Doctoral Dissertation

A Study on Spatial Distribution and Socio-Spatial Changes of Danwei Compound: A Case Study in Hefei City, Anhui Province, China

単位大院の空間分布と社会空間の変化に関する研究：
中国安徽省合肥市を事例として

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Abstract

Danwei, the urban local community and neighbourhood organisation born during socialist China, is the basic social and spatial pattern of modern Chinese cities. While its spatial container, Danwei compound, is considered to be the unit of Chinese urban construction. For a long time in the history of the People's Republic of China, the Danwei system and the Danwei compound were the embodiment of its political and economic system in the cities. However, after the Reform and Opening Up (1978) and the Urban Housing Reform (1997), China's political and economic environment began to change and the Danwei began to decline and disintegrate as a result of the loss of the external environment in which it existed.

In this context, as the basic urban neighbourhood unit, what is the current status of Danwei compounds? In order to explore this big picture, the city of Hefei, the capital of Anhui Province, was chosen as the research target and the following research questions were formulated at different spatial scales from city to neighbourhood: What is the current distribution of different types of neighbourhoods in the city? How do functional facilities in the city interact with the neighbourhoods? And what is the current situation within Danwei neighbourhoods in the context of their recession?

This dissertation attempts to respond to these questions and contribute to the future development of Chinese urban neighbourhoods by investigating the city-scale spatial distribution features of Danwei compound and Non-Danwei residential in Hefei city, and studying the historical socio-spatial changes of the AMS Danwei compound in Hefei city. Both quantitative and qualitative methods were used in the study. In addition, to get the data of commercial distribution, which was necessary for the city-scale spatial distribution analysis, a large-scale urban business sensing technology based on deep learning and street view images was developed.

Based on the field surveys conducted in 2018 and the various types of urban data collected, this study revealed that even though the urban land reforms have led to a steady rise in non-Danwei residential sites, Danwei compounds predominate the urban spatial structure, exhibiting a certain degree of spatial inequalities with historical continuity. Comparatively, Danwei compounds have lower plot ratios with higher levels of accessibility to commercial centres and hospitals but poor accessibility to schools. In the neighbourhood scale, this dissertation found that the AMS Danwei Compound has experienced a significant reduction in public space, an increase in building density and a reconfiguration of compound management actors.

The study suggests the need for local planning officials to support the revitalisation of old residential compounds through integrated and community-centred spatial planning, the need for local planning authorities and government to pay attention to planning and design of the old city core by emphasising improvement in public spaces, attention to compact design principles for urban neighbourhood planning, and establishment of local community management body.

This study contributes to the urban neighbourhood researches by detailing one of China's urban community forms – the Danwei compound, introducing its current spatial function and relation to the city, and deconstructing the socio-spatial diffusion that occurs in its decline. These information could potentially lead to more comprehensive and insightful paradigms for future urban neighbourhood studies and inclusive local urban renewal in Hefei city.

Acknowledgements

In mid-2016, I was fortunate enough to receive a PhD offer from Prof. KITA Michihiro while on my Masters programme in Welsh, UK; the following May, after a transient internship at Beijing UrbanXYZ Corp., I was excited to arrive at Osaka University. During the subsequent studies and life, I was again immersed in the diversity of the discipline of architecture and planning: almost any objective reality in buildings and cities can be chosen as an object of study. This means that there are no natural boundaries to the research. After a year of topic selection and another year of research and data collection, it was in the third year of my PhD that I entered the final sprint to write and publish my papers.

But at this time, the end of 2019, the whole world was pressed to pause. As a kid growing up in a family from the public health sector, I was used to being immersed in a serious "anti-epidemic" atmosphere, but this particular pathogen made me realise that this new outbreak would be the worst one I had ever witnessed. But as it turned out, I had far underestimated the scope and duration of its impact. During this difficult period, I received help from Prof. Kita Michihiro, Prof. Seth Asare Okyere, and my friends, WANG Bowen and XIE Ming, to write and publish my thesis in early 2021.

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Contents

List of Figures

List of Tables

Chapter 1

Introduction

1.1 Background

Urbanisation has been one of the most important in field related to architectural and planning since the industrial revolution brought mankind into urban civilisation. While communities and neighbourhoods, the basic units for urban inhabitants, have been the central topics of urbanisation and have becoming priorities in international urban research in recent decades.

The concept of 'community' emerged during the rapid urbanisation of Europe after the first industrial revolution, when a massive influx of people from rural to urban areas led to fundamental changes in the social structure. In the 1880s, the German sociologist Tönnies introduced the concept of 'gemeinschaft(community)' (Tönnies, 2012). He divides the types of human group life into the 'naturally formed' 'intimate, secret, simple common life' of 'gemeinschaft/community' and the 'purposefully artificially integrated' 'communal, worldly' of 'gesellschaft/society'. On the basis of this analytical paradigm, he reflects a vision of an idyllic social form and expresses his melancholy and anxiety about the absence of community (Cotterrell, 1997). Later in the 20th century, the Chicago School, which focused on urban studies in the United States, gave the word community a richer connotation in a large body of urban social researches (Robert E. Park, 1928). They emphasised the importance of territorial space, the role of social organisation in the formation of communities (Park and Burgess, 2019), and argued that industrialism had a clear influence on the formation of modern urban communities (McKenzie, 1924). In 1929, the American scholar Perry introduced the concept of 'neighbourhood unit', which is a type of settlement unit centred around a primary school, surrounded by urban roads and with organised internal roads (Perry, 1929a,b). This concept has since become one of the most common models of community building in the United

States and around the world. These studies and definition of 'neighbourhoods' and 'communities' became the beginning and cornerstone of urban settlement researches in the field of architecture and urban planning.

In the 1930s the concept of "community" was introduced to China through communications and related academic activities with the representatives of the Chicago School, including Robert E. Park. The Chinese scholar Wu Wenzao first translated the word of "community" into the Chinese word "She Qu(社区)" (Wu, 1990). Fei Xiaotong first studied and discussed the Chineseization of "community" (Fei, 1992), which identified many characteristics of Chinese communities later showed up in the Danwei compounds. After the World War II and the Chinese Civil War, China finally had the opportunity to begin the development of a modern society in 1949. In order to rebuild and industrialise the country, the Danwei system was introduced all around the country, which is a grassroots urban community structure with strong organisational and mobilisation capacity and administrative power (Chai et al., 2007). Generally, a "Danwei" could be understood as a publicly owned institution, e.g. a school, a hospital, a weather forecasting station, etc., while "Danwei system" is the social-political system built on the "Danweis" (Tian, 2014). Based on the "Danwei system", a number of "Danwei compounds" (also called "Danwei communities" or "Danwei compound communities") were established as the spatial unit of the Danwei system. Basically, "Danwei compound" refers to a compound enclosed of walls with one or several gates for access. The interior is often a mixed-use spatial environment of offices, dwelling and public facilities and hence, includes all the working, living, and relaxing spaces and facilities of a Danwei (WANG, 2010). It can be described that a Danwei compound, as a physical space, is a neighbourhood unit, while all the people living in it (usually a Danwei's employees and their family), form a community. The Danwei system was compulsorily applied as a general social structure in all of China's cities and towns. As a result, the Danwei community created a unique urban space and social structure over the whole territory of People's Republic of China (Tian, 2014). Thus, understanding the 'Danwei system' becomes a necessary step in order to obtain a full understanding of modern Chinese cities.

In the second half of the 20th century, the relatively peaceful world environment and the dramatic progress in productivity brought about new waves of stormy cultural and ideological trends, under the influence of which the patterns of community organisation were constantly changing. As a developing country, China's social structure changed more drastically during the second half of the 20th century compared to the developed countries mentioned above. Danwei communities also experienced dramatic changes in the midst of this turmoil. Various countries have been exploring and building community models that suit their own realities, typical of which are the Danwei community model in China, the shared autonomous community model of government policy + residents + NGOs + community enterprises in the USA, the government-led community model in Singapore, the community urbanisation model brought about by small government and large society in Northern Europe, and the Town Association/Neighborhood Association model in Japan. During these five decades, along with the development, resistance, turmoil, self-enclosure and re-opening of China, the Danwei community has gradually matured.

Nevertheless, at the beginning of the 21st century, China's Danwei communities suffered irreversible structural problems. As the Danwei system fell into irreversible decline at the beginning of the twenty-first century with China's massive socio-economic reforms and urban expansion, the Danwei communities began to decline with it. As this decline progressed, various problems began to emerge in the cities. In the two decades since the turn of the 21st century, China has experienced an unprecedented rate of productivity growth and social change in its history. However, this rapid economic development has failed to bring about a new and efficient model of community organisation to replace the Danwei. Although the social system on which Danweis were based has disintegrated, the Danwei compound, as their spatial carriers, are still prevalent in all Chinese cities, especially in the older urban areas. This disconnection between social structure and physical space has led to a number of problems in urban life. Chinese scholars refer to this period, in which the Danwei system has declined and the new community system has yet to take shape, as the post-Danwei period.

In order to gain a detailed understanding of the current situation and changes in Danweis and Danwei compounds in Chinese cities, the city of Hefei in Anhui Province was chosen as the subject of this study. As an emerging city which developed after the establishment of New China, Hefei has experienced the establishment, development, transformation and decline of the Danwei system. It has a large number of Danwei compounds in its urban area, especially in the old city, making it a suitable subject for this study.

Since its inception in the 20th century, the concept of the 'neighbourhood', the basic unit of urban habitat, has embodied the dual meaning of urban geographic space and human life (Lee, 1968). In other words, a 'neighbourhood' is a complex that encompasses both the internal physical space, such as buildings, roads, open spaces and public facilities, and the internal social elements, such as interpersonal relations, community structures, economic flows, and the maintenance and management of facilities. Particularly in urban studies, the 'neighbourhood' has been characterised as a Socio-Spatial Schema in order to precisely perceive and explain the concept of 'community' locally (Lee, 1968; Wang and Liu, 2017).

1.2 Problem Statement

After Danwei and Danwei compounds had completed shaping the basic landscape of Chinese urban communities and cities at the end of the 20th century, they have once again undergone dramatic changes. Policy changes, urban development and demographic changes have had brought about devastating impacts.

On the policy front, two of the most significant Chinese reforms of the second half of 20th century–the Reform and Opening Up (1978) and the Urban Housing Reform (1997) fuelled the decline of Danwei communities and neighbourhoods. On the one hand, the Reform and Opening Up, which began in 1978, loosened the economic and social structure base of the Danwei system with significant effects on space, society and economy (ChuangLin, 2009). Prior to this reform, China implemented a planned economy system in which most public goods were rationed (Wen, 2013). In this planned system, the entire society was de-monetised and hence had no free market in which goods could be bought and sold freely with money. Thus, urban residents were required to be part of a government-recognised organisation or institution (a Danwei) in order to get access to industrial or agricultural products (Liu, 2000). This system tied all citizens onto the same social system, forming a single community of interest. However, this so-called class-neutral planned economy led to a low level of productivity and other social problems, such as the urban-rural dualism, and hence necessitated the need for reforms (Tian, 2014). As a result, The Reform and Opening Up was launched in 1978, which among other things, led to the reversion of private ownership, and the use of currency to buy and sell goods (Wen, 2013). On the social front, the notion of China as one original 'single community' was dismantled, allowing the population to have free mobility across the country. Consequently, social organisations independent from the Danwei system proliferated after 1978. However, due to historical inertia, a slow integration of market-based society and the apparent contradiction between the goal of the reform and the local realities, the Urban Housing reform was not introduced until 1997. The Urban Housing reform, on the other hand, is considered to have particularly impacted the spatial base of the Danwei compound. It was a top-down reform of housing and urban land-use. Before this reform, all urban land and housing resources belonged to the State and could not be traded (Li and Dai, 2009). Typically, the government would allocate the rights of land use to Danweis, while the ownership and title to the land remained with the State. A Danwei would build a compound and thus control the land and houses. After the Urban Housing reform in 1997, the property rights of the residential houses in the Danwei compounds were distributed to individual occupants, leading to the gradual loss of the Danwei's (organisational entity) control over its territory. Expectedly, this resulted in the creation of a new real estate market, permitting individuals to own homes as assets (while land ownership remained with the State) (Li and Dai, 2009). While the above reforms contributed to rapid economic growth, they have also unleashed a fundamental transformation of the social and spatial structure of Chinese cities (Zhang, Chun & Chai, Yanwei., 2009). Unfortunately, the constituent changes in Danwei compounds' socio-spatial system impacted by these reforms have not attracted relevant empirical attention in the scholarly literature. Previous studies of Danwei system and Danwei compound have looked at historical (Bian, 2005; Tanigawa, 1999), political (Tian, 2014), economic (Zhou, Yihu. and Yang, Xiaomin, 2002) and social (Zhang, Chun & Chai, Yanwei., 2009) aspects of the Danwei. However, most of these studies focus on the city-wide scale rather than the micro level of the neighbourhood or compound. The few studies that focus on the micro-level do not provide a historical context for socio-spatial changes. For example, Peiling (Peiling, 2014) studied the micro-level features of the Jingmian Danwei compound in Beijing, which revealed dislocated identities in the socio-spatial relationships among residents without engaging the historical context of the reforms. This is also true for the study of Zhang et al. (Zhang, Chun & Chai, Yanwei & Zhou, Qianjun, 2009) on the spatial changes of a Beijing Danwei compound by analysis its maps between the 1990s and 2006.

