphasizing the housing market where injustice is most evident, they have pointed out that capital and power significantly invade people's interests in the contemporary urban transformations, and clearly stated that cities are for the people, not for profit (Brenner, Marcuse, & Mayer, 2011).

In general, the approach of the "New Marxist" urbanists emphasizes Marxist and post-Marxist urban political economy, the independent role of organized and constructed space itself, and the role of culture, symbols, signs, themes, and processes of signification in settlement space activities (Gottdiener, 2019). More fundamentally, their research stresses that: cities are the areas where political and economic interests are most concentrated; only by adhering to the principle of human-centered, can this very concentrated and massive amount of political and economic interests be enjoyed by the broad masses of the people without being manipulated by minority people or a few interest groups.

In China, the recent rapid urbanization is a case in point on the fading of the urban-rural divide, which has proceeded at an astonishing pace and scale towards the direction that Lefebvre predicted, calling for the human-centered urban restructuring and regeneration. Wu Liangyong (吴良镛), who is considered the most influential architect and urban planner in China, creatively pioneered the theories about "sciences of human settlements (人居环境), " emphasizing that the core task of urban construction is to serve the people. In his book *The Science of Human Settlement in China*, he discusses the relationship between humans and environments, with an outlook for human settlements in China after essential changes have taken place over the past few decades. He also pointed out that the construction of livable environment is indeed a collective creation among all the residents. Hence, we should trust the people and tap on their creativity. Although human settlements are an extremely complicated system, we should believe that the people contains the enormous potential of creative solution to tackle any new problem arises (Wu, 2010). During his professional career of more than 60 years, Wu has made meaningful contributions to the advancement of architecture and urban planning in China, including co-founded the Faculty of Architecture of Tsinghua University in 1946, together with his teacher, Professor Liang Sicheng. He continued teaching for fifty years, focusing on urban planning, architecture, and design[xxiv]. In 1993, Wu was granted a World Habitat Award of the United Nations because of his unparalleled contribution through leading the Ju’er Hutong Courtyard Housing Project (WU, 2011), the first time such an honorable international award given to a Chinese housing project, which will be examined in the following session.

2.2 Selected urban regeneration projects in Beijing

Ju’er Hutong (菊儿胡同)

The Ju'er Hutong (the Chrysanthemum lane) was the beginning of a series of projects to apply the principles of organic renewal to the planning of the Old City in Beijing and stands as one of the few models in present-day Beijing that are genuinely worthy of emulation. In his book *Rehabilitating the Old City of Beijing: A Project in the Ju'er Hutong Neighborhood*, professor Wu Liangyong appealed to turn the tide of mass demolition and provided a new direction for the urban planning and redevelopment of the ancient capital (WU, 2011). Wu was a student and colleague of China's first architectural historian, Liang Sicheng, a champion of human-centered development and an advocate for conservation, especially the old city walls. As introduced earlier, he is an honorable architect and urban planner in China, and it is through his own projects that he advocates a more humane vision of the city renewal.

As an experimental operation of rehabilitation, in 1979, the Beijing Municipality had entrusted a group of architects from Tsinghua University led by Wu to remodel slices of the 8.2 ha block of Ju'er hutong, close to the Drum Tower (鼓楼), the heart of Beijing’s Old City. This project for the renewal of the Ju'er Hutong neighborhood is one of Wu’s most recent building projects and takes pride of place in the book. A thoughtful reflection of those aspects of the ancient capital's features, which the project aims to respect and preserve, is followed by a detailed recording of the design and development process of the project. Large amount of architectural drawings and photographs of the completed project, as well as data on the neighborhood’s resident population, present the state of the art in Chinese residential design and planning. The author attempts to recreate a "native Chinese" style, so as to avoid the destruction of the cultural capital and its transformation in a set of towers and bars in an "international" style.

The most original contribution of this book is the presentation concerning the creation of a livable urban environment that respecting traditional culture while accepting certain constraints of modern life. Wu designs a new model of "houses to yard," taking up a certain number of characteristics of the large houses in the south of the Yangzi River, where is his hometown, and especially from Suzhou houses. Nevertheless, he refuses a nostalgic view of the past, ultimately devotes only a few pages to defense and conservation of the architectural heritage of the capital, and finally presents as an urbanist opposed to "globalization" over the redevelopment progress in the central heart of the ancient capital.

Although the international experts have affirmed the design of the housing model at Ju'er Hutong, the domestic Chinese architects only gave it moderate grade that slightly higher than the other similar projects. As Wu commented himself over an interview, Ju'er Hutong Courtyard Housing Project only provided a direction, not supposed to be promoted as a universal model for all the houses. Searching for a new housing model is undoubtedly tricky, but developing and promoting a new housing model is even more so. In a big country like China, it is necessary to explore many more creative approaches to solve housing problems, for every place has its regional characteristics to take into consideration. The fundamental goal is to improve the comfort of the houses and ultimately to satisfy the residents. Ju'er Hutong was redeveloped tailoring to its unique background at that time. Even in Beijing, different hutongs will need different solutions[xxv].

Nanluoguxiang (南锣鼓巷)

Nanluoguxiang (South Gong and Drum Lane), located in Dongcheng district very close to the heart of Beijing to the north of the Forbidden City and within the Second Ring Road, is probably the most renowned renovation project of historic and cultural district in old city in terms of prosperous commerce and tourism. With a history of more than 800 years, it is one of the oldest streets in Beijing and has remained one of the most extended surviving imperial street layouts. It was built in the Yuan Dynasty (1271–1368) and received its current name during the Qing Dynasty (1644–1912) around 1750 (Shin, 2010). The main street is approximately 800 meters long and 8 meters wide, extending between Drum Tower East Street in the north and Di'anmen East Street in the south, with some other narrow lanes known as hutong emanate from the central lane, showing "a classic fishbone pattern" (WU, 2011). The area is rich with examples of more than 1200 classic courtyard residences, thus justifying the area's conservation. In 2002, Nanluoguxiang had approximately 22,000 registered residents in an area of 83.8 hectares, for a high population density of 262 people per hectare (Shin, 2010).

Researches have evaluated the Nanluoguxiang project from various approaches and presented some interesting findings. For instance, economic benefits generated by urban conservation, if any, were shared disproportionately among residents. Furthermore, residents' lack of opportunities or channels to "voice out" further solidified the property-led characteristic of urban conservation and failed to pay attention to social lives (Shin, 2010). Another paper argues that the historical and cultural values of Nanluoguxiang are undervalued. Moreover, distinct differences exist between the actual motivations for visiting held by domestic and international tourists and their motivations as perceived by residents and business operators (Su, Wall, & Ma, 2019). Another paper conducts a quantitative assessment of the sustainable urban development capacity considering the main features of historic district and finds that in Nanluoguxiang, the ecological footprint (EF) was substantially higher than the ecological carrying capacity. In contrast, the EF of tourists was higher than the EF of residents (Dai, Xu, & Wu, 2017).

The opening of Nanluoguxiang subway station in 2012 greatly enhanced the area's accessibility and facilitated its tourism development. Although primarily a pedestrian area, apart from the occasional local cars, delivery vehicles and the more numerous motorbikes can be seen everywhere. There are twenty-nine hutongs in the area, including Ju'er hutong, yet only 15.4% of them have a width of 6 meters and above. Determined to solve the prominent parking problem within hutongs, in June 2019, Dongcheng district authority released the city's first historical and cultural block parking plan - *Nanluoguxiang Historical and Cultural Street Motor Vehicle Parking Plan* (hereinafter referred to as "the Plan"). The plan regulates no parking allowed in the Nanluoguxiang area in order to return public space to the residents, while fully supporting the neighborhood renewal projects and creating a public space with "green shades, bird sounds, and old Beijing characteristics" to evoke the memories of the good old days in hutong[xxvi]. Since July, including the Ju'er Hutong, five hutongs in the Nanluoguxiang area no longer allow motor vehicles to park. The short-term goal of The Plan is to ban parking in the Hutong with a width of less than 6 meters and to set up parking spaces for the Hutong over 6 meters wide. While the long-term goal is to reduce the parking inside the hutong area gradually and the end goal is to achieve no parking throughout all of the 29 hutongs by 2025[xxvii].

New Qinghe Experiment (新清河实验)

The New Qinghe Experiment (NQE) is an experiment of social science and urban planning conducted by an interdisciplinary group of sociologists and architects in the Qinghe area, Haidian district of Beijing, which combines academic research with social governance, social development, and community planning. The original Qinghe Experiment was first launched in 1928 by a group of old-generation sociologists led by Yang Kaidao (杨开道) and Xu Shilian (许仕廉) from the Department of Sociology, Yenching University. They started by conducting a general survey of the history, geography and environment, population, marriage and family, economic organization, politics, education, religion, etc. in Qinghe. A research report titled *Qinghe – An Analysis of Sociology* was produced, which provided a description and analysis of the necessary information on society, economy, politics, and the like in the then Qinghe, and highlighted the significance and value of the area therefore successfully set ground for the establishment of the Qinghe Social Experiment Zone. The historical project was mainly aiming to examine whether it was possible to promote rural construction through farmers and the residents' organizations, yet unfortunately, got interrupted by the Japanese troops' invasion of Pekin in 1937 (Q. Li & Wang, 2016).

Until 2014, the NQE was relaunched at the Department of Sociology, Tsinghua University, in collaboration with the Department of Architect, and has since then transformed the area into an active urban community. Different from 80 years ago, today's Qinghe has no more farmlands but rather tall buildings and crowded population, covering 9.37 square kilometers. It is now home to 160,000 permanent residents, including 74,000 residents with household registration of Beijing, and 84,000 migrants (Q. Li & Wang, 2016). Theoretically, the NQE takes the academic goal of the old Qinghe Experiment to seek well-being for the people. In the new period of China's reform and opening up, however, the NQE is more of a comprehensive and innovative social governance experiment, and an experiment of social intervention and community organization and management of social science.

Despite its historical origin, the main reason why the area is reselected for the social experiment is that the change in Qinghe is a glance of what happened in Chinese society after the reform, and almost all the problems in terms of social change can be tracked here. First of all, the community types are extremely complicated here, including high-end and top-grade science parks, lagging urban villages, migrant population centers in poor conditions, high- and middle-grade commercial housing communities, and traditional and even declined old '*unit* (单位) communities'. Therefore, the population composition is also extremely diverse, with high-income groups, high-tech talents, and businessmen, and also low-income migrant workers, old residents moving from old districts, traditional laid-off workers, and even farmers with original rural household registration. As a rural-urban fringe zone, Qinghe suffers quite unbalanced internal development.

Given its background, the prominent problem facing the research group, from the perspective of social science, is an insufficient growth of society and insufficient participation of community residents. Therefore, one important part of the experiment is to motivate the social vitality through two parts, "social reorganization" and "community improvement". Social reorganization is to seek new social forces and improve the representativeness and self-governing capacity of organizations; community improvement is to make the community live better by encouraging proposals oriented to residents' needs (Q. Li & Wang, 2016).