In terms of urban development, China's urban construction and urbanisation accelerated significantly after 1978. According to Xu (Xu and et al., 1988), between 1950 and 1980, the share of the world's urban population rose from 28.4% to 41.3%, with developing countries rising from 16.2% to 30.5%, but mainland China only rose from 11.2% to 19.4%. After the 1980s, China's urbanisation process accelerated significantly, and according to the China Nation Bureau of Sitatistics (National Bureau of Statistics, 2020) the urban population had grown to 394 million in 1997, accounting for 31.9% of the total population; in 2019 it reached 848 million, accounting for 60.6%. During the same period, China also gradually developed from an agricultural country to a country with modern industrial capacity. In 1952, the value added of the primary industry (agriculture) was CNY 34.29 billion and the value added of the secondary industry (industry) was only CNY 14.11 billion, accounting for 20.8% of the national GDP, making China a typical pre-modern agricultural country at that time; in 1978, the value added of agriculture was 101.85 billion In 1978, the value added of agriculture was CNY 101.85 billion and the value added of industry was CNY 175.51 billion, accounting for 47.7% of the national GDP, and the industrial system had initially taken shape; in 1997, the value added of agriculture was CNY 1,426.52 billion while the value added of industry was CNY 375.45 billion, accounting for 45.8 of the national GDP, and industry had become an absolute pillar industry; in 2019, the value added of agriculture was CNY 704.73 billion and the value added of industry CNY 380,670.06 billion, accounting for 38.6% of the country's GDP, with industry and the tertiary sector together supporting the economic system. These economic changes correspond to the development and transformation of social structures, production relations, and urban functions at a national level. For Hefei city specifically, the population (and urban built-up area) in 1953, 1978, 2000 and 2019 were 153,570 ($9.8km^2$), 3,117,600 ($50.48km^2$), 4,381,800 ($125km^2$), and 7,704,400 ($481km^2$) respectively. Because of the strict implementation of family planning (known by the name of 'one-child policy') in China's cities after 1982, a large proportion of the above urban population growth has been due to in-migration, mainly from rural areas.

In the wake of these processes, Chinese cities are faced with a plethora of new problems. For example, Li et al. (2019) argue that the decline of the Danwei system has caused a decline in urban community organisation, which in turn has led to a series of problems such as rising costs of living for residents, especially poor residents, and the breaking of social bonds. Li and Wu (2006) note that while commercial facilities and new commercial housing have developed rapidly in China's commercialised cities, community building has been neglected and urban human relations have been challenged. In their study, Wang et al. (2013) point out that the irrational distribution of functional areas in urban planning and construction has led to inefficiencies in functions including urban transportation.

Accordingly, our research on Danwei systems and urban communities raises several questions.

(1)What is the current distribution of different types of neighbourhoods in the city?

(2)How do functional facilities in the city interact with the neighbourhoods?

(3)What is the current situation within Danwei neighbourhoods in the context of their recession?

1.3 Objectives of the Study

In order to obtain answers to the above questions, the spatial and social structure of urban neighbourhoods and the overall city needs to be perceived at different scales. In this regard, the research process is split into 3 specific objectives.

(1) City-scale Spatial Analysis of Neighbourhoods – Danwei compound and Non-Danwei Residential.

(2) Historical Socio-Spatial Change of a Danwei compound.

(3) City-scale Spatial Analysis of Hefei city – Commercial Distribution.

1.4 Significance of the Study

1.4.1 Theoretical Significance

Although the existing studies have described in some details of the origin, economic basis, development process and decline mechanism of the Danwei system and the Danwei compound, the majority of the relevant studies fall into the fields of sociology, and economic and political science. Despite there being a certain amount of research in the field of urban planning, which has been profoundly influenced by the Danwei compounds, the relevant research is still rather scarce, and systematic research is even more rare, with less well-developed theoretical systems. In the literature available to the author, only Professor Chai Yanwei and his team in human geography at Peking University have conducted a relatively in-depth and systematic study in this field. The existing researches of Danwei system in the field of urban planning are often of large scales. The vast majority of studies have remained at the scale of macro-urban planning or general urban design, with little spatial research at the human scale, community scale or building scale. There is no single study that combines the cognitive levels of macro socio-economic environment, meso urban planning and design, and micro living space. This makes it difficult for existing studies to play an effective role in guiding the regeneration of specific Danwei compounds. In addition, most of the existing studies are static studies based on field research or simple before-and-after comparisons, and the few dynamic studies suffer from short control time periods and lack of detail and depth. This has resulted in the conclusions of these studies lacking historical longitudinal knowledge. This dissertation seeks to fill these research gaps.

1.4.2 Practical Significance

Most of China's cities have adopted a crude economic-centred approach to development over the past 30 years, and much development and construction has even exceeded the original urban planning, with a lot of construction first and planning later cases. This has led to massive chaos in urban management and perception. Such chaos is even more pronounced at the community level, to the extent that many urban planners, builders and managers are unable to accurately and comprehensively perceive the current urban community. In recent years, the pace of China's economic development and social transformation has reached an inflection point, signalling the arrival of a window period for urban renewal in China. In-depth studies of urban neighbourhoods at this time can contribute to recent urban planning, urban regeneration and community governance, and provide a reference for future community and city building.

1.5 Previous Studies

The Danwei and the Danwei compound were born in the 1950s. Later, with the opening up of China to the outside world, international scholarship on the Danwei and the Danwei compound began in the 1980s and gradually reached its peak after 2005 (Figure 1.1). These studies are concentrated in the fields of China studies, urban studies, environmental and geographical studies, planning studies, transport studies, and economic and development studies (Figure 1.2). Among the researchers in this field, Professor Chai Yanwei, who graduated from Hiroshima University in Japan and currently works at Peking University in China, has contributed the largest number of articles and has covered many areas of Danwei studies.

Underlying these researches is the fact in the international scholarly literature, the absolute number is still too smal since most of the research outputs have been published in Chinese [see (Chai et al., 2007; Li, 2016; Qiao, 2004; Tian, 2014; WANG, 2010; Zhang, 2004) etc.]. Hence, quantitative and spatial research on the state quo of Danwei compounds, including studies on the current distribution of Danwei compounds is scarce, especially in English language. In the international

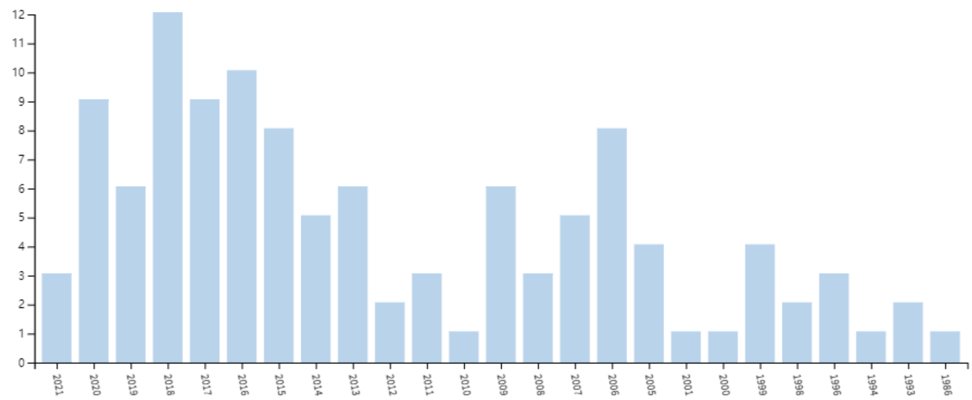


Figure 1.1: Number of Danwei Related Researches on Web Of Science (by year)

Figure 1.2: Number of Danwei Related Researches on Web Of Science (by field)

scholarly literature, most of the discussions on Danwei system and Danwei compound are focused on political economy (Bian, 2005; Bray, 2005; Lü and Perry, 1997), and a few on urban spatial studies about Danwei compounds (Peiling, 2014). For example, the book edited by Lü and Perry (Lü and Perry, 1997) provides a series of analysis of the Danwei from perspectives of historical development, international comparisons and reforms. Bray (Bray, 2005) investigated the Danwei compound and Danwei system and described them as neighbourhood social space and local governance of China. He identified enclosed walls as the distinctive ' of the compound. In another study, Bian (Bian, 2005) introduced the Danwei system of China by exploring different kinds of industries and enterprises promoted by such a system. Peiling's recent study (Peiling, 2014) provided a comprehensive survey of Jingmian Danwei compound in Beijing through micro-space analyses. He identified that the most serious issue in Jingmian compound might be residents' dislocated identity of whether they are socialist workers, rural farmers or modern citizens.

In recent years, as Chinese cities enter a new stage of development and the requirements of people-centred urban planning, more and more research on the Danwei system in the field of urban planning has focused on the transformative study and historical comparison of their socio-spatial system.For example, Peiling (Peiling, 2014) studied the micro-level features of the Jingmian Danwei compound in Beijing, which revealed dislocated identities in the socio-spatial relationships among residents without engaging the historical context of the reforms. The study of Zhang et al. (Zhang, Chun & Chai, Yanwei & Zhou, Qianjun, 2009) on the spatial changes of a Beijing Danwei compound by analysis its maps between the 1990s and 2006. At the same time, with the rise of urban data science, large-scale urban sensing techniques such as spatial distribution have provided new entry points for the study of various urban functional blocks, including urban communities.Spatial distribution is a common research method to map a specific kind of object in urban space and study about their characteristics. Dang et al. studied the spatial distribution of affordable housing development in Beijing (Dang et al., 2014). Quinn et al. mapped the neighbourhood physical disorder in New York City using a similar approach (Quinn et al., 2016). Within the spatial distribution approach, accessibility analyses have been used as an analytical tool to understand spatial equalisation (Kelobonye et al., 2020). For example, Lotfi and Koohsari studied the accessibility of neighbourhood facilities in Tehran, Iran (Lotfi and Koohsari, 2009) while Oh and Jeong studied the accessibility of urban parks in Seoul, South Korea (Oh and Jeong, 2007). Indeed, evidence shows that for urban neighbourhoods, their distribution and their connection to the city in terms of access to commercial and public facilities is an important component of the overall quality of the urban living environment. For example, Bonaiuto et al.'s study showed that having adequate commercial coverage, variety of goods, school and health facilities in the neighbourhood that can be easily reached on foot, are important indicators for residents to quality of their residential areas (Bonaiuto et al., 2003).

This study, therefore, contributes to existing research in four ways. First, to provide an empirical understanding on the distribution of Danwei compounds as an entry for future in-depth analysis on their conditions and socio-spatial transformation. And secondly, to provide insights at the city scale on accessibility to public facilities in terms of the reshaping of the urban environment following recent housing reforms (e.g. The 1997 Urban Housing Reform). Third, to shed useful insight on challenges and potentials for effective community level planning at this critical stage of urban development in old Chinese cities. And fourth, to give information from an urban research perspective specific to the city of Hefei, and in particular to the Danwei compounds within Hefei.

1.6 Structure of the Dissertation

This dissertation consists of eight chapters. Each chapter of this dissertation intertwines the important narrative of this study. For reference, the conceptual structure chart of this dissertation is shown in Figure 1.3.

Chapter 1 provides a general background to the study by placing this research and the concept of 'Danwei' within the historical development of neighbourhood from the world to the Chinese environment.

Chapter 2 reviews the literature related to the research objects, building a knowledge base of historical overview and status quo of research in related fields for understanding the development and changes of Danwei system and Danwei compound.

Chapter 3 presents the history and recent development of the city of Hefei as the case for this study. Materials such as urban planning histories, demographic changes, city maps and city images can help to build a basic social and spatial understanding for later studies.

Chapter 4 provides a detailed narration of the methodological approach employed through out the study, including an detailed explanation of methods for data collection, data analysis, and even the research methods developed for data acquisition.

Chapter 5 shows the spatial distribution of the Danwei compound and other neighbourhoods in the old city of Hefei, their spatial characteristics, and the accessibility between these neighbourhoods and public facilities.

Chapter 6 shows the socio-spatial changes of the AMS Danwei compound from its inception to the present time. The evolution of the spatial, architectural, residential and community management aspects of a typical Danwei compound neighbourhood is illustrated.

Chapter 7, the final chapter of the thesis, summarises all the key findings of the study and provides recommendations for policy implementation based on them. The future research is also presented in the light of the findings and limitations of this study.

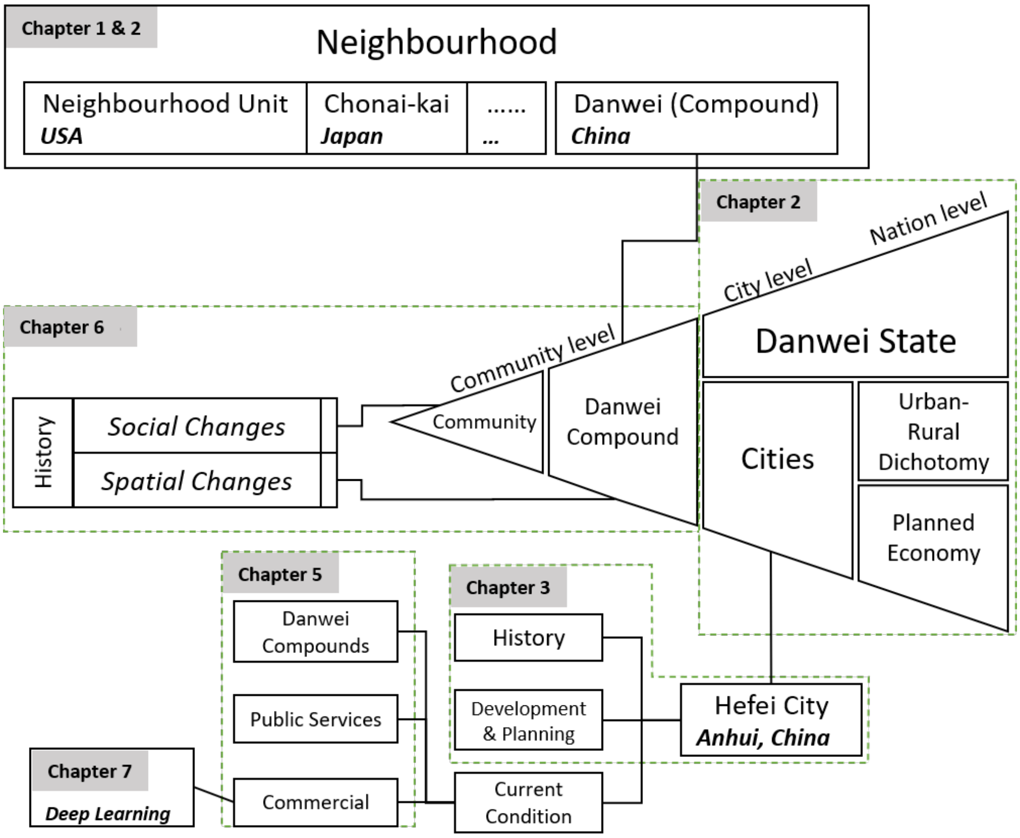


Figure 1.3: Conceptual structure of this dissertation

Chapter 2

Literature Review

2.1 Modern Neighbourhood and Community

Following the emergence of the concept of urban neighbourhoods and communities in the 20th century, a variety of different forms have emerged around the world. Two of these successful and representative forms are studied as follows. They are the Neighbourhood Unit in the USA and the Chonai-kai in Japan.

In 1929, the American scholar Perry proposed the concept of a neighbourhood unit centered on a primary school and public facilities, proposing six principles such as Size, Boundaries, Open Spaces, Institution Site, Local Shops and Internal Street System. The concept was to create a neighbourhood unit with a population of about 5,000 people, a walking radius of about five minutes, approximately 10% of the land being open space, commercial facilities at the entrance to the neighbourhood, centred on a primary school, surrounded by urban roads and organised internal roads. Perry's concept of the Neighbourhood Unit was based on many of the sociological ideas of the Chicago School, including

(1) Robert E. Park's ideas on school districts.

, and the practical form and spatial planning of the residential communities that had been built or were under construction at the time, including

(2) the design named *'A City Area Developed on the'Neighborhood Unit' Plan'*, by architect William E. Drummond in the competition of *Plan of a Typical Quarter Section in the Outskirts of Chicago*, which was based on the British garden city theory and provides the basic concept of the settlement unit and the name 'neighbourhood unit'.

(3) Hampstead Garden Suburb in London, England, with its public services (hospital, school, etc.) around a central green space.

(4) Forest Hills Gardens, New York, with its system of separate streets promoted by neighbourhood units.

(5) The Mariemont Settlement in Cincinnati, Ohio, with its planned open internal spaces.

(6) Radburn Settlement, New Jersey, with its pioneering new mode of intra-settlement car traffic.

Perry's Neighbourhood Unit Theory can be considered as a generalisation of these projects, as well as an accurate summary of the social needs expressed by these projects by Perry using sociological theory. Neighbourhood Units have become the template for urban development in the United States, and in many other countries, for decades afterwards, because of their efficient land use in new town development as opposed to the traditional rough-and-tumble urban development model in the United States.

However, it has been criticised from various quarters over the years. For example, Tridib Banerjee and William C Baer (Banerjee and Baer, 1984) point out that, firstly, the neighbourhood unit theory is a conceptual theory that lacks scientific evidence and uses schemes and data that are not fully validated; and secondly, it cannot adapt to local conditions. In addition, according to the Chinese scholar Jiang Jiawei (江嘉玮, 2017), neighbourhood units in practice have been criticised for contributing to regional class divisions and racial segregation in cities and for increasing low-density urban sprawl. In the New Urbanism movement that emerged in the United States after the 1980s, scholars modernised and reconceptualised the shape and concept of the neighbourhood unit. In 1994, Andreas Duany and Elizabeth Plater-Zyberk (Duany and Plater-Zyberk, 1994), based on their theory of Traditional Neighbourhood Development (TND), redesigned the neighbourhood unit to address the car dominance, the inconvenience of pedestrian systems, the lack of connectivity between neighbourhoods and the outdated commercial space typology. Douglas Farr (Farr, 2008), in 2008, built on the work of his predecessors by designing and mapping out a new sustainable neighbourhood in response to growing ecological concerns. In summary, the Neighbourhood Unit in the United States is a planning model for residential spaces based on commercial properties, where the formation of social relationships within them relies heavily on the sharing of public services by residents.

The Japanese Chonai-kai is a voluntary organisation formed by the geopolitical unit of the Japanese neighbourhood, the town, to promote friendship among participants, to improve their welfare and to facilitate cooperation with various government organisations. Nakata (NAKATA, 2017) summarises the five characteristics of a machi-kai: it has a certain regional division and does not overlap with each other; it is formed as a household; in principle, participants are household-based and include all family members; it is fully involved in local issues; and as such, it is an organisation that represents the local community before the administration and external third parties. The main functions of the town council are: communicating with each other, such as providing information on events and distributing announcements; informing the government; Obon dances and festival festivals; managing infrastructure such as street lighting; making requests to the administration and other communication matters (内阁府国民生活局总务课调查室). The former name of the Chonai-kai was the "Neighbourhood Group" during the Second World War. This structure was forcibly disbanded after the war during the American occupation, but was restarted after 1952 when the relevant legislation lapsed. In the decades that followed, it played an important role in organising local residents, disaster relief, public order, youth development, infrastructure maintenance, environmental beautification, resource recycling and social activities (Kikuchi, 2002). The Chonai-kai system has also faced, and still faces, many questions and problems. The first of these questions came at the beginning of the re-establishment of the Chonai-kai in 1952, when scholars questioned whether the re-establishment of this social structure, which had its roots in the grassroots organisations of the Japanese Empire's foreign invasion period, was a sign of the post-war ebb of 'democracy'. The fears of these scholars were not realised, and the Chonai-kai was eventually run mainly by the residents of the town itself, and did not become a top-down organisation subject to government control (FUJITA, 1980). The biggest challenge faced by the Chonai-kai system in recent years has been the declining rate of participation. Unlike some communities in other countries, the membership rate is voluntary and dues-paying, and this has led to a decline in the number of people willing to join, in a modern society where mobility is becoming more pronounced and social services more commercialised. In 1968, the participation rate for urban households was 88.7% and 90.5% for rural areas (内阁府, 1968); in 2010, the overall participation rate was only 73.0% (内阁府, 2010). According to the Nihon Keizai Shimbun (日本经济新闻地域经济, 2019/12/14), in 2019, participation rates in the Nerima Ward of Tokyo will be only 36%. Although the current rate is still high and sufficient to perform its basic functions, this trend poses a potential challenge to the continued functioning of the Chonai-kai in the future. In summary, the Japanese Chonai-kai is a geo-based local social organisation, which is generally a bottom-up regional self-organisation of local residents.

2.2 Tradition Local Social System of China

Contrary to the general perception that China is a strictly centralised society, the local community has maintained a high degree of autonomy throughout its long history, which has led to the saying that 'imperial power does not go to the townships'. Naturally, in order to achieve basic state rule and administration at the local level, central power has also been struggling and merging with local powers. This long historical process has built up China's unique indigenous grassroots local social structure and system.

According to Tian's (Tian, 2014) summary, the basic structure of traditional Chinese society before the radical social transformation of the PRC could be divided into two directions: the 'small community' and the 'large community', representing the viewpoint of the local community from the bottom-up and the viewpoint of the state organisation system from the top-down. As this study focuses on the local affairs, the theories related to the 'small community' are highlighted. It is to be noted that this does not mean that we believe Danwei systems do not have the characteristics of top-down large communities. On the contrary, we think that for a considerable period, the Danwei system, which covered all of China's towns and cities, constituted a single 'large community' of a huge scale rarely seen in human history. However, as the analysis of this large community is difficult to approach from the perspective of physical space and urban planning, and is mainly concerned with political and economic aspects, it is not the focus of discussion in this study.

Below is a brief introduction to the "Earthbound China" theory (Fei, 1992), which is widely accepted in academic circles as a description of local interpersonal relations, and the "scholar-gentry society" theory (Chang, 1955), which describes local social hierarchies.

2.2.1 Earthbound China

"Earthbound China" is a concept coined by the famous Chinese sociologist Fei Xiaotong to refer to the characteristics of Chinese grassroots society with a "differential pattern". A "differential pattern" is a network of private relationships and is the counterpart of the "group pattern" (where all people are integrated into a certain organisation, which in turn is linked to form a network system). Described in today's concepts, the "differential pattern" is similar to a distributed grid structure and the "group pattern" is close to a tree structure. In a network of disorderly patterns, each individual generates a circle of influence related to him or herself. According to Fei Xiaotong, this structure arises because the Chinese are extremely settled and socially immobile, thus exposing individuals to a 'grassroots society without strangers' in their daily lives. This social reality has consequently led to the fact that "Chinese grassroots society is Earthbounded", both in urban and rural areas.

The characteristics of this "Earthbound society" can be summarised as follows. (1) Unlike the contractual power of the West, the form of power in local society is "paternalistic" and " fatherly" correctional power. (2) a degree of autonomy from the imperial power and bureaucracy, due to the presence and governance of the local gentry. (3) a strong sense of exclusivity and stability, based as it was on a "grassroots society without strangers". (4) In the differential pattern, there is no notion of individuality or absolute hierarchy as in the Western sense, authority, power and responsibility are spread through this distributed grid structure and decay through the individuals who act as nodes, creating a clear pattern of differences. And in this grid, public and private "are also relative", depending on their distance from you in the network.

Earthbound China is a very important theoretical perspective in the study of Danwei System, as the it inherited most of the above-mentioned characteristics of earthbound society.

2.2.2 Gentry Society

Prior to the establishment of the People's Republic of China, in the traditional grassroots society, the group of people who held the real power and voice at the local level was known as the "gentry". The gentry were the de facto local leaders and acted as a bridge between the public power of the government and the private power of the households. The membership of the gentry was usually acquired through an intellectual examination known as the imperial examination system. Ordinary people were also able to progress through the examinations and become part of the gentry class, while the best or most powerful gentry were able to enter the national bureaucracy as officials through certain channels. This social construction with a certain degree of hierarchical mobility was so stable that Chinese society remained in this social hierarchy for thousands of years, only breaking down completely after the founding of the PRC.

In his book *De la division du travail social*, Émile Durkheim (Emile et al., 1984) argues that a series of subgroups must exist between the government and the individual in order to integrate the individual into mainstream social life. Otherwise, the relationship between the state and the individual would become more and more distant and the state would not be able to penetrate deep into the consciousness of the individual. In traditional Chinese society, the gentry and the clans constituted such sub-groups. After the social revolution of modern China, the "Danwei" became a buffer and a medium of communication between the violent apparatus of the state and the individual human being at the grassroots level.

2.3 The Origin and Development of the Danwei System

2.3.1 The Origin

There are four representative views on the origins of the Danwei and Danwei system (Tian, 2014), including the "theory of revolutionary base areas experience", "theory of the unification and association of post-revolutionary society", "theory of the origins from the Republic of China period" and "theory of the origins of the typical Danwei system in the northeast".