On the other hand, from the perspective of urban planning, the prominent problem is the extreme imbalance between "urbanization of space" and "urbanization of population" ("空间城镇化与人口城镇化发展高度不均衡的问题"). On the other hand, from the perspective of urban planning, the prominent problem is the extreme imbalance between "urbanization of space" and "urbanization of population. " Under the quest for a novel type of community planning, professor Liu Jiayan from the School of Architecture at Tsinghua University proposed a pathway from "community construction" to "community building, " with the core focus being on the "human development, " and pay attention to the role of spatial production processes in the reproduction of social capital and networks. Ultimately, rediscover and rebuild community to make it indeed a matter of residents own concerns rather than the government only（"致力于探索基于社会-空间生产的新型社区规划路径，以‘人的发展’为核心理念，关注空间生产过程对于社会资本和关系网络的再生产作用，重新发掘和培育社区共同体，使社区发展真正成为居民自己的事，而不仅仅是政府的事。"）(J. Liu & Deng, 2016).

Different from the previous two urban regeneration projects, the New Qinghe Experiment is on a much smaller scale and not on hutong area. Yet, its grass-root social governance and spontaneous community building initiatives based on a diverse background of residents is extremely valuable and inspiring for this study, and may contribute to finding a Chinese localized urban sociological theory and methodology in the practice and experiment.

2.3 Streetscape measurements and street view image processing

City streets are considered as "the most widely distributed and heavily trafficked urban public spaces", which could be defined as a combination of two major components: roadways and streetscapes. Roadways are infrastructure for linear travel, often in motor vehicles, but also by non-motorized users such as pedestrians and bicyclists, and are designed to be functional for safe and efficient travel. Streetscapes are the three-dimensional built environments surrounding roadways, the "outdoor rooms" one encounters when stepping out the door into the street or turning the corner (Cullen, 1971). As cities strive to improve livability in the built environment, planners and designers need to have a concise understanding and proper measurements of what contributes to the quality of street space.

In the field of architecture and related interdisciplinary areas, a considerable number of studies have discussed approaches regarding quantitative measurement of the built environment and street space quality. Well-known academic works have repeatedly proven that physical space and street form are the cornerstones of street activities. From the perspective of environmental psychology, they play a fundamental role in social interaction, while good form brings better perceived visual feeling. In sum, "greenery, openness, enclosures, street wall continuity, and cross-sectional proportion, are some of the basic morphological features among all the variables that contribute to the quality of street space. " (Lynch, 1984).

Within the field of urban design, efficient and objective measurement of streetscape is a formidable challenge. The most straightforward and well-established strategy for measuring urban design is to send human auditors into the field trip, where they record direct observations using an audit protocol. Dozens of audit tools have been developed to support academic and policymaking research, and they are often reused or modified as off-the-shelf methods for investigating and documenting streetscapes (Brownson, Hoehner, Day, Forsyth, & Sallis, 2009). While field audits could present several challenges, including huge expenses and logistics effort, they are nonetheless attractive as a well-documented strategy for collecting reliable urban design measurements and became the dominant method.

Since the utilization of Geographic Information Systems (GIS) and remote sensing has spread to several science areas, from oceanography to geotechnics, aerial photos with high resolution are increasingly used for top view analysis. Its application in the field of urban mapping was intensified in the last century, which allowed a significant development due to the use of geographic database, new analysis tools, and more recently, free and open-source software. Moreover, there is a distinct collection of literature that exclusively uses GIS methods to measure the built environment for research on walking, physical activity, and broader livability indicators (Brownson et al., 2009). These methods provide many efficiency, scalability, and data consistency benefits, but shortcomings in the availability of appropriately-scaled data have traditionally made them inadequate for measuring urban design at the streetscape scale. Several studies are dedicated to fill this gap, exploring precise, replicable, and efficient GIS-based methods for measuring streetscape skeletons which may allow them to be incorporated alongside macroscale urban form measures in future assessment of human behavior in built environments (C. W. Harvey, 2014; Tang & Long, 2018).

Another difficulty of validating GIS measures with observational audits underscores the ambiguity of urban design characteristics and explains the scarcity of design research using quantitative methods. With no standard definitions for qualities such as enclosure, greenness, and human scale, it is very challenging to measure them with the consistency and precision necessary to include them in the built environment models. For instance, the term "human scale" is commonly used in urban design literature to generally refers to an appealing scale for users on foot, although there are few definitive interpretations of its boundaries (Alexander et al., 1977). Sense of scale can be conveyed by embellishments, such as furniture, planters, and ornamentation, or by the size of encompassing structures and spaces. Theorists also discuss scale in the context of speed, i.e., a broad street may feel appropriate when moving fast in a car, but uncomfortably vast for a pedestrian. Hence, human scale generally refers to an appealing scale for users on foot (Ewing & Handy, 2009).

As computer-assisted auditing and evaluation become increasingly popular due to efficiency, another group of researchers have investigated how streetscape images can be used as data-collecting means in conducting field audits remotely. Over the last decade, the emerging dataset of street view image and evolving computer sciences technologies like deep learning algorithms for processing images provided an alternative approach on measuring the visual aspect of street quality and had been widely used as a tool for remotely conducting systematic observation of the built environment. Street view images create an actual view of a streetscape, allowing users to imagine the real street scene easily. It presents all surrounding information equivalent to an on-the-spot investigation on a larger scale at one time (A. R. Zamir, A. Darino, & M. Shah, 2011).

In recent years, growing numbers of quantitative methodologies and empirical investigation studies have been explored to integrate street view image data in existing methods. Studies have found that street view images offer advantages over in-person field audits, such as efficiency, safety, cost, and the potential to roll out built environment research to larger areas and more places globally (Griew et al., 2013; Rundle, Bader, Richards, Neckerman, & Teitler, 2011). Specifically, there are plenty of literature using street view images for urban planning and evaluation of the human-viewed street greenery that suggest this might indeed be effective and efficient (X. Li, Zhang, Li, et al., 2015; Long & Liu, 2017; Tang & Long, 2018; Yin & Wang, 2016). Moreover, replicable and efficient ways of processing street views images allow assessment of large, geographically dispersed samples of streetscapes visuals that would be otherwise impractical to survey using traditional field audits.

Researchers from various science fields have increasingly investigated the reliability and feasibility of assessing streetscape characteristics and neighborhood environment using Google Street View (GSV). By stitching the pictures together, GSV image can create a continuous 360° image of a streetscape. And the GSV image library has been proposed as a useful potential data source for urban studies, such as the identification of commercial entities (Clarke, Ailshire, Melendez, Bader, & Morenoff, 2010; Griew et al., 2013; Rundle et al., 2011; Yin & Wang, 2016). By stitching the pictures together, GSV images can create a continuous 360° image of a streetscape. In fact, the GSV image library has been proposed as an effective potential data source for urban studies, such as identification of commercial entities (A. R. Zamir et al., 2011), 3D city modeling (A. Torii, M. Havlena, & T. Pajdla, 2009; B. Micusik & J. Kosecka, 2009), public open space audit (Edwards et al., 2013; Taylor et al., 2011), neighborhood environmental audit (Clarke et al., 2010; Griew et al., 2013; Odgers, Caspi, Bates, Sampson, & Moffitt, n.d.; Rundle et al., 2011).

Powered by machine-learning, MIT Media Lab launched a project called Place Pulse, aiming to quantitatively identify which areas in a city are perceived as "wealthy, modern, safe, lively, active, central, adaptable or family-friendly", through its official website (http://pulse.media.mit.edu) and large-scale street view images. Further studies by (C. Harvey, Aultman-Hall, Hurley, & Troy, 2015; X. Li, Zhang, & Li, 2015; N. Naik, J. Philipoom, R. Raskar, & C. Hidalgo, 2014; Salesses, Schechtner, & Hidalgo, 2013) were based on the dataset of Place Pulse. The latest exciting method from SegNet presents a deep learning framework for semantic segmentation of street view images through which 12 categories of objective elements are recognized (Kendall, Badrinarayanan, & Cipolla, 2015). Together with other similar methods, this breakthrough increases the potential for tremendous advances in the field of urban design, especially in studies of the built environment and streetscape quality, and therefore provided a direction for the methodology that I have designed and used for the study at Baitasi hutong at a much smaller and entry level.

Chapter 3

The term "image recognition", "image classification" or "scene parsing" is often connected to "computer vision", which is an overarching tag for the process of training computers to see like human beings, and "image processing", which is a term for computers doing intensive work on massive amounts of image data. Today, the emergence of machine learning, mainly deep learning algorithms have set the benchmark on many accessible datasets and projects. The primary focus of the image recognition task of this study is on the traffic volume and streetscape quality based on the street view image dataset collected from the field audit. This chapter firstly gives a glance at three mainstream image recognition methods to explain why specific methods and tools are selected for the research purpose of this study, then demonstrates the full computer-assisted analysis in detail, including data retrieving by using Python to access Baidu APIs and OpenCV, data validation and pre-processing, as well as final spatial data visualization in GIS software.

3.1 Image recognition methods

With the rise of artificial intelligence (AI) and machine learning, image recognition and classification is widely used to describe the computer technologies that could recognize specific objects, like vehicles, people, animals, landscape, or other targeted subjects through the use of algorithms and deep learning concepts. It is one of the most actively pursued areas in the broad field of imaging sciences and engineering. The main idea is to inspect an image scene by processing data obtained from sensors. In the past, most image recognition and classification applications have been for military hardware because of high cost and performance demands. With recent advances in optoelectronic devices, sensors, electronic hardware, computers, and software, image recognition and classification systems have become available with many commercial applications (Javidi, 2002).

For commercial applications, there are currently three mainstream image recognition methods: label information recognition, color texture recognition, and semantic segmentation. The basic idea is, label information recognition identifies the element information contained in the content-wise image, while color texture recognition identifies the element by a specific color and calculates its proportion, and semantic segmentation identifies relevant elements and calculate their respective proportions at a pixel level.(Badrinarayanan, Kendall, & Cipolla, 2015; C. Liu, J. Yuen, & A. Torralba, 2011; M. Guillaumin, J. Verbeek, & C. Schmid, 2010)

Approaches of label information recognition typically work with a fixed number of object categories and require training generative or discriminative models for each category from training data. In the recognizing stage, these systems try to align the learned models to the input image and associate object category labels with pixels, windows, edges, or other image representations. However, these learning-based methods do not, in general, scale well with the number of labels. For example, to include more labels in an existing system, new models have to be trained for the new labels and, typically, adjust system parameters. Increasing the quantity and diversity of hand-labeled images improves the performance of the learned classifier while labeling images is a time-consuming task. Therefore, training can be a tedious job if a project needs to include thousands of labels in an image recognition system. Besides, the complexity of contextual relationships among objects also increases rapidly as the quantity of labels expands(C. Liu et al., 2011; M. Guillaumin et al., 2010).

Traditionally in color texture recognition, RGB color space is widely used. However, RGB color space is not accurate in human visual perception and statistical analysis because colors are coded using the three channels (figure 12a), it is more challenging to segment an object in the image by its color. Instead, the hue, saturation, value (HSV) color space model is applied to obtain more accurate color statistics for extracting features. Since the hue, representing the color portion of the model expressed as a number from 0 to 360 degrees, is the only channel that models the color type, it is advantageous in the image processing tasks that need to segment an object by its color. Saturation describes the amount of gray in a particular color from 0 to 100 percent; Value works in conjunction with saturation and describes the brightness or intensity of the color, from 0-100 percent, where 0 is completely black, and 100 is the brightest and reveals the most color (figure 12b). Using the HSV model for image recognition, an object with a specific color can be detected and to reduce the influence of light intensity from the outside. One form of application of the HSV model is for facial recognition as the process is fast thanks to the advantage of being simple in programming (Chang, Yu, Chen, & Tsai, 2010).