The "theory of revolutionary base areas experience" attributes the origin of the Danwei to the system of production and distribution established by the Chinese Communist Party within its revolutionary bases during the Second World War and the civil war. This is also the most commonly accepted theory of the origin of the Danwei system by scholars both in China and abroad. Many scholars, including Chinese scholar LU Feng (路风, 1993), Japanese scholar TANIGAWA Shinichi (Tanigawa, 1999) and American scholar Mark Selden (Mark, 1995), agree with this theory. According to Selden (Mark, 1995), the main characteristics of the Danwei system was its "total reliance on the creativity of the people, especially the peasants, and the belief in the ultimate triumph of man over nature, poverty and exploitation, and the unambiguous rejection of the domination of the upper administrative or technical cadres through centralised bureaucracy, emphasising popular participation, local decentralisation and reliance on social forces". Lv et al. (Lü and Perry, 1997) examine this theory more specifically, pointing out that the specific institutional origin of the Danwei system was the 'small communal economy' from the revolutionary base period, whose economic characteristics and basic contradictions were highly continued in the subsequent Danwei system.

The "theory of the unification and association of post-revolutionary society" suggests that after the founding of the PRC, at a time of complex domestic and international political and economic conditions, a scarcity of social resources and a serious lack of productivity, the Danwei system was established as a strategic design to 'extract and redistribute resources through authority in order to meet the needs of modernisation' (Liu, 2000). While this view offers a good explanation of the function, purpose and context of the Danwei system, it should be seen as a analytical appeal to the function of the Danwei rather then the origin of it.

The "theory of the origins from the Republic of China period" suggests that the origins of the Danwei system lie in an earlier period, dating back to the reign of the Republic of China (1912-1949). The Republic of China was the first democratic republic in Asia and had established some modern industry and commerce prior to the outbreak of the Japanese invasion. Morris L. Bian (Bian, 2005), a Chinese-American scholar, argues that the state-owned enterprise system, later represented by the Danwei system, originated from the pressure to produce and deploy strategic materials during the war against Japan, and the integration of this pressure with the administrative system.

The "theory of the origins of the typical Danwei system in the northeast" by Tian holds that the formal origins of the Danwei system were found in the construction of industrial cities in Northeast China after the establishment of the PRC, and eventually developed into a form of grassroots social organisation (Tian, 2014). He points out that the Communist Party of China did not develop a seamless Danwei system directly after taking over power, but gradually established the prototype of the 'Danwei system' in the industrial cities of the Northeast through trial and error and continuous improvement, and then extended it to the whole country.

In summary, there are many different views in the academic community on the origins of the Danwei system. Each of these views also has its historical and theoretical underpinnings, and all can be used to explain some features of the Danwei system. In summary, the Danwei system is a form of productive organisation that was explored in China during a specific historical period, under great pressure for survival, and was inherited and developed by the PRC after 1949.

2.3.2 The Development

By the end of the 1950s, China had basically formed a "Danwei-run society" in which almost all members of urban society were integrated into the Danwei system. At this time, the closed Danwei compounds, which included work and production areas, residential areas and various living facilities in a concentrated urban space, was basically formed, and Chinese cities entered the era of Danwei compound dominance (Liu, 2000).

After the reform and opening up in 1978, the Danwei system underwent another period of rapid expansion. Although the ultimate goal of the reform and opening up was to break the planned economy, to break the Danwei society as a single social framework and to unleash social dynamism, China did not have the social foundations to integrate into the neo-liberal world of the time at the beginning of the reform, so the Danwei system took the lead in the early stages of a social reform that would eventually eliminate itself, with many Danweis establishing their own subsidiary industrial and commercial sectors to participate in the market economy. This led to a deeper integration of the Danwei system into China's economic operations (于光远, 1984). The 'child succession system' of the same period also had a profound impact on Chinese society. This system allowed the children of employees to work directly in the Danweis after their parents retirement through a formal assessment. On the positive side, the system ensured urban employment and social stability during the turbulent period of reform; on the negative side, urban youths were guaranteed decent jobs without having to work hard, which led to a deterioration in the quality of employees in the Danweis (劳动部保险福利司, 1989).

The economic efficiency and competitiveness of the Danwei system has been historically proven to be sub-par. Its main shortcomings are:

Firstly, as relatively independent social organisations, individual Danweis were organised by their internal members, with the Danwei compounds as their spatial stronghold, creating closed communities of interest within them. These communities of interest have led to the stagnation of the city's economic development. Because the individual Danweis are largely self-managed and lack external constraints of a day-to-day nature, inefficiency, laziness and even corruption within the internal interest groups are difficult to detect.

Secondly, due to the "egalitarian practice" in the planned economy, and the fact that the budget of each Danwei is allocated by the state, there is no direct relationship between the efficiency of the Danwei and the income of its employees, which leads to low motivation of the employees to work.

Thirdly, as the budget of the Danwei is allocated by the state treasury, this leads to a strong bond between the credit of the Danwei and the credit of the state, resulting in a rigid payment of the credit of all Danweis. In this case the state treasury must endorse all the financial risks of the Danwei, which even includes the Danwei's financial expenditures on social benefits for staff, food and housing subsidies, infrastructure upgrades and so on. There is a great deal of randomness in the occurrence of these expenditures, which results in the government only being able to impose soft budgetary constraints on the Danwei, and due to various factors these expenditures always exceed expectations, resulting in a great financial burden.

2.3.3 The Decline: Two Reforms

Since the 1990s, some changes began to occur in the Danwei compounds due to the above deficiencies and the decline of the macro socio-spatial system it was based on. This decline was fuelled by two of the most significant Chinese reforms of the second half of 20th century—the Reform and Opening Up (1978) and the Urban Housing Reform (1997). On the one hand, the Reform and Opening Up, which began in 1978, loosened the economic and social structure base of the Danwei system with significant effects on space, society and economy (ChuangLin, 2009). Prior to this reform, China implemented a planned economy system in which most public goods were rationed (Wen, 2013). In this planned system, the entire society was de-monetised and hence had no free market in which goods could be bought and sold freely with money. Thus, urban residents were required to be part of a government-recognised organisation or institution (a Danwei) in order to get access to industrial or agricultural products (Liu, 2000). This system tied all citizens onto the same social system, forming a single community of interest. However, this so-called class-neutral planned economy led to a low level of productivity and other social problems, such as the urban-rural dualism, and hence necessitated the need for reforms (Tian, 2014). As a result, The Reform and Opening Up was launched in 1978, which among other things, led to the reversion of private ownership, and the use of currency to buy and sell goods (Wen, 2013). On the social front, the notion of China as one original 'single community' was dismantled, allowing the population to have free mobility across the country. Consequently, social organisations independent from the Danwei system proliferated after 1978. However, due to historical inertia, a slow integration of market-based society and the apparent contradiction between the goal of the reform and the local realities, the Urban Housing reform was not introduced until 1997.

The Urban Housing reform, on the other hand, is considered to have particularly impacted the spatial base of the Danwei compound. It was a top-down reform of housing and urban land-use. Before this reform, all urban land and housing resources belonged to the State and could not be traded (Li and Dai, 2009). Typically, the government would allocate the rights of land use to Danweis, while the ownership and title to the land remained with the State. A Danwei would build a compound and thus control the land and houses. After the Urban Housing reform in 1997, the property rights of the residential houses in the Danwei compounds were distributed to individual occupants, leading to the gradual loss of the Danwei's (organisational entity) control over its territory. Expectedly, this resulted in the creation of a new real estate market, permitting individuals to own homes as assets (while land ownership remained with the State) (Li and Dai, 2009).While the above reforms contributed to rapid economic growth, they have also unleashed a fundamental transformation of the social and spatial structure of Chinese cities and local neighbourhoods (Zhang, Chun & Chai, Yanwei., 2009).

2.4 The Political & Economy Base of the Danwei System

2.4.1 Political Systems in the Danwei Community

The Danwei system was born as an instrument of integration in the Chinese cities, which 'forced' China into a 'Danwei state' (Liu, 2000). In other words, the Chinese society was constructed in a typically fractal way, with individual units being both part of this fractal structure and its basic units. The primary objective of the construction of the Danwei system at the practical level was to bring Chinese society as a whole into a highly organised and structured overall framework, thereby achieving a strong state mobilisation capacity, a modernisation of productivity and social organisation. Through the introduction of the Danwei system in all cities across the country, a social framework of 'state-Danwei-individual' was established in all Chinese cities. The Danwei becomes a monopoly that mediates between the state and the individual, meaning that the state can control all urban residents simply by controlling the 'Danweis', while urban residents can enjoy all national rights and benefits through their 'Danwei', and can exert influence on state decisions through the democratic processes within the 'Danwei'. This holistic framework enables the monopolistic allocation of social resources and binds the fate of all members of society together, forcing them into the grand narrative of the 'Great Community' of catch-up development.

As a result of common life and common work within the same Danwei, relatively separate communities of interest and society were formed within each closed Danwei compound. Both the state and the government would benefit from the notion of 'the people being in charge' under the socialist system, and to a large extent China at that time formed a community of interests and ideas within the Danwei compound, achieving 'universal' democracy within the compound. Although this community takes place within the framework of a system designed from the top, it is also a bottom-up grassroots social organisation, benefiting from the existence of grassroots consultative democracy. As a social complex with complete internal functions, Danweis and Danwei compounds form closed boundaries that, while constructing urban communities, create rigidities in the functioning mechanisms of urban society (Tian, 2014).

2.4.2 The Urban-Rural Dichotomy

The context in which the Danwei system was established in the cities was the political and economic environment of a particular period in China during the transition from pre-modern to modern society. The urban-rural dualistic structure of political and demographic management during this period (1949-1978) and the economic urban-rural centre-periphery structure built upon this dualistic structure are considered to be the basis for the existence of the Danwei state and a typical feature of Chinese society at the time.

Before 1949, China was a completely agrarian country with an urbanisation rate of only 10.46% of the population. China's industrial capacity had been almost completely destroyed by years of war, and agriculture was a smallholder economy with limited productivity. Such an economic structure was not sufficient to provide for the needs of a large urban population. If the population had been allowed to flow into the cities, the result would have been a shortage of food and goods, and ultimately a breakdown of economic order and security. China did in fact experience such a crisis, before the formation of the urban-rural dual structure, and after a period of free movement of people in the 1950s, when structural unemployment and even deaths from hunger occurred in the cities (Wen, 2013). Since then, China has taken strict measures to restrict the flow of people from the countryside to the cities. An urban-rural dichotomy of the household registration system was established and the mobility of rural origins was strictly confined to the rural areas. The vast countryside and agriculture, with its easy access to food, became a huge employment pool, housing China's huge population. Luo Ruiqing, then Minister of Public Security, explained the purpose of the policy at the time: "neither to allow the urban labour force to increase blindly, nor to allow the rural labour force to drain away". Through this system, China avoided a complete economic collapse, providing time and space for initial industrialisation, but also becoming the trigger for a long period of uneven urban-rural development in the decades that followed.

Although the problems caused by the urban-rural dichotomy are numerous, and the controversies and problems arising from the public power forced solidification of the dichotomy have been highly criticised in various fields, but for China, there was a certain historical inevitability in choosing this path. It can even be asserted that without the forced urban-rural dichotomy of those decades, there would have been no subsequent full-scale industrialisation and development of China. The only way to achieve wider urbanisation was to develop basic industry first, and then to consider increasing the urbanisation of the population once the level of industrialisation had increased to the point where it could feed agriculture and provide sufficient supplies for living. However, as China was penniless at the time of its founding, it had to develop its industry from scratch with no primitive capital. It is commonly known that the economic system on which industry is based is bound to undergo a process of primitive accumulation through price scissors at the beginning of its development. The first industrial countries accomplished this primitive accumulation through colonial expansion and foreign wars, while the later countries had to rely on external investment or internal oppression. At the time, however, China adopted a fully socialist system, the legitimacy of which came from the fact that "everything the state owns is owned by the people", so it was impossible to accept foreign investment to complete the process of primitive accumulation. Therefore, China inevitably embarked on a process of internal oppression, and the creation of a price scissors difference between the products of the non-industrial sector and those of the non-industrial sector, in order to achieve primitive accumulation for the industrial sector. The stable, labour-abundant rural and agricultural areas brought about by the dualistic urban-rural household registration system were at this point the natural targets of exploitation. This dichotomy led to many negative outcomes, however China did take advantage of this industrial-agricultural price scissors to build up its basic industrial capacity over the years, particularly in the defence industry, and prevented further fragmentation and collapse of the country.

It is important to note that the dichotomy between urban and rural areas is not unique to China, as almost all developing countries face similar problems to a certain extent. In particular, the same phenomenon is very common in countries and regions with large populations and a small-holder agricultural base. But China's response to the urban-rural dichotomy has been unique. Rather than attempting to dissolve this structural dichotomy directly, the Chinese government has used administrative coercion to reinforce it, even to the extent of prohibiting the movement of people between urban and rural areas. In its process, this artificial antagonism was dehumanising, cruel and illiberal. But in terms of its purpose, this artificial internal market differentiation and scissors difference succeeded in helping China to establish a modern industrial and commercial system as quickly as possible; in terms of results, the suffering of a part of the population enabled China to develop from a backward and extremely poor agricultural country to the largest industrial country in the world in a single generation, and it is reasonable to speculate that it objectively reduced the length of time that the urban-rural dichotomy existed.

For the sake of economic development and also to alleviate the contradictions of the urban-rural dichotomy, after the reform and opening up began in 1978, China's urban-rural dual household registration system was gradually loosened and residents with rural household registration gradually began to move across the country. Until 2001, this population movement was strictly regulated, yet as the social security and welfare system of urban society was still tied to the Danwei system, the rural household registered population moving to the cities still could not benefit from the same social rights and benefits as the urban household registered population (including social security, various state subsidies, education, etc.). From 2001 to 2012, China began to reform its household registration system, and gradually increasing the social security, rights and benefits available for the rural registered population in the cities. The urbanisation process in China is advancing rapidly. It should be noted that, due to the socialist nature of China, all rural household registration holders have free access to land for farming and to residential land for building houses. As the most basic factor of production, land has acted as a stabiliser, so that even in the most difficult times, China did not produce a full-blown humanitarian crisis. Now, at a time when the rural population has been drastically reduced, the value of rural household registration is even surpassed by the urban one due to the added value of land. This phenomenon is not relevant to this study and will not be delved into.

2.5 Danwei Compound

Based on the "Danwei system", a number of "Danwei compounds" (also called "Danwei communities" or "Danwei compound communities") were established as the spatial unit of the Danwei system. Basically, "Danwei compound" refers to a compound enclosed of walls with one or several gates for access. The interior is often a mixed-use spatial environment of offices, dwelling and public facilities and hence, includes all the working, living, and relaxing spaces and facilities of a Danwei (WANG, 2010).

2.5.1 Classification and Typology of Danwei Compounds

Danwei compounds can be divided into three main categories, namely government authorities, enterprises and public service institutions. Among them, enterprise compounds include industrial, commercial and service ones; while public service institutions' compounds include administrative, educational, medical and so on (Qiao, 2004; 任绍斌, 2002). From the scale of supporting facilities, Danwei compounds could be divided into three categories: fully functional, low external dependency, and strong external dependency, and the results could be further divided to the classification of large, medium and small scales. According to the degree of rejection of the city, they are divided into six categories: military, paramilitary, central government, ministry and municipal authorities, research institutes, universities and factories (Qiao, 2004; 任绍斌, 2002). According to the location of the Danwei compound in the city, they can be divided into urban ones and peri-urban ones (赵晓凡, 2006).

According to the architect Qiao Yongxue (Qiao, 2004), the spatial structure of the Danwei compound is similar to that of the traditional Chinese urban courtyard of 'front shop and back bed', and he summarises three spatial characteristics of the Danwei compound: the space enclosed by walls, the functional complexity of the coexistence of various functions, and the spatial overlap of different functions.

Li (Li, 2016) presents a detailed typology study of Danwei compounds and classifies them (a example of Figure 2.1). He also proposes seven key points for the spatial analysis of Danwei compounds, namely: boundaries, functional composition and zoning, entrance and traffic organisation, spatial structure, green landscape, architectural texture and public space. His study provides a complete theoretical and practical reference case for the study of Danwei compounds from a typological direction.

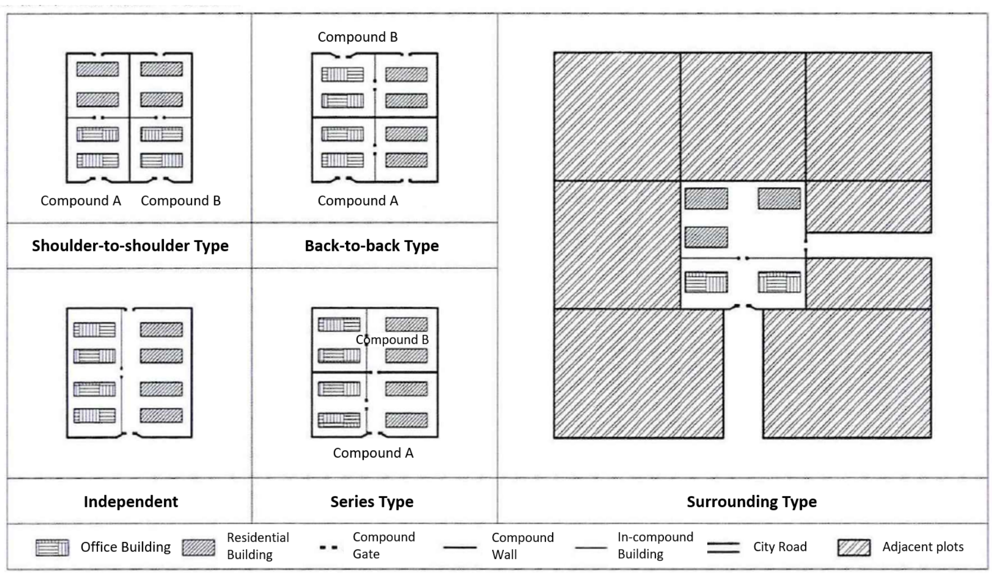


Figure 2.1: A typology classification of the relationship between the Danwei compound and its surroundings (Li, 2016)

2.5.2 Danwei Compounds in the city

Professor Chai Yanwei and his team at Peking University must be mentioned when it comes to the study of Danwei compounds from an urban spatial perspective. Professor Chai Yanwei and his team at Peking University must be mentioned when it comes to the study of Danwei compounds from an urban spatial perspective. Professor Chai has been using the Danwei compound perspective to study Chinese cities since his days at Hiroshima University in Japan in 1990 (Chai, 1990). They argue that the Danwei system has had a profound impact on the spatial form and social life of Chinese cities in the development and transformation of modern Chinese cities, especially in the rapid development of Chinese cities after the 1990s. Professor Chai Yanwei and his team's research on Danwei compounds includes but is not limited to: the relationship between Danwei compounds and residents' living space in Lanzhou City, Danwei compounds and urban spatial reconstruction, spatial comparison between Danwei compounds and new residential neighbourhoods, the formation and evolution of Danwei compounds from a geographical perspective, a number of studies on the historical spatial evolution of Danwei compounds in Beijing, etc. In addition, they have studied various aspects of the formation of the Danwei system, including changes in property rights, social impacts, and the evolution of residents' lives. It can be said that Professor Chai Yanwei's team is currently the most in-depth research team on the Danwei system from a geospatial perspective.

Qiao Yongxue examines the impact of Beijing's Danwei compounds on the city's urban space from the perspective of an architect. He argues that the courtyard walls and entrances of the Danwei compounds greatly influence the streetscape and function, and that the interiors of the compounds carry a large number of functions of urban public space. Qiao Yongxue examines the impact of Beijing's Danwei compounds on the city's urban space from the perspective of an architect. He argues that the courtyard walls and entrances of the Danwei compounds greatly influence the streetscape and function, and that the interiors of the compounds carry a large number of functions of urban public space. Li Chen (Li, 2016) examines the relationship between Danwei compounds and urban spatial development from an urban macro perspective alongside the typology of Danweis. He finds that there is a clear correlation between urban development and the spatial growth of the Danwei compounds in the 1970s and earlier, when urban development was inevitably accompanied by the construction of the compound, while after the 1990s urban development was no longer accompanied by the construction of the compounds (Figure 2.2). He further investigates the relationship between the Danwei compound and the different road network structures at the meso level, the types of patches in the urban form (Danwei compound, neighbourhood, urban village), and summarises and analyses the different combinations of these patches.

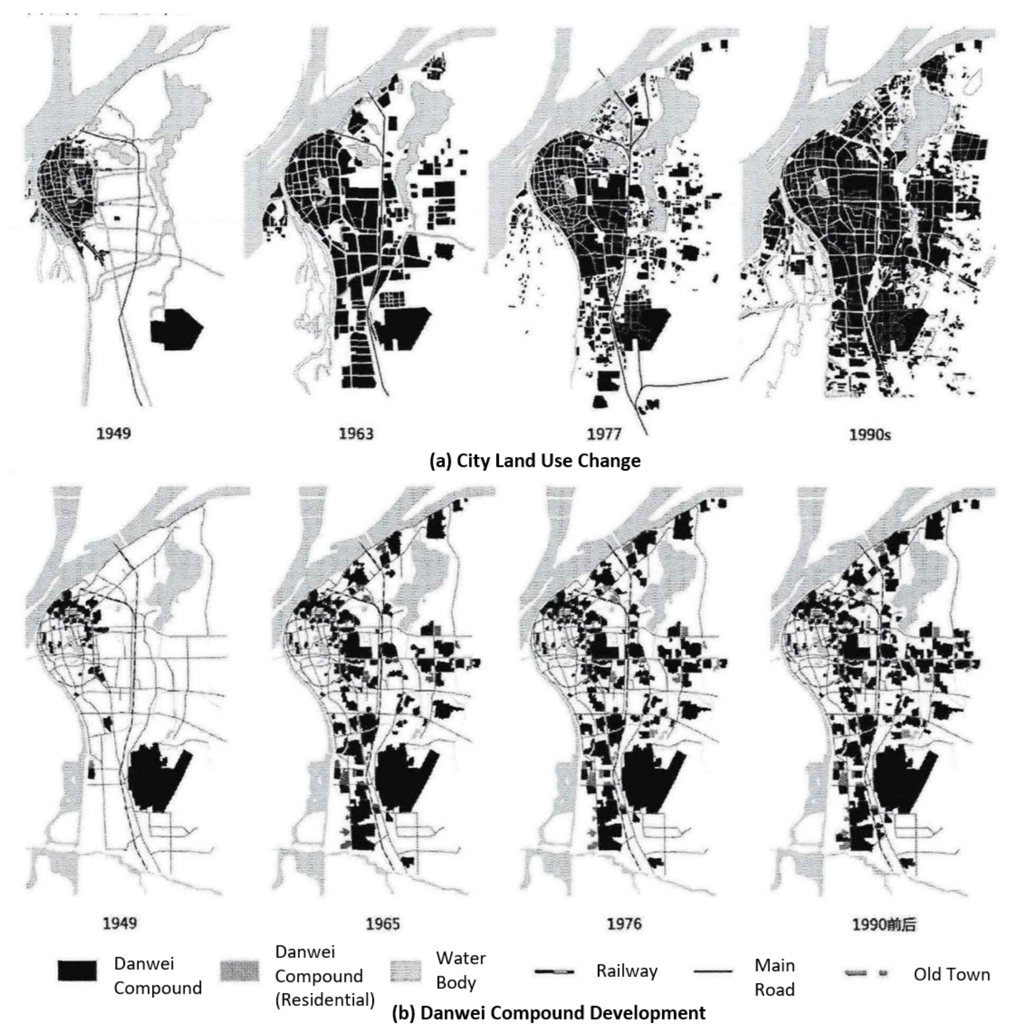


Figure 2.2: Nanchang Urban Land and Danwei Compound Development ((Li, 2016))

2.6 Spatial Distribution Study

Spatial distribution is a common research method to map a specific kind of object in urban space and study about their characteristics. Dang et al. studied the spatial distribution of affordable housing development in Beijing (Dang et al., 2014). Quinn et al. mapped the neighbourhood physical disorder in New York City using a similar approach (Quinn et al., 2016). Within the spatial distribution approach, accessibility analyses have been used as an analytical tool to understand spatial equalisation (Kelobonye et al., 2020). For example, Lotfi and Koohsari studied the accessibility of neighbourhood facilities in Tehran, Iran (Lotfi and Koohsari, 2009) while Oh and Jeong studied the accessibility of urban parks in Seoul, South Korea (Oh and Jeong, 2007). Indeed, evidence shows that for urban neighbourhoods, their distribution and their connection to the city in terms of access to commercial and public facilities is an important component of the overall quality of the urban living environment. For example, Bonaiuto et al.'s study showed that having adequate commercial coverage, variety of goods, school and health facilities in the neighbourhood that can be easily reached on foot, are important indicators for residents to quality of their residential areas (Bonaiuto et al., 2003).

2.7 Socio-Spatial Changes in Urban Neighbourhoods

Since its inception in the 20th century, the concept of the 'neighbourhood', the basic unit of urban habitat, has embodied the dual meaning of urban geographic space and human life (Lee, 1968). In other words, a 'neighbourhood' is a complex that encompasses both the internal physical space, such as buildings, roads, open spaces and public facilities, and the internal social elements, such as interpersonal relations, community structures, economic flows, and the maintenance and management of facilities. Particularly in urban studies, the 'neighbourhood' has been characterised as a Socio-Spatial Schema in order to precisely perceive and explain the concept of 'community' locally (Lee, 1968; Wang and Liu, 2017). This framing allows scholars and practitioners to better comprehend the neighbourhood as a whole or in it constituent parts by deconstructing into smaller, measurable elements which can be observed and assessed. In other words, the urban neighbourhood can be considered as a socio-spatial unit of human habitation with constituent but interrelated parts that are usually in constant interaction (He, 2013).