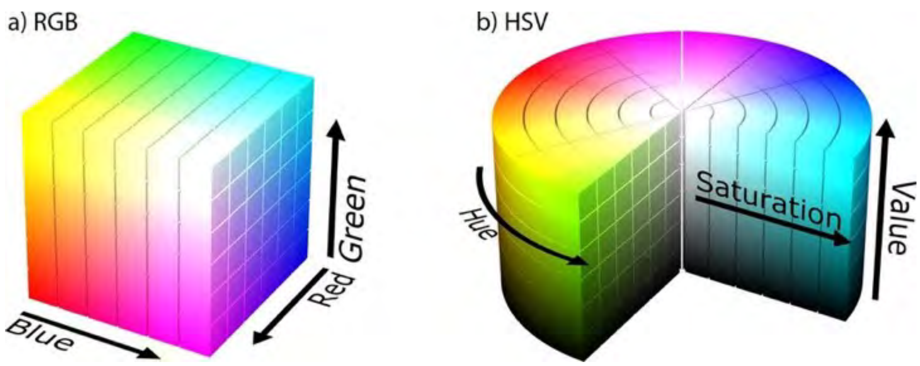

Figure 12: RGB versus HSV color space model (source: OpenCV tutorial[xxviii])

In regard to semantic segmentation, it requires an understanding of an image at a pixel level and is an essential tool for scene understanding, which has wide-ranging applications from robotic interaction to autonomous driving (Badrinarayanan et al., 2015). A lot of semantic pixel-wise image segmentation methods based on convolutional networks have emerged recently, such as YOLO, ImageNet, SegNet, DeepLab, among which SegNet (https://mi.eng.cam.ac.uk/projects/segnet/) is highly accurate and easily accessible for free public use (Tang & Long, 2018). The architecture, according to SegNet's website, consists of a sequence of non-linear processing layers (encoders) and a corresponding set of decoders followed by a pixel-wise classifier. However, since most of the projects applying semantic segmentation are using western datasets of labeled images as training samples for the deep learning algorithm, which are quite different from the unique streetscape of hutong area in China, therefore this method is not suitable for the study of Baitasi area.

Typically, academic studies on image recognition in the field of computer vision would consider much larger datasets featuring millions of images and hundreds of label categories. However, given the total 543 geotagged street view images I have collected from Baitasi area for this study, a simple recognition task should be designed and tailored for the dataset of this size and type. As mentioned above, the recognition accuracy of those learning-based methods highly depends on the quality and quantity of training samples, which means for the specific scale of this study, it would make more sense to use methods developed for the context in China. After investigating two of China's biggest tech giants, Baidu and Tencent, I found that despite both provide open AI platform with free API for image recognition, face recognition, and Optical Character Recognition (OCR), only Baidu AI (http://ai.baidu.com/) has a stand-alone category of six APIs on vehicle analysis which meets the main detecting target for this study. Since the company has directed significant funding into developing autonomous driving and runs the largest fleet of autonomous driving test vehicles in China[xxix], it is reasonable to trust its image recognition system is the best available of its kind in domestic China.

3.2 Retrieve image data using Python to access Baidu APIs and OpenCV

An API, shorts for Application Programming Interface, is an interface or communication protocol between different parts of a computer program intended to simplify the implementation and maintenance of software[xxx]. Basically, an API enables one piece of software "talk" to another piece of software. More recently, a specialized form namely WEB API has been often used to define a specific kind of interface between a client and a server, which has been described as a "contract" between both. When clients use an API, generally one program makes a set of services available for use by other applications and publishes the APIs (i.e., the "contract") that must be followed to access the services provided by the program. In the case of APIs provided by Baidu AI, each API has a subpage of tech documentation including the function description, how to request data in different coding language, and what specific data could be retrieved. It is quite common that a client needs an API key to make use of a vendor’s API. The general idea is that they want to know who is using their services and how much each user is using. Normally they have free and pay tiers of their services or have a policy that limits the number of requests that a single individual can make during a particular time period.

For the research purpose of this study, two APIs from Baidu AI were selected, vehicle detect and body detect. The API for vehicle detect[xxxi] provides users an endpoint to detect all motor vehicles within a single frame image and return the type and coordinate position of each vehicle. It can identify five major types of vehicles, including car, truck, bus, motorcycle, and tricycle, count the total numbers of each type of vehicle, and also locate the license plate position for car, truck, and bus (figure 13, left). At present, it is mainly applicable to common monitoring scenarios, such as roads and parking lots. Another API for body detect[xxxii] provides users an endpoint to identify and count the number of human bodies in the image with appropriate aspect ratio (static statistics only, does not support tracking or deduplication). It works the best on mid-to-long-range aerial photography above 3 meters, with head and shoulders as the main target to identify the number of people (figure 13, right). It does not require frontal or full-body photos and is suitable for various crowded scenes (i.e., airports, exhibition shows, tourist spots, urban squares). It can also detect and count the number of people in a specified irregular area, and the rendered picture can be output at the same time.

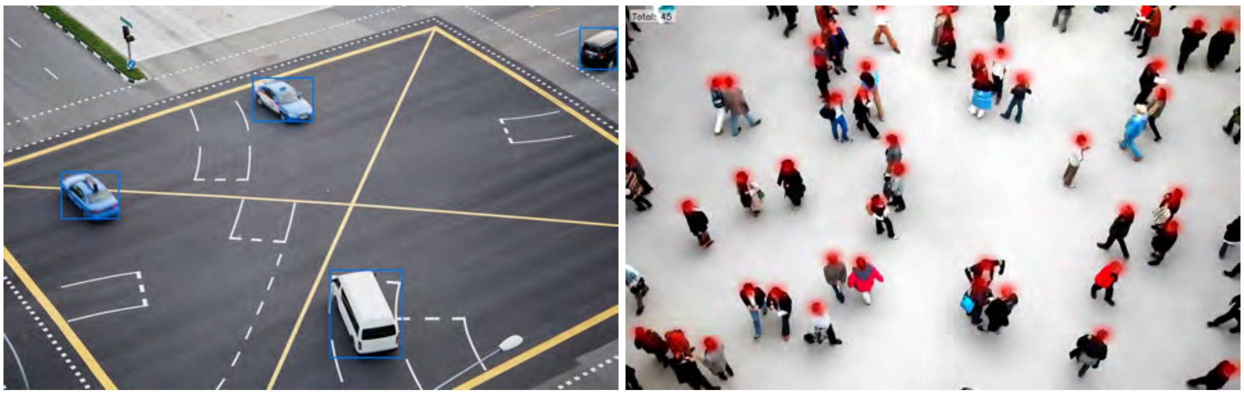

Figure 13: Sample images on Baidu API for vehicle detect (left) & body detect (right) (source: Baidu website[xxxiii])

Depending on the intended use of an API, the way to access it may differ. There are a couple of third-party tools like Postman (https://www.getpostman.com/) or Runscope (https://www.runscope.com/) that allow users to make one-off requests to API endpoints without coding, which are suitable for those non-programmers. Having taken a few lessons on basic Python during the master program and some advanced online courses in spare time, I chose Python as the programming language to access the Baidu APIs as mentioned earlier to tackle the image recognition task. The entire process can be summarized into three steps: Firstly, due to the original image is oversized (3648 × 2736 pixels, 3-5 MB) for the API endpoint to identify, write and run a code (figure 14) to downsize all the images to 1000 × 750 pixels by dimension, below 200KB; Then, write and run two codes (figure 15 & 16) to make separate requests to APIs on vehicle detect and body detect, and retrieved specific data in two CSV documents; Lastly, merge the two and consolidated into one excel sheet that lists the total numbers of people, bus, car, motorbike, tricycle, and truck, detected on each photo (table 2), which is used in the following mapping and analysis.

```python
# -*- coding: utf-8 -*-
from PIL import Image
import glob


image_path = '/Users/ellenjin/Desktop/Thesis/Image_street'
save_path = '/Users/ellenjin/Desktop/Thesis/Image_street_sm/'
i = 0

filenames = glob.glob(image_path+"*.jpg")
for filename in filenames:
    examname = filename[-23:-4]
    print (examname)
    i = i + 1
    basewidth = 1000
    img = Image.open(filename)
    wpercent = (basewidth/float(img.size[0]))
    hsize = int((float(img.size[1])*float(wpercent)))
    img = img.resize((basewidth,hsize), Image.ANTIALIAS)
    file_new = save_path + examname + "_NEW.jpg"
    img.save(file_new)
    print ('The ' + str(i) + ' image is finished!')
```

Figure 14: Python script for image downsize

```python
# -*- coding: utf-8 -*-
from aip import AipImageClassify
import cv2,time
from urllib import request
import ssl
import json
import base64
import requests
import glob,os
import pandas as pd

client_id = "Q3B9el1BZlItK1jUsqssdwG1"  # AK retrieved from Baidu API
client_secret = "at4CvbSgmGrF5AyrhizYMVOsCzL7uZBb"  # SK retrieved from Baidu API
image_path = "/Users/ellenjin/Desktop/Thesis/Image_street_sm/"  # image folder
results_path = '/Users/ellenjin/Desktop/Thesis/Data/'    #results text folder

#INIT
gcontext = ssl.SSLContext(ssl.PROTOCOL_TLSv1)
while True:
    host = "https://aip.baidubce.com/oauth/2.0/token?grant_type=client_credentials&client_id=" + client_id + "&client_secret=" + client_secret
    req = request.Request(host)
    response = request.urlopen(req, context=gcontext).read().decode('UTF-8')
    result = json.loads(response)
    if (result):
        #print(result)
        print(result['access_token'])
        break
    else:
        continue #if can't authenticate, let's loop back and try again

#To count the number of cars by usig the Car_detect API. it will return a dictionary of each vehicle type and its number.

def carsnum(image_path,results_path):
    result_list=[]
    i = 0
    filenames = glob.glob(image_path+"*.jpg")
    for filename in filenames:
        print (filename)
        f=open(filename,'rb')
        img = base64.b64encode(f.read())
        host = 'https://aip.baidubce.com/rest/2.0/image-classify/v1/vehicle_detect' #Url for the endpoint from Baidu API tech documentation
        headers={
               'Content-Type':'application/x-www-form-urlencoded'
            }
        access_token= result['access_token']
        host=host+'?access_token='+access_token
        data={}
        data['access_token']=access_token
        data['image'] =img
        print ("ok, proceeding to request")
        res = requests.post(url=host,headers=headers,data=data)
        print ("request processed")

        req=res.json()
        results=req['vehicle_num']
        print(results)
        result_new={**results,**{"Image":filename.split("/")[-1]}}
        result_list.append(result_new)
        i = i + 1
        print ('The ' + str(i) + ' image is finished!')
        time.sleep(5)
    return pd.DataFrame(result_list) #Return a dataframe with all the results

if __name__ == '__main__':
    carsnum(image_path, results_path).to_csv(results_path+"cars_results2.csv",sep=";",mode="w",index=False) #Write the dataframe to a .CSV file
```

Figure 15: Python script to access Baidu API of vehicle detect

```python
# -*- coding: utf-8 -*-
from aip import AipImageClassify
import cv2,time
from urllib import request
import ssl
import json
import base64
import requests
import glob,os
import pandas as pd

client_id = "Q3B9el1BZlItK1jUsqssdwG1"  # AK retrieved from Baidu API
client_secret = "at4CvbSgmGrF5AyrhizYMVOsCzL7uZBb"  # SK retrieved from Baidu API
image_path = "/Users/ellenjin/Desktop/Thesis/Image_street_sm/"  # image folder
results_path = '/Users/ellenjin/Desktop/Thesis/Data/'    #results text folder

#INIT
gcontext = ssl.SSLContext(ssl.PROTOCOL_TLSv1)
while True:
    host = "https://aip.baidubce.com/oauth/2.0/token?grant_type=client_credentials&client_id=" + client_id + "&client_secret=" + client_secret
    req = request.Request(host)
    response = request.urlopen(req, context=gcontext).read().decode('UTF-8')
    result = json.loads(response)
    if (result):
        #print(result)
        print(result['access_token'])
        break
    else:
        continue #if can't authenticate, let's loop back and try again

#To count the number of people by usig the Body_num API. it will return a list of body numbers in each photo.

def pplnum(image_path,results_path):
    result_list=[]
    i = 0
    filenames = glob.glob(image_path+"*.jpg")
    for filename in filenames:
        print (filename)
        f=open(filename,'rb')
        img = base64.b64encode(f.read())
        host = 'https://aip.baidubce.com/rest/2.0/image-classify/v1/body_num'
        headers={
            'Content-Type':'application/x-www-form-urlencoded'
          }
        access_token= result['access_token']
        host=host+'?access_token='+access_token
        data={}
        data['access_token']=access_token
        data['image'] =img
        print ("ok, proceeding to request")
        res = requests.post(url=host,headers=headers,data=data)
        print ("request processed")

        req=res.json()
        results=req['person_num']
        print ("total ppl:",results)
        resultppl={"Image":filename.split("/")[-1],"Number of Person":results}
        result_list.append(resultppl)
        i = i + 1
        print ('The ' + str(i) + ' image is finished!')
        time.sleep(5)
    return pd.DataFrame(result_list) #Return a dataframe with all the results

if __name__ == '__main__':
    pplnum(image_path, results_path).to_csv(results_path+"ppl_results2.csv",sep=";",mode="w",index=False) #Write the dataframe to a .CSV file
```

Figure 16: Python script to access Baidu API of body detect

Image	People	Bus	Car	Motorbike	Tricycle	Truck
IMG_20190911_074130_NEW.jpg	0	0	5	0	0	0
IMG_20190911_074140_NEW.jpg	3	0	5	2	0	0
IMG_20190911_074151_NEW.jpg	4	0	5	0	0	1
IMG_20190911_074202_NEW.jpg	1	0	6	2	0	2
IMG_20190911_074212_NEW.jpg	2	0	6	1	0	0
IMG_20190911_074217_NEW.jpg	3	1	3	1	0	1
IMG_20190911_074229_NEW.jpg	6	0	7	2	1	0
IMG_20190911_074239_NEW.jpg	6	0	2	1	0	1
IMG_20190911_074251_NEW.jpg	1	0	6	0	0	2
IMG_20190911_074301_NEW.jpg	0	0	4	0	0	3

Table 2: Sample of the consolidated data retrieved from Baidu APIs

For the color texture recognition, rather than using API, a library called OpenCV can be used directly in Python to process the recognition task of this study. OpenCV is an Open Source Computer Vision library that is written in C and C++ and runs under Linux, Windows and Mac OS X, with active development on interface for Python, Ruby, Matlab, and other programming languages. It is designed for computational efficiency and one of its goals is to provide a simple-to-use computer vision infrastructure that helps people build fairly sophisticated vision application quickly. The OpenCV library contains over 500 functions that span many areas in vision, including factory product inspection, medical imaging, security, user interface, camera calibration, stereo vision, and robotics. Because computer vision and machine learning often go hand-in-hand, OpenCV also contains a full, general-purpose Machine Learning Library (MLL) which is focused on statistical pattern recognition and clustering (Bradski & Kaehler, 2008). The MLL is highly useful for the vision tasks that are at the core of OpenCV's mission, yet not for this study given the size of the datasets.

```python
# -*- coding: utf-8 -*-
import cv2,time
import glob,os
import pandas as pd



image_path ='/Users/ellenjin/Desktop/Thesis/Image_street_sm/'   #original image folder
if not os.path.isdir(image_path):
    os.mkdir(image_path)
results_path = 'greenspaces/results/'    #results text folder
if not os.path.isdir(results_path):
    os.mkdir(results_path)
save_path_hsv = 'greenspaces/hsv/'   #results image folder
if not os.path.isdir(save_path_hsv):
    os.mkdir(save_path_hsv)


def brg2hsv(image_path,save_path_hsv):
    result_list=[] #Save all results
    filenames = glob.glob(image_path+"*.jpg") #Search for certain files & put them in a list
    for filename in filenames:
        print (filename)
        t = int(time.time())
        examname = filename[-23:-4]
        type = filename.split('.')[-1]
        img = cv2.imread(filename)
        img_hsv = cv2.cvtColor(img,cv2.COLOR_BGR2HSV)
        save_hsv = save_path_hsv + examname + '_HSV'+'.'+type
        cv2.imwrite(save_hsv,img_hsv) #Save a HSV backup of the file
        row_num = img_hsv.shape[0]
        column_num = img_hsv.shape[1]
        k=0
        for i in range(0,row_num):
            for j in range(0,column_num):
                if 77> img_hsv[i,j,0] >35:
                    k=k+1
        Percentage=k/(row_num*column_num)
        result={"File":filename.split("/")[-1],"Green %":str(Percentage)}
        print (result)
        result_list.append(result)
        print(filename+" "+"recognition completed! "+"time: "+str(int(time.time()-t))+"s")
    return pd.DataFrame(result_list) #Return a dataframe with all the results

if __name__ == '__main__':
    brg2hsv(image_path, save_path_hsv).to_csv(results_path+"greenspaces_results2.csv",sep=";",mode="w",index=False) #Write the dataframe to a .CSV file
```

Figure 17: Python script to use OpenCV for calculating greenness ratio

For the research purpose of this study, only the function COLOR_BGR2HSV to convert image format from RGB to HSV is used in the Python code (figure 17), followed by the built-in range() function in Python to extract the value of the hue channel from the converted HSV image and calculate the pixel ratio. Note that OpenCV hue range goes from 0 to 180, and there is no agreed benchmarking of confirmed range for a specific color. Recommended by a Chinese urban planner, a hue range of 35-77 is defined as the color green for this study (table 3). Nonetheless, I acknowledge the potential bias in setting the greenness range, and different illumination conditions or shadows could have influenced the calculation results, which is beyond the topic of this paper and will therefore not be addressed. As described in the code, the visible vegetation ratio or greenness ratio for each HSV image is calculated by dividing the sum of the attributes falling into the range of 35–77 by the total. After running the code on all 543 images, final percentage results are written in a .csv file, which is used in the following mapping and analysis.

Figure 18: Standard hue range (OpenCV hue range goes from 0-180) (Source: Medium website[xxxiv])

	黑	灰	白	红		橙	黄	绿	青	蓝	紫
hmin	0	0	0	0	156	11	26	35	78	100	125
hmax	180	180	180	10	180	25	34;	77	99	124	155
smin	0	0	0	43		43	43	43	43	43	43
smax	255	43	30	255		255	255	255	255	255	255
vmin	0	46	221	46		46	46	46	46	46	46
vmax	46	220	255	255		255	255	255	255	255	255

Table 3: Example of the color range in OpenCV (hue range for green highlighted in the green box) (Source: online blog[xxxv])

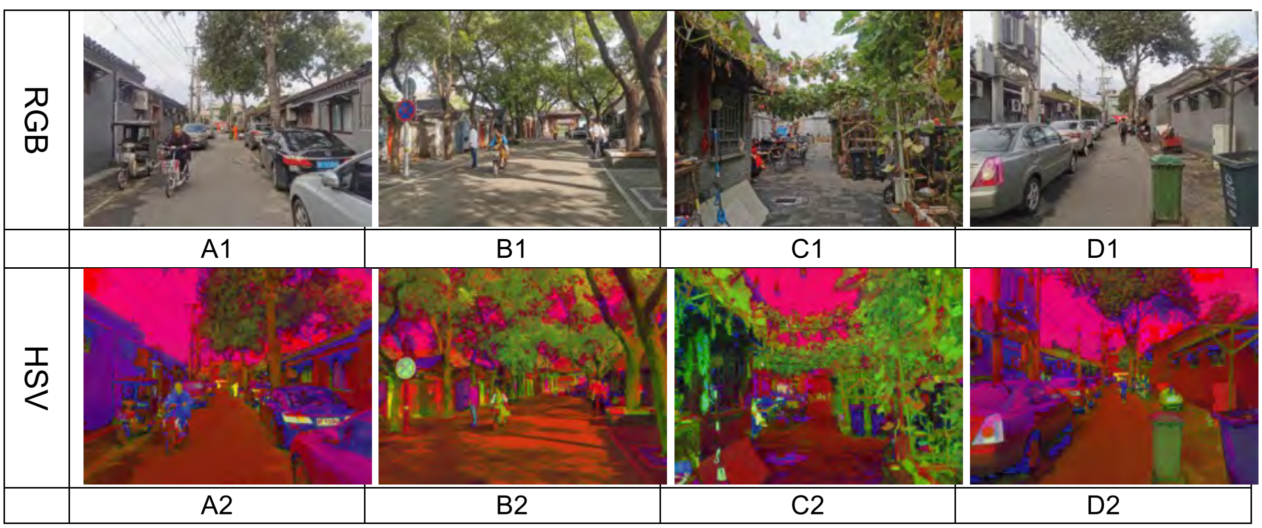

Table 4: Sample HSV images converted from original RGB images

3.3 Data pre-processing and visualization

Final results were analyzed using both QGIS and ArcGIS. QGIS, previously also known as Quantum GIS, is a free and open-source desktop Geographic Information System (GIS) application that is designed for viewing, editing, mapping, and analyzing geospatial data. Born in May of 2002, the project was later established on SourceForge in June of the same year[xxxvi]. QGIS currently runs on most Unix platforms, Windows, and macOS while its competitor ArcGIS can only run on Windows system. Moreover, with a dominant 43% share of the GIS software market [xxxvii] , ArcGIS desktop products by Esri (http://www.esri.com) provide high degree of specialization and complexity for the work of professional planners, yet are intimidating for first time users, and only available through purchasing a single-use license which is quite expensive. For the research of this study, both are selected as the spatial analyzing tools to visualize the location-based results from the above session due to the required functions.

Firstly, all the 543 street view images were imported into QGIS project to create a point layer corresponding to the geotagged locations from JPEG images. Because images were taken proximately every 15 meters, each of a red dot on the map (figure 19) is a cluster of many points. The base map was added from OpenStreetMap (http://www.openstreetmap.org), a free world map under an open license.