The conception of the urban neighbourhood as a socio-spatial schema allows for qualitative or quantitative description of a particular community in several analytical dimensions. For example, Gür and Enön used various qualitative and quantitative methods for measuring the significance of various social and spatial elements in neighbourhood design and verified the inseparability between these elements (Öymen Gür and Enön, 1990); Sykora used several methods such as mapping, quantitative statistics and qualitative description for different elements in his study of neighbourhood differentiation in Prague (Sykora, 1999); in their study of the relocation of a neighbourhood in İzmir, Turkey, Eranıl et al. mainly adopted interview and field observations to collect and describe changes in various socio-spatial elements in great details before and after the relocation of the neighbourhood (Eranıl Demirli et al., 2015); He and Wu used qualitative descriptions, quantitative statistics and other methods to collect information in their framework, while incorporating logistic regression and other methods to discuss the changes in socio-spatial elements of two different types of neighbourhoods in Shanghai, China under the context of property-led redevelopment (He and Wu, 2007).

Indeed, the use of mixed methods in analysing and comprehending urban neighbourhoods as socio-spatial units helps to bridge the scaling gap between community studies and urban studies at the conceptual and methodological level. In addition, it unravels the mechanisms and processes involved in urban development and changes. For example, Sykora (Sykora, 1999) chose three elements of income, housing system, social mobility and migration in this framework to study neighbourhood differentiation and changes all across the city of Prague in its post-communist transition. Additionally, by using the Factor Ecological Analysis and Hierarchical Cluster Analysis, Wang and Liu (Wang and Liu, 2017) analysed the evolution of urban social space and its mechanisms in the city of Xi'an, China. Moreover, He (He and Wu, 2007) examines the evolving of enclave urbanism in community and urban development in the city of Guangzhou, China in this framework.

In the extant literature, the common use of the socio-spatial framework is to first select a number of measurable socio-spatial elements and to build a structural framework for describing the neighbourhood; then to obtain a qualitative or quantitative description of the elements through various research methods; and finally to synthesise the descriptions of these elements into a coherent picture of the community. This method is often used for comparative studies between different neighbourhoods over the same period of time. For example, in the study on socio-spatial differentiation and residential inequalities in the residential restructuring process in Shanghai, Li and Wu (Li and Wu, 2006) firstly build a cascading framework by the elements of social stratification, residential stratification, housing tenures, neighbourhoods and socio-spatial transformation. Then, a case study of three neighbourhoods was implemented to collect spatial, demographic, socio-economic and housing data for the discussion of the framework noted above. In the same research, they also compared different neighbourhoods' socio-spatial elements by logistic regression while confirming the gentrification of central city neighbourhoods. Other scholars employ socio-spatial framework of urban neighbourhoods in comparative studies of the same community at different times. For example, Eranıl et al. (Eranıl Demirli et al., 2015) studied the relocation of Kadifekale inhabitants to TOKI Uzundere in İzmir. They used interviews and field surveys to describe the changes in the spatial aspects and social aspects of the community before and after the relocation, using a large number of photographs, descriptions of the inhabitants' life scenes and interview transcripts. Specifically, in spatial aspects their research concluded that the disappearance of flexible common spaces and the use of multi-storey apartment housing caused the shrinkage of public life, the loss of common defensive space led to the elimination of children's play space, and the replacement of small local shops by shopping centres and the changes in the way coffee shops being used made public life in the community less accessible and less frequent. At the same time, they examined changes in migration, traditional values, social solidarity, olfactory recognition and social bonding in social aspects. Finally, after studying these elements, they evaluated the relocation as "the project implementers failed to consider the residents' accustomed home-neighbourhood environment and communication zones" and caused the residents to be separated from their neighbourhood physically and consequently become fragmented socially. Table 2.1 provides details about some of the common socio-spatial elements analysed in existing literature that frames the urban neighbourhood as a socio-spatial unit of human habitation often in processes of change.

Table 2.1: Neighbourhood Studies Using a Socio-Spatial Schema

Author & Year	Location	Backgroud	Elements		Focus
Gür, S., & Enön, Z. (1990).	six neighbourhoods in Turkey	Comparison of different communities over the same period	spatial	Layout Microclimate Open space Street Building condition	Design implications
			socio	Neighboring activities Social and cultural Residents' attitude	
Li, Zhigang; Wu, Fulong (2006)	Three neighbourhoods in Shanghai, China	Comparison of different communities over the same period	socio-spatial	Socio-economic status Housing type Residential inequalities	Residential inequalities
He, Shenjing; Wu, Fulong (2007)	Two neighbourhoods in Shanghai, China	Comparison of different communities over the same period	spatial	Building style Average floor area Housing facilities Change of housing conditions in 10 years	Impacts of property-led redevelopment
			socio	Education level Working condition Income Housing tenure	
Eranıl Demirli, Meltem; Tuna Ultav, Zeynep; Demirtaş-Milz, Neslihan (2015)	The relocation of a neighbourhood in İzmir, Turkey	Comparison of before and after community relocation	spatial	Common spaces Housing style Noise Children play space Shops	Impacts of neighbourhood relation
			socio	Migration Traditional values Social solidarity Olfactory recognition Social bonding	
Gu, Chaolin; Shen, Jianafa (2003)	Beijing, China	Macro Urban Community Study	socio-spatial	Urban function Capital Migration Urban renewal Urban sprawl	Transformation of urban socio-spatial structure in Economic system transition
Wang, Yanjun; Liu, Kewei. (2017)	Xi'an, China	Macro Urban Community Study	socio-spatial	Population Household Industry Occupation Housing	Urban development and evolutionary mechanisms
Sykora, Ludek. (1999)	Prague, Czech Republic	Macro Urban Community Study	socio-spatial	Income Housing system Social mobility & migration	Post-communist transition and Socio-spatial Differentiation
He, Shenjing (2013)	Guangzhou, China	Macro Urban Community Study	socio-spatial	Housing Socio-economic status Demography Management	Enclave Urbanism

Drawing on the literature in Table 2.1, and in agreement with growing body of work on the socio-spatial aspects of old Chinese cities, we derive a framework (Figure 2.3) that posits that changes in urban neighbourhoods result from major policy or regulatory interventions at the national level in China (Wang and Liu, 2017; Ye et al., 2021), specifically the Urban Housing Reform and the Reform and Opening Up. Following the existing literature, spatial changes are considered from the physical and morphology aspect of the built environment such as building condition, street and public space accessibility and housing facility. On the other hand, social condition encompass phenomena and modifications in the human sphere, such as residents activities, housing tenure and social solidarity. While we identify spatial and social changes separately in our framework, we concur with Gür and Enön (Öymen Gür and Enön, 1990) that social and spatial changes do not occur independently but rather as interdependent process that constantly intersect and also respond to various policies and factors at global, national and local levels.

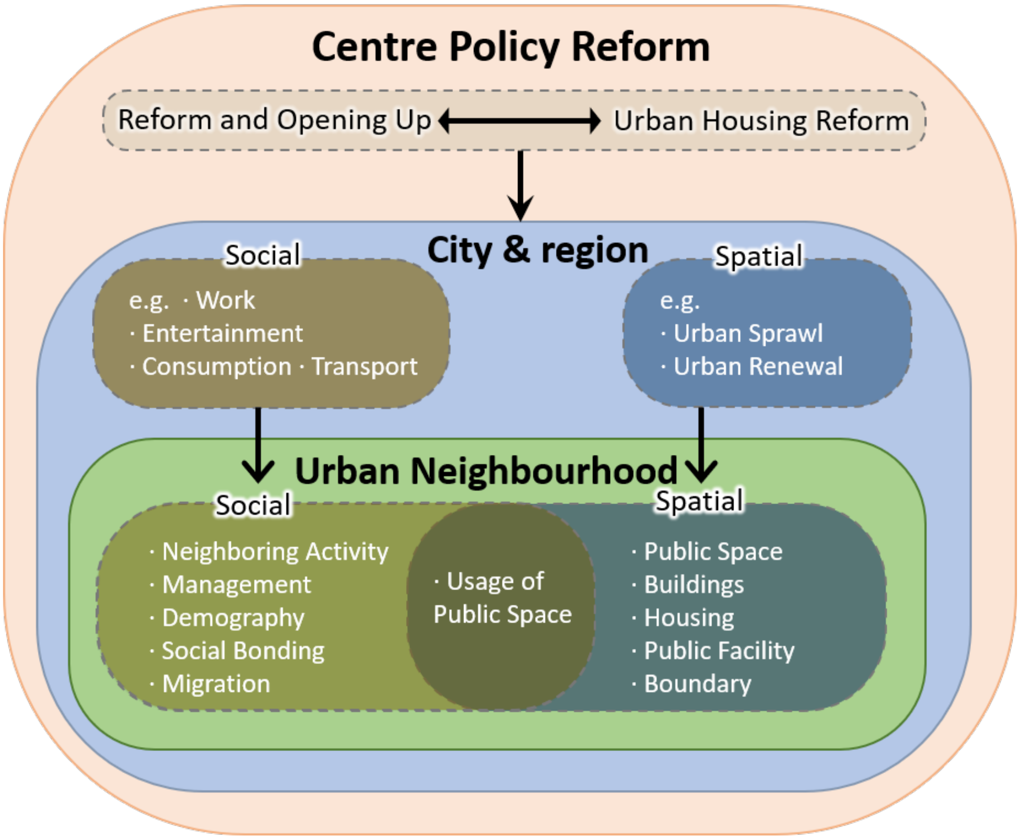


Figure 2.3: Frame of Socio-Spatial Changes: elements and impact transmission at different levels

In summary, this socio-spatial changes framework provide certain specificity that help to properly understand dynamics of urban neighbourhood transformation. Based on this, our study argues that in the case of cities experiencing rapid urban transformations, such socio-spatial changes help unravel the specific details of evolution of urban neighbourhoods and to respond in a manner that capture the dynamics especially against socio-spatial discontinuities.

2.8 Urban Commercial Distribution Sensing and Deep Learning

In the early stage, most of the urban business distribution researches are discussing the patterns of urban commercial distribution based on modernist urban planning ideas (Cox Jr, 1969; Davies, 1972). Later, with the standardization and dataization of urban management, there are studies based on regional statistical data with maps(ITOH, 1982), of which the methodology is advanced at that time. However, such research work is usually time-consuming and at low-precision, and not sufficient as a basis for specific construction and policy formulation.It is because that most of the data is counted in unit of single administrative districts, and the granularity is too large for practical reference. In recent years, with the growth of online map services, POI data has become a new raw data for urban spatial distribution research (Chezhi et al., 2019; Pujiang, 2018; Yang et al., 2019). These studies use POI data to perform detailed analysis of the distribution of commerce in different cities. Moreover, Yang, et al. (2019) also try to fix the problem that POI data could not match with the street network. In our study, we use Street View image based on street network to solve the problem of mismatch, and realize the sensing of commerce distribution base on the feelings of human vision.

Urban researches based on deep learning and Street View image have gained more and more attentions in recent years. Researchers used Street View images to study about the cities and communities as early as 2011 (Rundle et al., 2011). In this study, the artificial evaluation method is used to compare the similarity between street view photos and field surveys, and the feasibility of street view images for urban studies is studied. Generally, urban research has the characteristics of big data, high repetition, high similarity rate, and wide spatial range. Traditionally, a lot of field research need to be done as data source, and as a result, it is time-consuming and laborious to complete such work. Online big data and machine learning provide a tool for researchers to get rid of the massive repetitive works. With the improvement and maturity of machine learning technology, urban research scholars have begun to use deep learning for ultra-large-scale researches and other tasks that were difficult to achieve in the past. For example, Liu et al. (Liu et al., 2017) use the Street View images to research the building condition all across Beijing. They use the images that are perpendicular to the direction of the road as the research object, and then make their own data set and analyze it with the advanced DCNN model at the time. Moreover, Kang et al.(Kang et al., 2018) develope a building type discriminating technique, which is based on Street View images and remote sensing data, for urban analysis. Wang et al (Wang et al., 2019) comprehensively analyze a variety of data including Street View image, to study the impact of greening on residents' stress and health from a physiological-psychological-social multivariate perspective. In addition, the Long Ying team in Tsinghua University has been doing long-term urban researches based on big data. They use the Street View images to study Shanghai's green looking ratio by image color analysis based on HVS color mode (HAO and LONG, 2017), and also study the changes in street quality from 2003 to 2013 (Tang et al., 2016) by image semantic segmentation and change detection. In this study, we adopt a new method to realize the classification task that cannot be realized by previous research's method, and expand the application scenarios of big data and deep learning in the urban research field.

Chapter 3

Overview of Hefei City

Hefei city is the capital of Anhui Province. It located in the middle and lower reaches of the Yangtze River plain with flat terrain in its built-up area (Hefei Planning Bureau, 2013). Anhui Province is located in the eastern part of China, borders JiangSu province to the east, ZheJiang and Jiangxi province to the south, HuBei, HeNan, and Shandong to the west and north. While the city of Hefei locates in the middle of Anhui province, about 400 km to the west of the city of Shanghai (Figure 3.1). As of 2019, Hefei had a total area of 11,445.1 square kilometres, a resident population of 8,189,000 and an urbanisation rate of 76.33% (Hefei City Statistics Bureau, 2020).