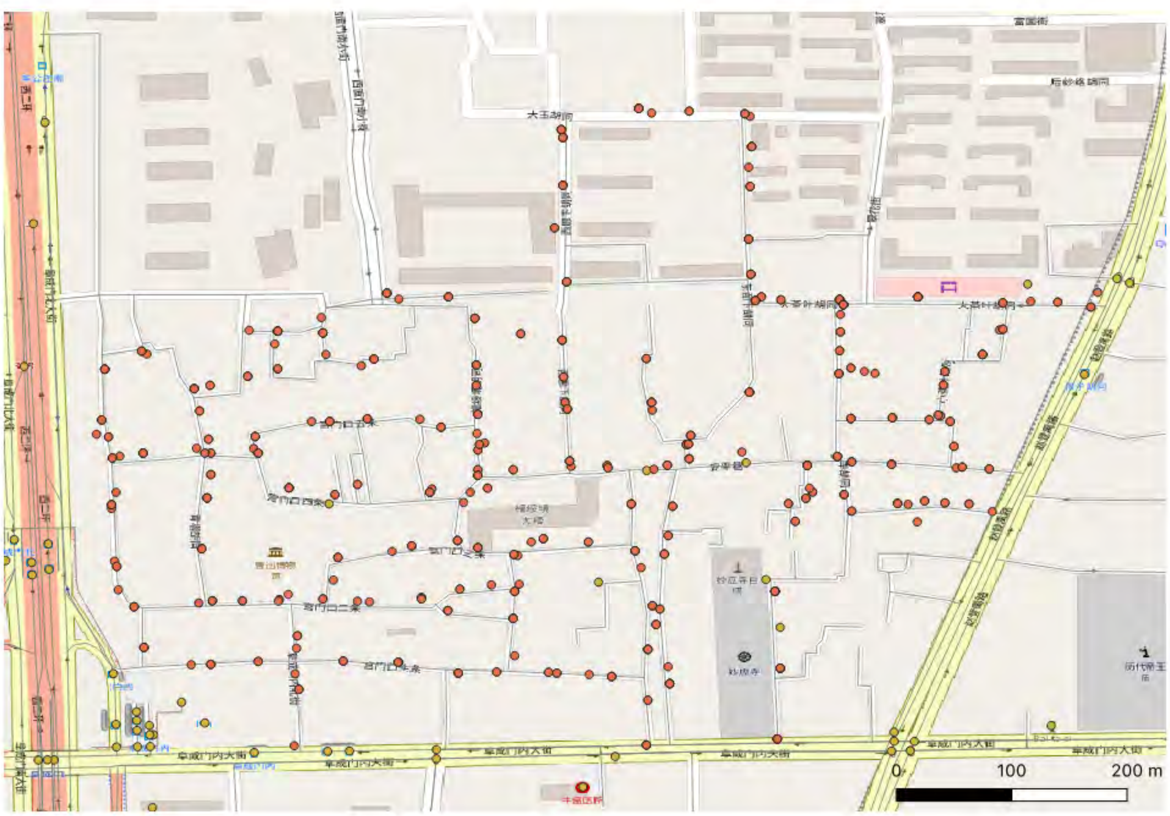

Figure 19: Geolocation of the street view images (created with QGIS)

Before adding the results from the previous image recognition process to the map, I had cross-checked the numbers with corresponding photos and found that some numbers of vehicles were not accurate. As introduced before, there are five primary types of vehicles detected from the image, including car, truck, bus, motorcycle, and tricycle. During the field trip, there were few buses or trucks spotted within the hutong except on the part of the outskirt road, which was indeed broad enough. However, the final results show among the total 543 photos, there are 40 photos has one bus, and 4 photos have two buses on them. Much worse for trucks, 153 photos have one, 64 photos have two, 28 photos have three, 9 photos have four, and 2 photos (#081457 & #081507) have six and ten on each (Figure 20).

Figure 20: Street view image #081457 (left) and ##081507 (right) with tricycles

After double-checking those "suspicious" photos one by one, I found that the API algorithm tended to identify the motorized tricycle as a "truck" rather than tricycle and seven-seater minivan as a "bus" rather than car, which could explain the wrong numbers that did not make sense in reality. Such three-wheel motorcycle, or elderly mobility e-car, as introduced before in 1.2, share similar appearance as trucks regardless of size difference. In some of the street view images, the shapes of vehicle could be dramatically distorted in various ratios given the distinct distance. Therefore, a small three-wheel motorcycle in front could be much bigger than a SUV in back, which would probably confuse the algorithm to identify it as a truck. Despite not specified on its official documentation, it could be speculated that the Baidu API on vehicle detect works the best on mid-to-long-range aerial photography above 3 meters, as shown in figure 13.

To solve this problem, manually correcting the numbers by visual check is not ideal because the correct numbers would mix with the other unchecked numbers, and thus it would not be possible to validate the accuracy level of the API. Therefore, the best solution is to add up the numbers of buses, cars, and trucks as the total number for vehicles with three and four wheels. The numbers of tricycles could be ignored as there are only 18 photos detected with one on each. Nevertheless, keep the numbers for motorcycles, which are mostly accurate after random checking some images. New data was consolidated into one single table, with greenness data as well, as in table 5 below.

Image ID	People	Motorbike	Vehicle	Greenness %
IMG_20190911_074130	0	0	5	0.032
IMG_20190911_074140	3	2	5	0.03
IMG_20190911_074151	4	0	6	0.058
IMG_20190911_074202	1	2	8	0.063
IMG_20190911_074212	2	1	6	0.025
IMG_20190911_074217	3	1	3	0.024
IMG_20190911_074229	6	2	8	0.066
IMG_20190911_074239	6	1	3	0.019

Table 5: Consolidated final results of image recognition after data pre-processing

The next steps were to add the clean data into ArcGIS project, join the new attributes to the existing photo layer by the same image ID, and format each attribute in the best way to visualize the data result in maps. As shown in figure 21, darkest blue dots represent areas with over a dozen vehicles, where are mostly private reserved street parking in the neighborhood and a few public parking lot like the two-lane 10 meters wide street to the west side bordering the only park in the area. The lightest blue dots represent areas with no vehicles, usually very narrow alleys accessible by foot or bikes only. The streets with only one vehicle are likely to be recognized with the three-wheel motorcycles mentioned earlier, mostly owned by the senior residents for transportation outside of hutong, or by the courier to deliver packages inside hutong.

Figure 21: Map of three-and-four-wheel vehicle numbers in the study area (created with ArcGIS)

In contrast, according to the map in figure 23, it seems there are not as many motorbikes as cars and three-wheelers on the street. It is understandable because motorbike has been increasingly replaced by e-bikes, which is cheaper, smaller, easier to drive, and no license plate needed. With the appearance very similar to a traditional bike, it is not identified by the API algorithm since the bike is not included in the five categories. Drawing on my field experience, e-bike is probably the most popular transportation tool to get around to the deep narrow alleys of hutong.

Figure 22: E-bike v.s. motorbike

Figure 23: Map of motorbike numbers in the study area (created with ArcGIS)

For the numbers of people, a heatmap (also called kernel density analysis) was created to get a more intuitive idea at which areas attract the most people, namely the center areas. Based on the visual in figure 24, the darker the red is, the denser human traffic there are on the street. Referring to the Tencent map of POIs (point of interests) in the area, it is clear to see the most populated places (in red circles on figure 25) are along the Gongmenkou east alley (宫门口东岔), where accommodate the busiest restaurants and grocery stores. Another dense area to the northeast is probably because there are two kindergartens (曙光幼儿园，快乐宝贝幼儿园) in the area. Considering the street view images were taken around 9 a.m., daily commuters for work were already left, and those who did not go to work early would more likely either have a late breakfast at restaurant, do groceries for cooking lunch, or send kids to kindergarten.

Figure 24: Heatmap of human traffic in the study area (created with ArcGIS)

Figure 25: Tencent map with POIs in the study area (accessed on December 15, 2019)

Regarding living facilities, though not shown on the map due to the scale, there are plenty of grocery stores, farmers markets, restaurants, barbers, pharmacies, and so on. Residents can buy all the life essentials without step out of hutong, or more convenient, put an order online and receive it by delivery. There used to have a saying that people can buy anything from birth to death from stores in hutong, which is not the case today due to the demolishment of many small business shops in the area ordered by authority. Additionally, given a lot of original inhabitants living in the area are seniors, medical resources are essential. There are over ten top public hospitals within 2km distance and several community medical service centers and pharmacies, which is very attractive to senior people who chose to stay and live by themselves rather than moving in their children's apartment further away. Since most of them are retired workers with full medical insurance coverage, they would like to take advantage of it.

For the greenness ratio, according to the paper by (Long & Liu, 2017), the Green View Index (GVI) for its project is classified into four categories—not green (⩽ 0.2), somewhat green (0.2 - 0.4), green (0.4 - 0.5), and very green (> 0.5). However, the result of this study ranges from 0.003 to 0.323 and mostly fall under 0.1. To better reflect the greenness reality of street space in hutong area, the ratio data was classified into four new categories—not green (⩽ 0.05), a bit green (0.05 - 0.1), quite (0.1 - 0.2), and green (> 0.2) — represented by red, orange, light green, and dark green. As shown in the map below (figure. 26), there is barely any green dot inside the hutong, and the only few green spots are scattered on the vertical road to the very west bordering the only park in the area, plus the main road in front of Luxun Museum to the southwest corner.

Figure 26: Greenness ratio in the study area (created with ArcGIS)

Not surprisingly, this result does match with my impression while walking around in the hutong. The only park on the west edge of the hutong bordering main street has always been the place where pet bird keepers take a stroll, hang their bird cages on the branches of a tree during breaks, and social with neighbors and friends. It is also the stage where middle-aged to seniors practicing group dancing as an exercise after dinner, very popular throughout all Chinese cities.

The explosion of studies into the benefits of nature suggests that green space in cities should not be considered an optional luxury. As research insists, it is a crucial part of healthy human habitat. Daily exposure is essential, which means we need to build nature into the urban system, and into our lives, at all scales (Clarke et al., 2010; X. Li, Zhang, Li, et al., 2015). Not every city needs a big, immersive destination park like Central Park in New York City. However, they could build medium-sized parks and community gardens within walking distance of every home. They also need pocket parks and green strips and potted plants and living green walls. Like people need clothes in different sizes, cities also need green space in sizes S, M, L, and XL. Otherwise, the human ecosystem is incomplete.

Based on the above spatial analysis of the data retrieved from street view images, a few concluding remarks and limitations can be summarized: 1) Baidu API of vehicle detect could not recognize a three-wheel motorbike accurately, which is a unique transportation tool commonly seen in hutong; 2) Motorbikes are not as many as cars or three-wheel motorbikes, because residents prefer bikes and e-bikes which are more economical yet not identified by the API; 3) Human traffics are highly concentrated around commercial area, intersection corner, and schools; 4) Street space inside hutong are not green at all, while only a handful of streets have trees by the sides and only one belt shape park to the western border of the area. The first two points are results from image recognition using API while the latter two points are from spatial analysis using GIS software, reflecting a mix of computer-assisted analysis tools used in this chapter.

A human-centered city should offer citizens real freedom to live, move, and build their lives as they wish. The challenge now is to see just how the shape and systems of our cities contribute to meeting them. How are today's cities performing? How would we build differently, and live differently, if we could chart the connection between the designs of our cities and the quality of urban life? Therefore, to determine what the new design plan might look like, it is essential to understand how places, crowds, views, architecture, and ways of moving influence the way people feel and react. The computer-assisted analysis of this chapter might be elementary, as the primary purpose is not to achieve any breakthrough technical results, instead, to explore the popular approaches among data-driven urban planners and thus investigate its feasibilities and limitations. It is helpful to understand the methodologies by which different groups of experts comprehend the urban challenge and make decisions about our future in it.

Chapter 4

The quality of the living environment in urban areas is of vital importance, which is one of the critical factors that determine whether a city is an ideal place to stay, whether we enjoy living there, and whether we want to raise our children there. This chapter intends to discuss alternative ways of urban regeneration that may lead to a more inclusive and vital future life in the Baitasi hutong. These alternatives mainly refer to locally oriented and human-centered incremental improvements under the concept of “Streets for People, Hutongs for All” in the era of self-driving technology. The last section discusses a bit about the policy recommendations through a collaborative creation and governance triangle model. Above all, this chapter shows the need for vision and courage on the part of the implementing local government, for convincing academia and authority that such an integrated plan can be highly achievable and successful, representing a sustainable regeneration option for hutongs and future cities in general.

4.1 Human-centered regeneration plan for the Baitasi hutong

The challenge facing urban planners and governments in many cities is that of balancing the demand for increasing personal mobility and continuing economic growth, with the need to respect the environment and provide an acceptable quality of life for all citizens. The search for sustainable development, though, may result in ways of intervening, or even preventing, urban planning from facing the problem which modern-day cities face. Urban challenges are rooted in complex systems, the understanding of which requires a holistic view that absorbs knowledge from multiple domains. A single-discipline cannot capture the complex nature of sustainability. Aside from physical and economic questions, there are also social, environmental, political, and cultural questions to be taken into account. Sustainable urban mobility incorporates all of these aspects while also tackling traditional questions about transportation planning.

Additionally, China has been setting the stage for a revolution in self-driving technology over the past two years, and Beijing has recently leaped towards allowing widespread adoption and commercialization of autonomous vehicles (AVs) in the city. In December, Beijing became the second Chinese city to issue permits allowing AVs to carry human passengers and freight in road test after Shanghai unveiled a similar policy in September[xxxviii]. Two years ago, the capital city became the first in China to allow AV companies to trial driverless cars in the south-eastern corner of the city called "Beijing-e-Town", one of a growing number of urban spaces across China designated for testing AVs, with digital lane markers can switch parts of the road to AV-only on demand and signs announce, "National Test Roads"[xxxix]. According to an estimate by McKinsey, in China, fully autonomous vehicles (SAE Level 4 and above) will see mass deployment in nine or ten years from 2019[xl].

Furthermore, there is a fierce competition in other cities between Chinese AV companies to push out robotaxis, self-driving taxis ordered through e-hailing services. Search engine giant Baidu's autonomous driving arm Apollo (http://apollo.auto/) rolled out a trial operation of 45 robotaxis in September in Changsha, the capital of Hunan province in central China, and set to deploy 100 by the end of 2019. Smart auto mobility start-up WeRide (https://www.weride.ai/) also opened test rides of its WeRide RoboTaxi service to the general public in early December in south China's Guangzhou city. This service, first announced in August, is a joint venture together with Baiyun Taxi Group and SCI (Guangzhou) Group, the first of its kind in tier one cities in China[xli].

Figure 27: Baidu Apollo's L4 driverless Minibus (source: Apollo website)

Figure 28: WeRide's L4 self-driving RoboTaxi (source: WeRide website)

Amid a continuous race between the US and China to achieve supremacy in AI, China's National Development and Reform Commission (NDRC) wants smart vehicles to account for half of all new cars sold domestically by 2020, while covering 90% of the big cities and highways with a wireless network that can support smart cars and ensure product supervision and information security[xlii]. Although it seems inevitable that provision for car-based mobility will remain an essential part of transportation planning, seeking ways to encourage more use of alternative modes of transport, i.e., public transport, cycling and walking, shall be the goal of any sustainable urban mobility policy. A neglected fact is that cities designed for car-based mobility are almost forcing people to sit down all day in their cars, offices, or homes, which has led to difficult health-wise situations. According to a study, those living in city centers have a longer life expectancy than those living in the outside areas because they walk more often throughout their lives when making their daily commutes. Hence, the design of urban environments has the potential to contribute substantially to physical activity and health (Sallis et al., 2016).

For Beijing, international trends in city planning usually offer very few lessons, as the sorry state of megacities all over the world contrasts most sharply with Beijing's technological, architectural, aesthetic, cultural, and demographic vitality. However, the concept of "traffic evaporation" illustrated in a publication by the Environment Directorate-General EU, *Reclaiming City Streets for People: Chaos or Quality of Life*, could be borrowed for the regeneration plan of Baitasi hutong. The handbook uses case studies from a selection of

European cities including Copenhagen (Denmark), Kajaani (Finland), Nuremberg (Germany), Strasbourg (France), Ghent (Belgium), Cambridge and Oxford (England), many of which have gone ahead with road space reallocation schemes despite predictions that traffic chaos would result. It shows that such schemes can be highly successful, and they can represent a very positive sustainable planning option for cities. The case studies demonstrate the importance of well-planned integrated strategies, combined with effective public consultation and communication (European Commission, 2004).

Copenhagen, for instance, perhaps the world's most people-friendly city where people cycle to work as a matter of course, yet until 1962, all streets in the medieval city center were filled with cars, and all the squares were taken as car parking. On 17 November 1962, Copenhagen's main street, Strøget, was pedestrianized, which marked the commencement of a gradual process that has continued increasing car-free areas ever since. Public space public life studies in 1968, 1986, and 1995 show that despite pedestrian traffic levels have remained mostly unchanged, activities connected with stopping and staying are almost four times greater in the period studied (figure 29). During the summer months, many of the pedestrian streets are full of people enjoying the many outdoor social and cultural activities; in the winter months, attractions include festivals and outdoor ice skating. Nowadays, Copenhagen has a vibrant city center with over 96,000 m2 of car-free space, of which 33% is streets and 67% city squares (Gelh, 2010).

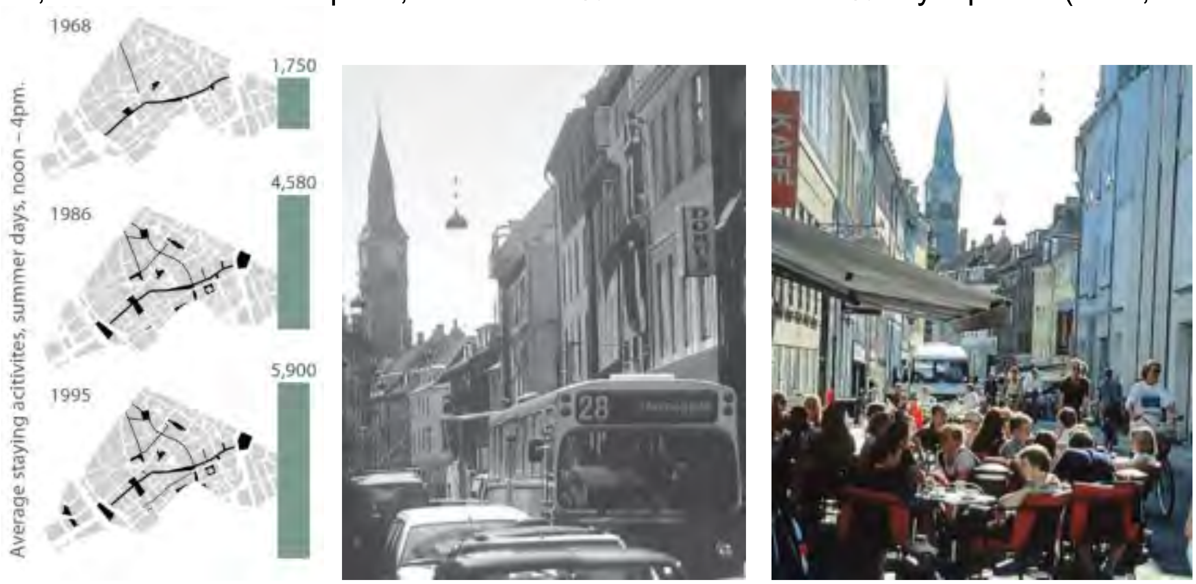

Figure 29: Better city space, more city life, example Copenhagen (source: *Cities for People*, p. 12)

In the city center, as the streets and squares have been pedestrianized, the area has become more attractive yet also less accessible for the motorist. Since 80% of all journeys are made by foot and 14% by bike, car traffic has been drastically reduced, and congestion is not a problem (Gelh, 2010). The key to the success of these inner-city transformations was undoubtedly the gradual way these rather bold changes were made, as this incremental approach has given residents time to adapt from driving and parking their cars to walking, cycling, and taking public transport. It is now a live showcase attracting visitors from all over the world to inspire a vision and experience of what integrated planning looks like in terms of inclusive public spaces, sustainable mobility, and climate adaptation solutions.

Jan Gehl, the pioneering Danish architect, urbanist, and planner who helped turn Copenhagen into one of the world's most livable cities over the past 50 years, is a world-renowned expert in all things related to urban design and public space. His career has focused on reorienting urban design towards people scale, advocating for bike lanes, shared streets, and walkable city, and ultimately improving the quality of urban life. In his book *Cities for People*, he and others have found that if a street features uniform facades with hardly any doors, colors, variety, or functions, people move as fast as possible. But if a street features various facades, lots of openings, and a high density of functions, people walk more slowly and pause more often. They are actually more likely to stop and make phone calls in front of lively facades than dull ones.

Projects like Copenhagen carry an increasingly urgent message about the role of public life in cities. Old cities were originally established as pedestrian cities, but modern cities and affluent economies have introduced car traffic and created a particular kind of social deficit. Today in Chinese cities, we can meet almost all our needs without going out or gathering in public, especially when e-commerce and digital payment are deeply embedded in everyone's daily life, that people can buy anything online and receive it by delivery even in a few hours. Another phenomenon is emerging social media platforms led by Wechat and TikTok; the latter is a video-sharing app that has reached over 500 million monthly active users globally in the second half of 2019, according to digital market research firm DataReportal. At the rate TikTok is growing, it may surpass Twitter and Snapchat's monthly actives, combined, in 2020[xliii]. Technology and prosperity have significantly digitalized a large part of our life, yet substantially divided our society and community. The question remains: Can we build – or rebuild – city space in ways that enable secure connections and more trust among both familiars and strangers?

The answer is a resounding yes. The spaces we occupy can not only determine how we feel but also change the way we see other people and how we treat each one. Therefore, the secret is, as Jan Gehl has been advocating, human-centered strategy – improving the quality of life for people living in cities by putting them at the heart of urban planning – that makes cities easy to navigate on foot and by bicycle and provide places to meetup. This approach has the benefit of bringing cities to life and making them more livable. Based on raising the quality of life and improving physical surroundings, we can allow children to be children and adults to be adults, and accommodating the fast-growing elderly in the hutongs.

In summary, the urban regeneration plan for the study area should move towards a more integrated human-centered way of delivering mobility and much more understanding of how important it is to focus on people and the social aspects of hutongs. Correctly, the plan should cover three main components: walking more, spending more time in public spaces, and getting out of "private cocoons" more, which will make Baitasi hutong more exciting, engaging, and safer, as well as promote social inclusion.

4.2: Redesign mobility: Streets for People

Most cities do not have the luxury of planning and rebuilding from scratch. The prime real estate in the densest parts of inner-city has all been accounted for, so cities that want some more space for people are left to trade airspace with developers in exchange for bonus plazas, or to invest heavily in acquiring new lands. As one of the twenty-five historical and cultural preservation zones in the inner-city of Beijing, Baitasi hutong is strictly regulated from any large-scale retrofitting. However, all the streets now used to facilitate the movement and storage of private automobiles is public, and it can be redesigned any way we decide. Hence, favoring more sustainable transport modes leveraging self-driving technology could be an approach that promotes social inclusion and accessibility for the hutong households, most of which have no access to private cars.