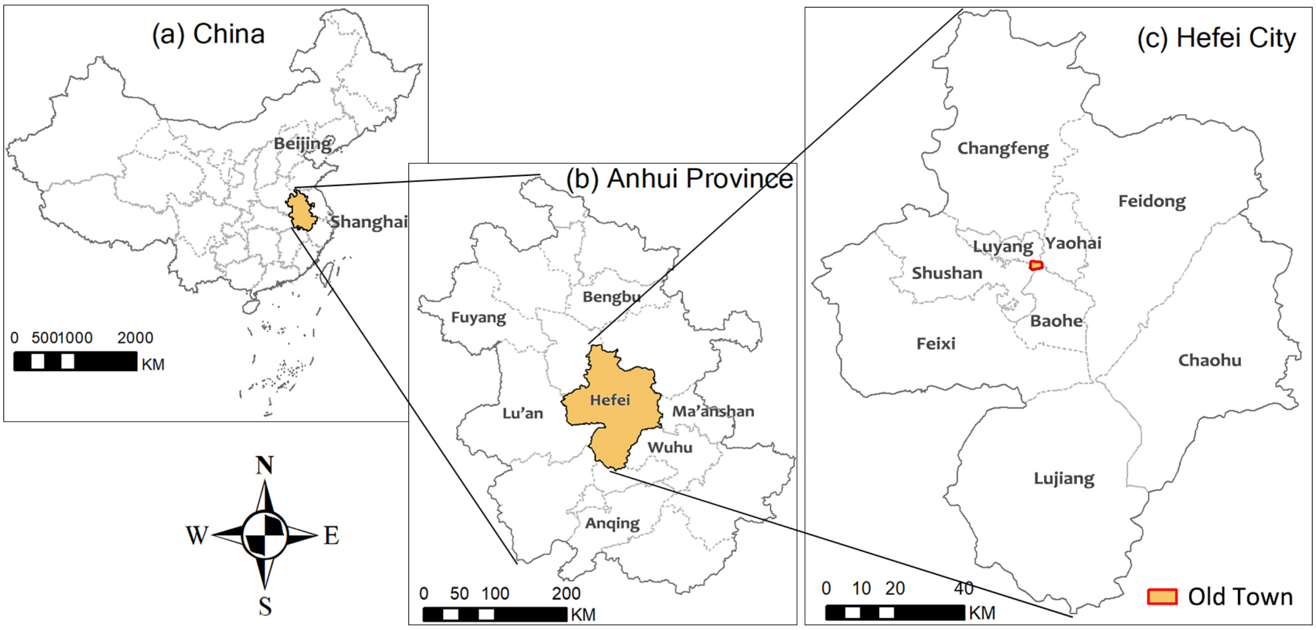


Figure 3.1: Location of Hefei City and its Old Town (data source: `mapbox.com`).

3.1 History Before 1949

Before the Eastern Zhou Dynasty (770BC-256BC), Hefei was only a small village; the Hefei county was set around Qin Dynasty (221BC-207BC) while the historic built-up area of that time was located about one kilometre northwest of the current Old Town area (Hefei Planning Bureau, 2013).

The city of Hefei has been destroyed and built for five times throughout history: (1) During the Three Kingdoms period (AD220-265), the new Hefei City was built for military purposes 15 km northwest of the present-day Old Town.

(2) During the Eastern Jin Dynasty (317-420) the city was destroyed and rebuilt in the southern half of the present-day Old Town in the fifth year of the Kaihuang reign of the Sui Dynasty (585).

(3) After that, the location of Hefei remained unchanged, with the boundaries gradually developing and expanding. During the Zhenguan period of the Tang Dynasty (627-649), the JinDou-city was built on the southern bank of the Inter River on the heights of Gangfu; During the Southern Song Dynasty (1127-1279), in order to defend against the invasion of the northerners, the city was expanded to the north and built as a 'Douliang City'. At that time, the city of Luzhou was high and firm, "surrounded by 26 li, with walls more than two zhang and eight chi high and a base more than 100 chi wide." This period formed the basis of the later Hefei City.

(4) The city walls were rebuilt in the twenty-eighth year of the Qianlong reign (1763), Qing Dynasty. The present-day Old Town was shaped.

(5) The city of Hefei was badly damaged during the wars up to 1949, and after the 1950s the walls were dismantled and the city modernised rapidly.

According to the *Hefei Local Gazetteers* (Hefei Local Gazetteers Compilation Committee, 1999), the population peaked before the foundation of the PRC (1949) was around 1,600,000 in the year 1820. Afterwards, the population dropped rapidly due to various wars and the overall recession of China. World War II and other civil wars particularly damaged the urban built-up areas and led to a decline in population to 69,015 residents in 1949 (Hefei Local Gazetteers Compilation Committee, 1999).

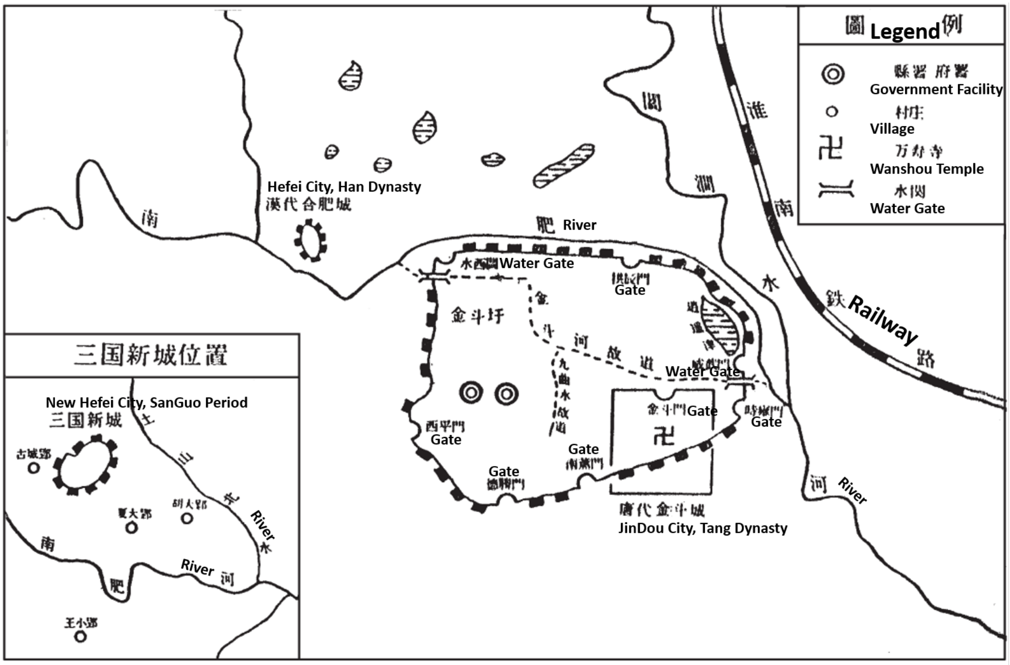


Figure 3.2: Hefei City in History (data source: Hefei Planning Bureau (2013) (Hefei Planning Bureau, 2013)

3.2 Development After 1949

Following the founding of the People's Republic of China, and especially after the city was designated as the capital of Anhui province in 1952, Hefei city has experienced a rapid development. In the early years of the PRC, the development of Hefei was concentrated in the old town and surrounding areas (Hefei Local Gazetteers Compilation Committee, 1999). The old town area mainly concentrates Danweis with functions such as government institutions, public services and commerce. Industrial production, universities, and other large-scale, resource-intensive, polluting Danweis were geographically situated outside the old town.

The population of Hefei has increased from 1.8 million in 1949 to 7.96 million in 2018 (National Bureau of Statistics, 2019). The dramatic data change between 2009 and 2010 was due to the merger of administrative divisions.

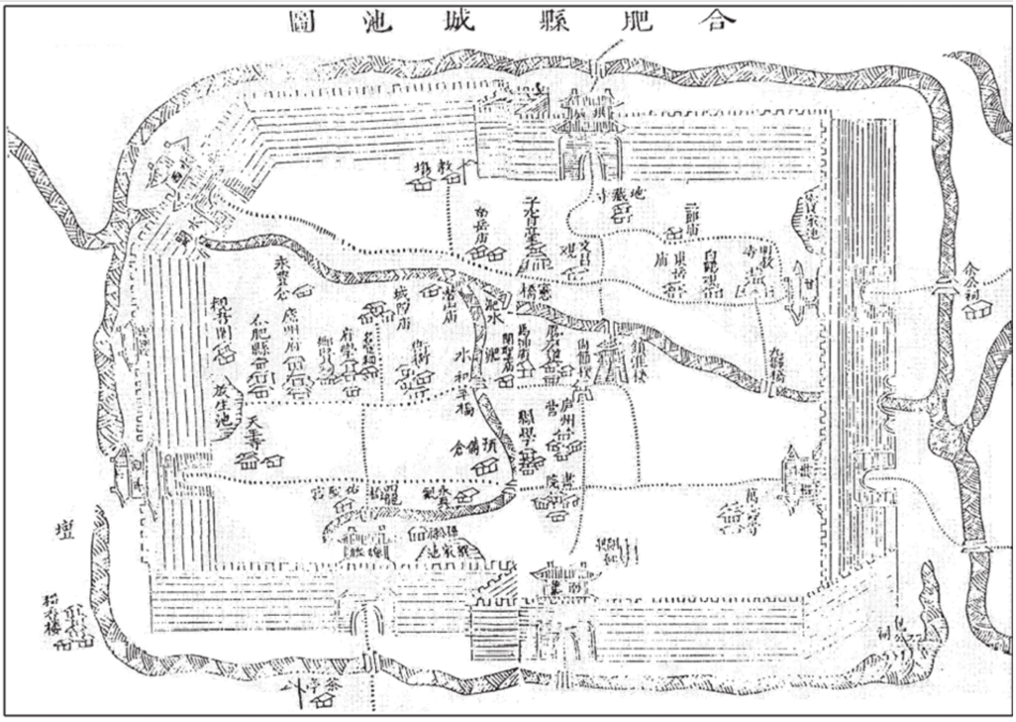


Figure 3.3: Hefei City in Qing Dynasty (data source: Hefei Planning Bureau (2013) (Hefei Planning Bureau, 2013)

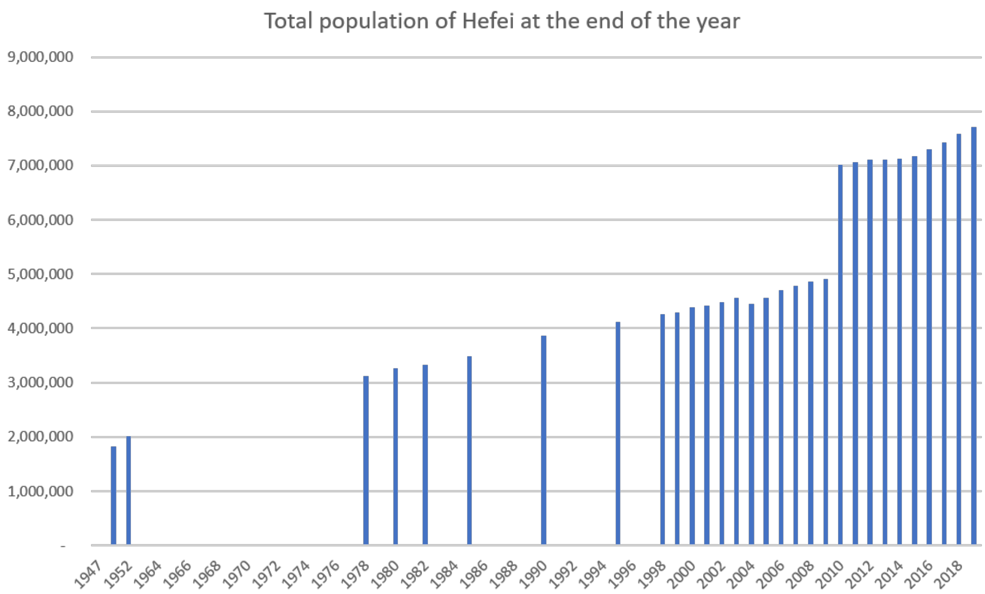


Figure 3.5: Population of Hefei (data source: Hefei Municipal Bureau of Statistics (2020); National Data (2020)