Based on the previous chapters about field trip observations and spatial data analysis on the street view imagery, the main problems associated with increasing motorized vehicles dominance and parking in Baitasi hutong include:

- Loss of living space: Motorized transport infrastructure- such as roads and car parking — takes up highly valuable space in hutong, and spoils and threatens existing public spaces.
- Visual intrusion: Diminished quality of the streetscape caused by parked vehicles and other infrastructure.
- Noise and Vibration: Transport is one of the primary sources of urban noise pollution.
- Severance and conflict: Congested streets cause severance of communities, which can have a social cost.
- Equity: For the many households without access to a car — they pay the price of traffic without enjoying mobility benefits offered by car ownership.

To tackle these problems, Baitasi hutong should strive to embrace complexity, not only in its mobility system but also in human experience. The bigger the size of any group, the harder it is to predict the variation in its characteristics or to find one solution to a problem involving vast numbers of the group. Given the previously discussed demographics dilemmas in the study area, everything is even more complicated, and there is no single clear answer to any of the above mobility problems. The solution must come from a multiplicity of answers. Moreover, the mobility problem is not merely a matter of technology or economics, but one of culture and psychology, and the vast variation in our behavioral preferences. To depend on just one technology innovation for hutong mobility would be to deny human nature itself. For the residents, each of them has a unique set of abilities, weaknesses, demands, and each of them is compelled and thrilled by a unique set of sensations. Hence every trip requires a unique solution as we are all much more unique in our preferences than urban planners acknowledge.

Concepts	Definitions	Examples	People
Mobility Activities	Actions operated by the traveler between the origin in hutong to the outside destination	Walking between home's door to the bus / metro station	All
		Biking and motorbiking between home's door to the bus / metro station	Young
		Walking between home's door to the nearest pick up / drop off point for taxi / Didi	Young
		Walking between home's door to the parked private car / elderly e-car	Young and old
Social and Economic Activities	Actions operated by the traveler within the realm of hutong	Shopping and dining	All
		Dropping kids at school	Kids & parents / grandparents
		Using public toilet	All
		Visiting the Park in the west	Old
		Visiting the Community Living Room	Old
		Delivering packages	Young
Situations	State of the surrounding of the traveler or events	Bad weather: rainy day, snowy day, high temperature day, sand storm, haze and pollution	/
		Traffic issue: bus delay, road accident, congestion	/
		Event: Beijing Design Week	/

Table 6: Micro-mobility scenarios examples in Baitasi hutong

Table 6 explains the observed mobility scenarios in Baitasi hutong, which includes the mobility activities of the traveler going outside of hutong, the social and economic activities inside the hutong, and the situations that may happen around him/her depending on the urban context. Moreover, the travelers are not necessary all living in the hutong, like the delivery men driving motorbikes or motor tricycles. The combination of the possible travel, social, or economic activities with situations, generates the travel scenarios of the micro-mobility system in Baitasi hutong. In order to redesign the streets for people under various scenarios, for phase one, the top priorities should be focusing on three aspects: driverless ride-sharing, smart package delivery, and age friendly.

All around the world, new systems of sharing mobility are setting commuters free. In China, not owning things usually means you are poor. And when you are poor, you are not free. You are stranded. But there is simply no room for everyone to drive nor to park. For residents in hutong, ownership could be a tremendous burden. In fact, most private cars spend the vast majority of their life span sitting, doing nothing but costing their owners money in insurance, maintenance, loan payment, and depreciation. Much of the pleasure of parking private cars outside of their door comes simply from being recognized the ownership of their fine cars. Therefore, providing ride-sharing would enable residents to become freer by owning no private cars. Everyone has an opportunity to shrink their ecological footprint by switching their transport modes from private car to sharing ride.

Figure 30: Toyota's e-Palette to serve athletes at Tokyo 2020 Olympic & Paralympic games (source: Toyota)

As shown in figure 30, the Japanese car company Toyota has announced their plan to put 20 of its autonomous, fully electric concept vehicle called e-Palette at athletes' village, as part of its big robot push for the upcoming 2020 Tokyo Olympic and Paralympic Games[xliv]. E-Palette was initially designed to function as a communal taxi, delivery truck, or mobile shop, depending on the time of day, simply updating their digital displays to reflect current use (figure 31)[xlv].

Figure 31: Concept of the smart micro-mobility system that could be applied in hutong (source: Toyota)

A similar concept can be applied to meet residents' needs for the micro-mobility system in Baitasi hutong. Driverless vehicles could be designed in three sizes to accommodate different amounts of cargo: the big size shuttle minibus providing short-distance transport services for everyone on the main roads, commuting people from their homes to bus/metro stations, schools, shops, park, or the Community Living Room; the medium size carriage is for freight and package; the small size basket is for food and other quick order that is more time-sensitive.

Alternatively, the big size self-driving vehicles might act as ride-sharing minibus during rush hour, work as delivery vehicles later that morning, offer a kindergarten shuttle service through the afternoon then return to taxi duties as people back from work. For the courier companies, they could customize the interiors to their delivery requirements, and update the digital exterior panels with their branding. The smart vehicle could automatically deliver packages and foods from the central distribution in the north of hutong, using facial-recognition technology or swiping QR code to confirm pickup by the correct recipient upon arrival.

Accordingly, the broad main streets will be divided into three lanes: AV-only lane designated for all three types of vehicles, bike lane, and pedestrian lane; while the narrow streets will only have AV-only lane for medium and small sizes of vehicle. The future of hutong should be all about good neighborhoods for walking and cycling combined with a really smart, efficient ride-sharing and package delivery system, where people could schedule their preferred time and place through smartphone so the AI system could calculate the optimal route to pick up and drop off efficiently. No more private cars, motorbikes, motor tricycles within hutong.

Lastly, since promoting equality in cities has become a mission in various parts of the world, we can also achieve more equality if driverless ride-sharing becomes accessible, efficient, and affordable alternative to cars, especially for the growing elderly population. Old residents usually do not have smartphones, which would potentially limit their rights to enjoy benefits of smart mobility. So, a "dumb" system tailored for the old people should be designed at the same time, for instance, making an easy phone call to talk with a robot receptionist can help request a ride, put an order, and so forth. The point is to take their demands and limitations into account when seeking viable solutions for building an age-friendly community.

4.3: Recapture public spaces: Hutongs for all

To ensure sustainable lifestyle in hutong, after taking steps to shift away from the current over-dependency on the private vehicles, we need to think about how we recapture and reorganize public spaces, for the purpose of not only new design and infrastructure but also all the residents to look at public spaces differently and therefore create new narratives around it. To start with, a temporary experiment can be conducted at Baitasi hutong to see what spatial redistribution might accomplish. Then temporary interventions would be carried out based on existing assets and focus on changing people's perception, which will ultimately shape how we understand and practice sustainable urban planning in the long term.

As one of the most influential sociologists, Erving Goffman implied, that life is a series of performances in which we are all continually maintaining the impression we give other people. "We are all just actors trying to control and manage our public images, we act based on how others might see us" (Goffman, 1959, p. 22). If this is true, then we can assume public spaces function as a stage in the same way that our own homes and living rooms do. Especially in hutongs, where some residents transformed public space into kitchen or living room as previously discussed, the shared space is part of their home and thus offer cues about how they perform and how they treat one another. The very few observed public facilities like chess table, ping pong table, gym corner, green park, and scattered public toilets are not trivial, neither urban decoration nor merely recreational. The life of a community would be incomplete without them, just as the life of the individual is weaker and sicker without face to face encounters with other people.

Hutongs—where large families traditionally live in courtyard houses that face inward and share communal spaces—represent the old and traditional Chinese lifestyle with blurry boundaries between public and private spaces and the spirit of sharing. However, the way people live in China is changing, shifting from multigenerational households occupying larger spaces to a diverse mix of big families, singles, and everyone in-between living in the same neighborhood. This evolution actually illuminated an opportunity for architectures and urbanists to maintain a hutong sense of community while bringing neighbors together. The famous Japanese architect Shuhei Aoyama, who lived in the hutong for ten years after moving to Beijing in 2005, has incorporated several elements of the old-style homes in hutong into modern living as a form of protection and conservation[xlvi]. By downsizing the footprint of a living space to bare essentials, he is promoting people—even strangers—to redefine and share a home. He also thinks furniture in public space for sharing could be all movable and assembled according to demand, which should be the design direction of future sharing space furniture.

Therefore, inspired by the families extending part of their homes into public spaces in hutong—such as kitchen, living room, garage—we could start temporary interventions by offering creative alternatives for futuristic public spaces shared by all people.

First of all, we should invite people back to public spaces by providing some public benches, an element of "triangulation" according to William H. Whyte, who is the mentor of a not-for-profit organization, Project for Public Spaces (PPS: https://www.pps.org/) because of his seminal work studying human behavior in urban setting[xlvii]. One of his famous researches is The Street Life Project started in 1971, intending to find out what determinates the quality of urban spaces beginning from the direct observation of human behavior. In the first phase, he studied playgrounds and parks of New York City and concluded a useful mechanism named "triangulation", in which external stimuli are arranged in ways to nudge people close enough to begin talking and bonding (Fitzpatrick, 2019). And that is what happens when public benches provide a linkage between neighbors and make it easier to sit and talk on the streets. Alternatively, movable chairs are more successful as they give users the flexibility of movement and direction, thus permit many sitting opportunities to facilitate different activities. Risk is that people may take them indoor as private owned furniture.

Another form of triangulation could be a community garden. We already know that the act of gardening heightens the benefits of nature, in part because gardening demands more focus than merely appreciating nature. Currently, there are few private gardens (figure 32) in the Baitasi hutong, which shows people are interested in gardening by themselves. However, gardening could also be a social activity, especially in dense cities, which is something we should consider when redesigning the Baitasi streets given its greenness ratio is at the lowest range. Vegetation cleans the air of toxic particulates, makes oxygen, and also captures and stores carbon. So, we know that nature in living space makes us happier, healthier, and nicer, which will help us build meaningful bonds with other people and the places in which we live. If we infuse hutong streetscapes with natural diversity, complexity, and, most of all, opportunities to view, feel, touch, and work with nature, we can gradually create a cohesive community.

Figure 32: Observed private garden in the study area

Additionally, the need for young families with children should also be taken care of if we want to design hutongs for all. In a fast-paced, digitalized, and divided world, opportunities for children to meet and play with peers in the neighborhood are rare. According to the field trip of Baitasi hutong, there are two kindergartens in the area, yet no playful facilities in the open spaces for children to hang around after school. Building a public playground where children and parents gather around will help break down social isolation and can create more trusting neighborhood ties. Moreover, strengthening community cohesion will also create a safe and harmonious situation where neighbors look out for one another and especially for the young newcomers to feel the sense of home.

Admittedly, those small installations as public bench, community garden, and children's playground will likely not engage all the residents in hutong. Yet as Whyte has praised highly on small spaces in city center, that the multiplier effect could be tremendous. It is not only the number of people using them, but the more significant number of those who pass by and enjoy them vicariously, or even the more significant number who feel better about the hutong for knowledge of them. Such small public spaces are priceless, whatever the cost. Because the more social a community becomes, the more inclusive it is for all its residents. By breaking barriers and pushing past preconceived notions on each other, we can bring people together, be it originals or newcomers, to create a stronger and happier community in Baitasi hutong.

4.4: Policy recommendations: encourage co-creation, empower co-governance

As indicated in Jane Jacobs's understanding of cities — "organized complexity" — certain spatial conditions can contribute to urban vitality, including walkability, mixed functions, place identity, and room for self-organization. Old urban fabrics in hutongs generally possess such spatial conditions, which were created by generations through time. As Jane stated in her book *The Death and Life of Great American Cities*, "Cities have the capability of providing something for everybody, only because, and only when, they are created by everybody" (Jacobs, 1992, p. 238). However, who would have thought that nearly 30 years after this was written, cities would still be built from the top down. That a city's future is still planned mainly by quite few influential people, rather than influenced by thousands of people based on what they believe or dream about that city's future.

When it comes to the policy, the first question we should ask is, who has the right to shape the cities and hutongs? When the architects and urban planners say, "created for everybody", often they do not necessarily mean "created by everybody". When we replace co-creation for consultation, we settle for an urban environment that is much less than the one that we are capable of creating. Consultation, if done well, results in better place outcomes. Co-creation has a much deeper agenda: it builds resilience. When we fail to encourage civic leadership in co-creation through neighborhood redesign initiatives, we miss out on local innovation, capacity, and skills that make our hutong regeneration projects better and communities stronger.

Co-creating hutong is, nevertheless, quite difficult to achieve, especially using traditional methods. It is not because residents are not willing to participate and lead (the New Qinghe Experiment showed they are), but it requires a different culture and system of participation. It is a design problem, but also a social problem. Our challenge lies in the way we build, and more fundamentally, in the way we think and collaborate. Therefore, to encourage co-creation, a few suggestions include: 1) See residents are experts in their own experience; 2) Inspire creative ideas, not just feedback; 3) Commit to backing local ideas with funding or support; 4) Invite people to contribute time and resources to the project; 5) Seek out local innovation, and be radically open-minded.

Every city has its unique political situation and DNA in terms of urban regeneration. The struggle for the redesign of "Streets for People, Hutongs for All" is going to be long and difficult. The broken hutong lives in the rituals and practices of planners, engineers, and developers. It lives in laws and rules, and in residents' habits too. Accomplishing an inclusive hutong agenda requires the active engagement of key stakeholders — such as central and local governments, academia, civil society organizations, experts and enterprises from the private sector, social activists, among others — in order to transform the existing policy priorities into practical and sustainable actions. In other words, we need a multitude of perspectives in participation and governance to ensure we are building inclusive, resilient hutongs with social cohesion.

Figure 33 shows the potential collaborative creation and governance triangle behind the suggested projects at Baitasi hutong. Several systemic issues and trade-offs need to be addressed. First, budget is always an issue. The proposed integrated approach of considering social, health, and environmental aspects in terms of planning, and working across different municipal agencies, can be quite expensive. A second issue concerns the renegotiation of public spaces from removing private vehicles and illegal informal constructions. Another challenge is political leadership, which is incredibly crucial for a municipal project that weighs heavily for the KPI. In the local authority of Baitasi hutong, civil servants could change when any politician changes in the system, so it means we could lose all the knowledge and experience which has been built up and might need to start over again.

Figure 33: Collaborative creation and governance triangle

Another problem with the smartphone app-based sharing mobility is that little or no data, knowledge, or other benefits were shared with governments. Big data on rides and users has been considered proprietary by companies. In Switzerland, such data can be purchased from the major telecom company, Swisscom, to conduct traffic analysis. And some Chinese telecom companies also provide customized data package for sale. However, even when shared, there is still the question of how private data can be monitored, processed, and exchanged to provide insights for urban planners and regulators at appropriate spatial scales and without violating individual privacy rights. To date, few platforms have emerged to facilitate such a public-private partnership (PPP) in knowledge exchange. Shared Streets (http://www.sharedstreets.io/) , though, is an example of such an initiative, a project by the independent nonprofit Open Transport Partnership to build software, digital infrastructure, and governance frameworks to support new ways of managing and sharing mobility data in cities. So, without data sharing from the hutong micro-mobility system that heavyweights on self-driving vehicle use patterns for machine learning, it is challenging for urban planners and policymakers to adapt to the rapid development of the technology and its impacts on the smart mobility services as well as the public good.

Therefore, on the Government-to-Private Sector side of the triangle, this means, in exchange for government's provisioning, supporting and regulatory services in the urban regeneration project, mobility services providers must work with government (or an appropriate designee) to co-create and co-maintain an efficient data-sharing platform on ride patterns, safety, and other critical metrics to inform urban planning and policies for secure, efficient, and sustainable mobility in hutong. Also, the private sector has to spend much effort on getting politicians on board, speaking to them, inspiring them, and taking them on field study tours if necessary.

On the Government-to-Civil Society side, in exchange for ensuring the public good and adequate support for sharing mobility and space, residents must be encouraged to abide by codes of sharing, including the care of public resources and self-driving vehicles. More critical, community shapers should proactively document the usage of public spaces: Where people go, how many there are, how long they sit on public benches, how many work at the community garden, and report to the government every year, just as if they were collecting big data on people behavior. Such data-driven, public space/public life library could be used as a baseline for recommendations on how to improve the livability of the hutong in question. And when the politicians have access to this library, they can make human-centered decisions and policies accordingly.

Finally, on the Private Sector-to-Civil Society of the collaborative triangle, shared mobility companies must provide accessible, affordable, safe, and sustainable mobility services without exploitative monetizing of residents, while the latter agree to abide by codes of usage for shared mobility that include reporting problems in services or sharing behavior. It is also mobility services providers' responsibility to engage with residents, listen to their needs and feedbacks, further mobilize them to shape the future of Baitasi hutong and to co-create the narratives around streets and public spaces.

In addition to strengthening relations among the three critical constituents in the collaborative creation and governance triangle, it is recommended that intermediary organizations are necessary to support continued adaptation of sharing creation and governance through co-learning, co-evolution, and the co-developing of value. Such intermediaries – non-governmental organizations in urban mobility and sustainability, domestic and international media, mobility services business associations, and other related groups – can contribute to a thriving collaborative ecosystem that aims to encourage co-creation, and empower co-governance.

Conclusion

China's urbanization progress will continue, with the urbanization ratio reaching 70% by 2035, according to a report published by the National Academy of Economic Strategy under the Chinese Academy of Social Sciences. Chinese cities will basically realize smart living by 2035. One billion Chinese people, or over 70% of residents, will live and work in cities with area of 100,000 square kilometers, and will use smart technologies[xlviii]. At the same time, the elderly population in China is growing exponentially and this growth will last for decades. According to a research, by 2050, there will be 400 million Chinese citizens aged 65+, 150 millions of whom will be 80+ (Fang et al., 2015). Future city strategies, therefore, need to incorporate this fact and cannot exclusively be drafted on the paradigm of technological progress.

The future of Chinese cities, as in human history, is not going to be defined by some kind of deus ex machina solution to all of our problems, but rather by step-by-step innovations and improvements applied to the tools and assets we already had to work with. This study is trying to find an urban regeneration plan for the Baitasi hutong in the future of self-driving technology, though sought the answer from the old day in both China and western world. After the decades-long experiment with automobiles, governments simply do not have the money to completely transform urban infrastructure to suit any one radically new technology like self-driving. But for a small scale as Baitasi hutong, it is perfect to be an experimental zone for the trial of disruptive technology and its applications.

The outlined human-centered integrated approach of Baitasi hutong provides a vision for the dense inner-cities of the self-driving future, which aims to create a smart and healthy environment for people, an inclusive, cohesive and resilient community for children to grow up, and for the growing number of older people to live for many years after they retire. The idea of approaching the problem from a caring human perspective is inspired by the observations and feedback from a three-week intensive field audit in the study area. It thus allows studying the unique hutong area in higher resolution in terms of human interactions with the mobility system and public spaces. Furthermore, the proposed redesign concept of "Streets for People, Hutongs for All" underlines the two dimensions of the regeneration plan: street space should be recaptured from vehicles and returned back to people, while the hutong community should be inclusive for all of its residents regardless of background. This concept works as a bottom-up mechanism, placing the residents at the center of regeneration considering needs, impacts and influences to start addressing solutions. At this point, it is not likely to evaluate self-standing policy recommendations. However, the proposed collaborative creation and governance triangle among three key actors could be applied in different contexts with diverse demographics, complex mobility and social problems, and outdated urban structures, which obviously will drive into different assumptions and recommendations.

As a support, the presented computer-assisted analysis methods and tools are capable of exploring and mapping invisible parameters retrieved from street view image recognition, leveraging existing Baidu APIs, and OpenCV library. However, there are still several limitations of this study that deserves further research. First, due to the limited time and resources, the collection of street view images was only carried out once during the morning rush hours. A few more collections could be conducted at different times during the day, on both workdays and weekends, to be able to compare the traffic results and gather more accurate data. And for variation recognition, long-term field tracking surveys and corresponding time-serial street view image data should be also collected simultaneously, as an additional verification of the computer-assisted image recognition by traditional methods. Secondly, it was found that the Baidu API for vehicle detect could not accurately identify between a tricycle and a truck due to the deformation of the parked vehicles on short-range street view images. Despite the manual cleanup of data, the accuracy of the final results of each indicator was thereby unclear; special attention is required to bridge this gap if working with extensive sample data. Lastly, there is more room to explore how to merge data mining concepts with human behavior in public spaces and micro-mobility systems, since nowadays the availability of robust consumers' data in China is no longer a concern. The further developments could be around the methods and techniques to map diverse sources of geotagged data as a key for interpreting urban phenomena and reshaping urban life.

Beijing’s city planners have made mistakes before. They tore down old city walls for the metro system; they built the second ring road and brought congestion; they rebuilt residential hutongs into the commercial tourist spots; they admired modernism over historical value; they tried to stamp out complexity instead of harnessing it. Nevertheless, it is never too late to rebuild the balance of life in the Baitasi neighborhoods and other hutongs and, in doing so, to build a more inclusive and sustainable future life. The task demands that we listen to the parts of ourselves that are more inclined toward curiosity, trust, and cooperation. It requires that we acknowledge truths that we have long told each other, but which we have forgotten in making our cities: we may have been wired for indifference and self-concerned, but we are also created to show kindness and feel good when we trust and cooperate. We all value privacy, but residents living in hutongs and courtyards are uniquely suited to get along in settings where, when the vibes are right, they manage to turn neighbors into a harmonious community where everyone watches over and takes care of each other like a large family.

Eventually, we must make fundamental changes to the way we think about and build hutongs if they are to become places where all people can thrive. The goal of "Streets for People, Hutongs for All" is to nurture the interpersonal relationships, to support inclusive urban innovation that contributes to resilient communities and cities where all people and nature can flourish. It will offer residents a thrilling new freedom to choose how to move and how to live. They should acknowledge that their space in the hutong and their mobility choice have tremendous power to shape their own daily lives, the life of their neighbors, and the future of their children. They should acknowledge that the smart hutong, the green hutong, the fun hutong, the safe hutong, the age-friendly hutong, the low carbon hutong, and the hutong that will make them proud are the same place, and that they are the key actors who have the power to co-create it and co-organize it, which is the truth that shines over the journey toward sustainable urban regeneration.

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