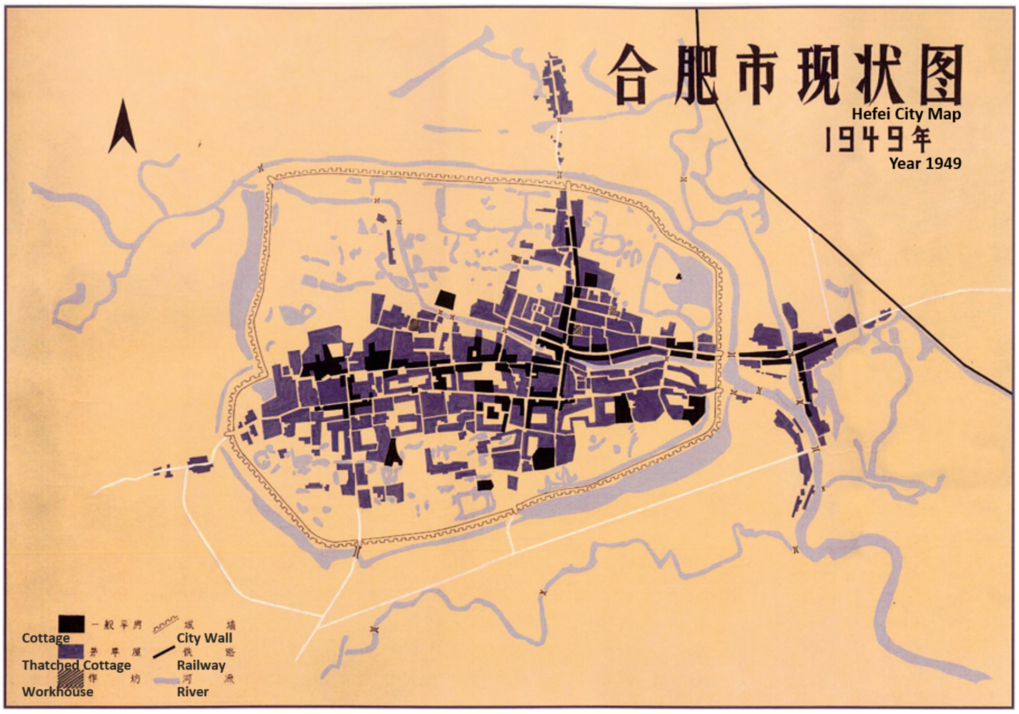


Figure 3.4: Hefei City in 1949 (data source: Hefei Planning Bureau (2013) (Hefei Planning Bureau, 2013)

As the population grew, the urban area of Hefei also expanded, with the built-up area expanding from less than 2 square kilometres at the end of the war in 1947 to 480.5 square kilometres in 2019 (Figure 3.6), with the total length of roads growing from 6.9 kilometres in 1949 to 3,029.1 kilometres in 2019 (Figure 3.7). Economically, Hefei's GDP has also increased. Due to a lack of statistics in the early days, data has only been available since 1978. The GDP of Hefei was 1.26 billion CNY in 1978 and 94.9 billion CNY in 2019 (Figure 3.8).

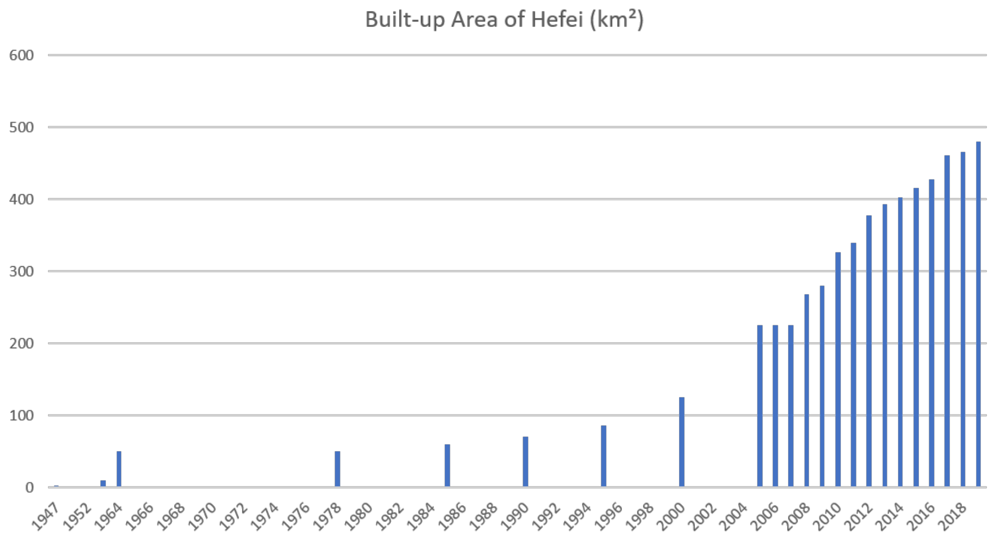


Figure 3.6: Build-up Area of Hefei (data source: Hefei Municipal Bureau of Statistics (2020); National Data (2020)

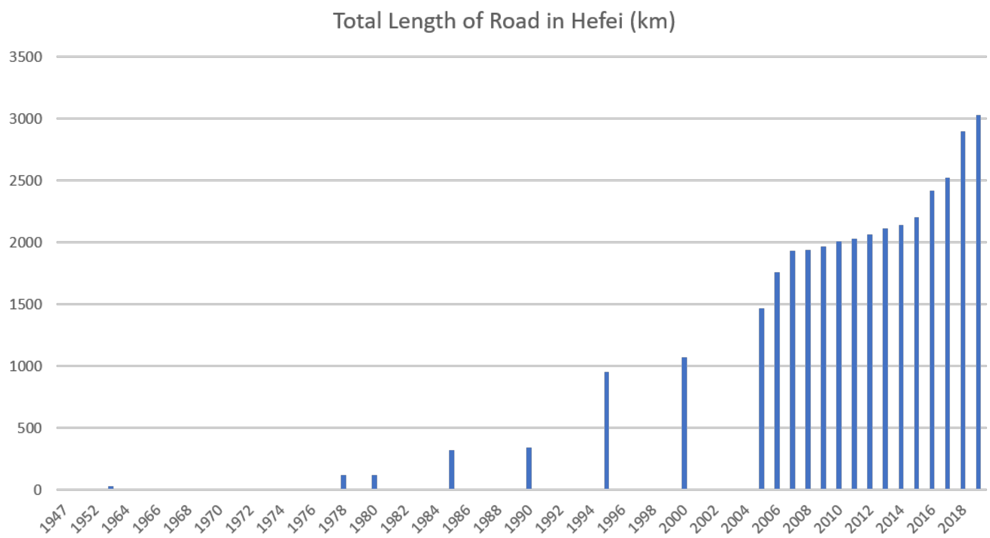


Figure 3.7: Total Road Length of Hefei (data source: Hefei Municipal Bureau of Statistics (2020); National Data (2020)

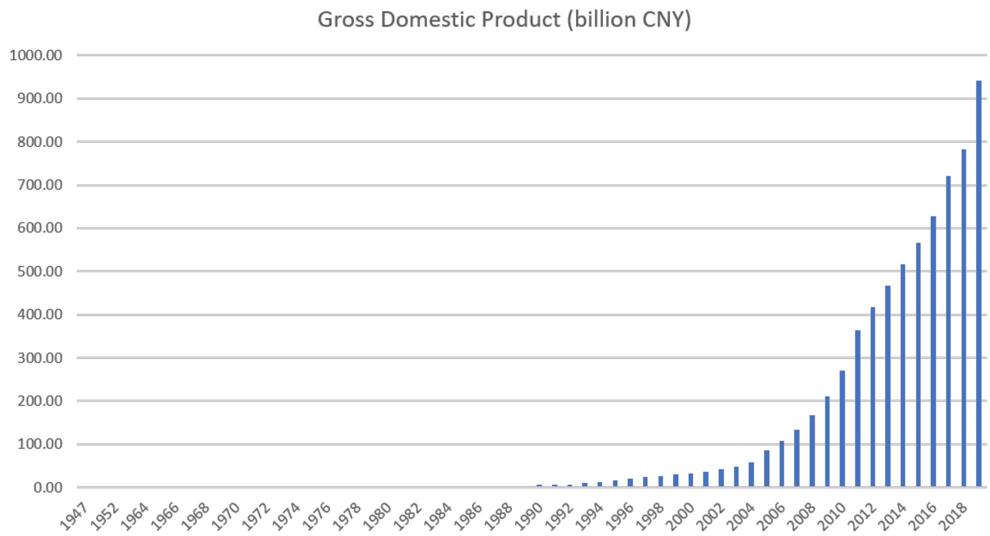


Figure 3.8: GDP of Hefei (data source: Hefei Municipal Bureau of Statistics (2020); National Data (2020)

3.3 Urban Planning of Hefei City

In the early days, construction and planning in Hefei was concentrated around the old town, and this remained the case until 1996 (Figure 3.9, 3.10,3.11), when the city's land use plan was formulated for the period until 2020 (Figure 3.12). However, with the rapid development of the city, as can be seen from the Urban Land Use Map 2010 (Figure 3.13), the city has grown far beyond the scope of the 1996 version of the plan. Prior to the introduction of the next planning scheme, the city had developed wildly without the guidance of a master plan, resulting in a disruption of all types of urban functions, including transportation. As a result, the new plan made in 2006 has greatly expanded the city boundaries (Figure 3.14). The satellite photos of 2021 (Figure 3.15) show that the construction of Hefei in the recent years has largely followed the above plan.

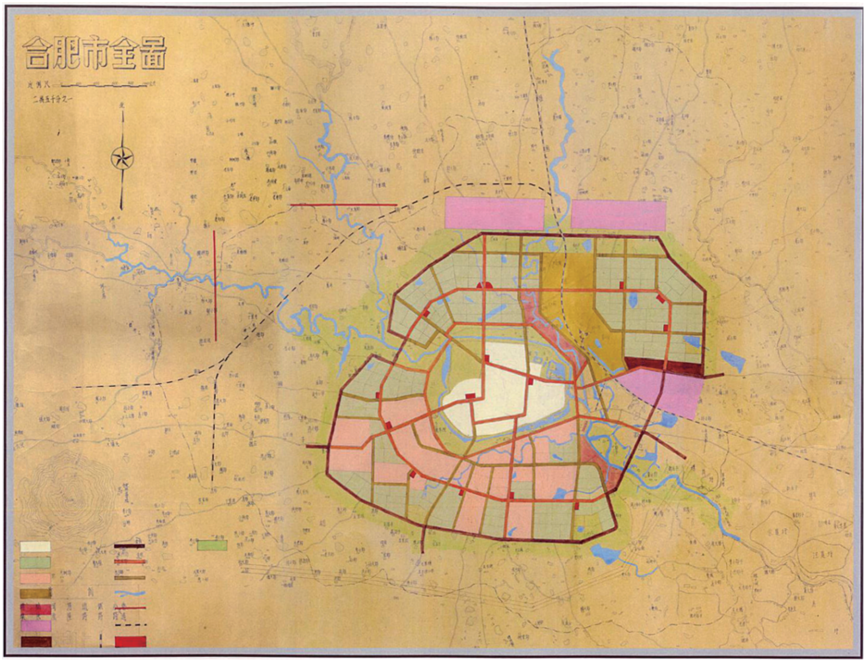


Figure 3.9: Hefei Master Plan 1957 (data source: Hefei Planning Bureau (2013))

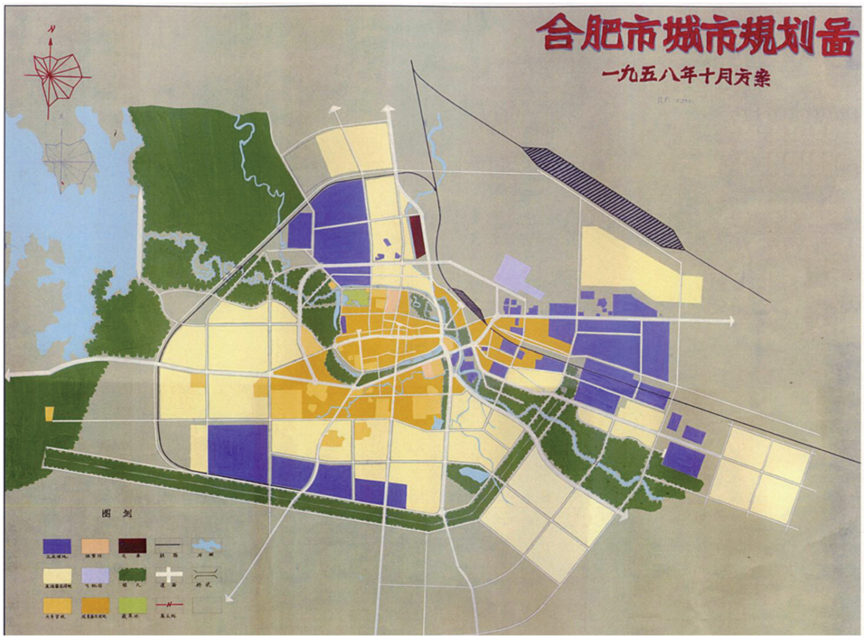


Figure 3.10: Hefei Land Use Plan 1958 (data source: Hefei Planning Bureau (2013))

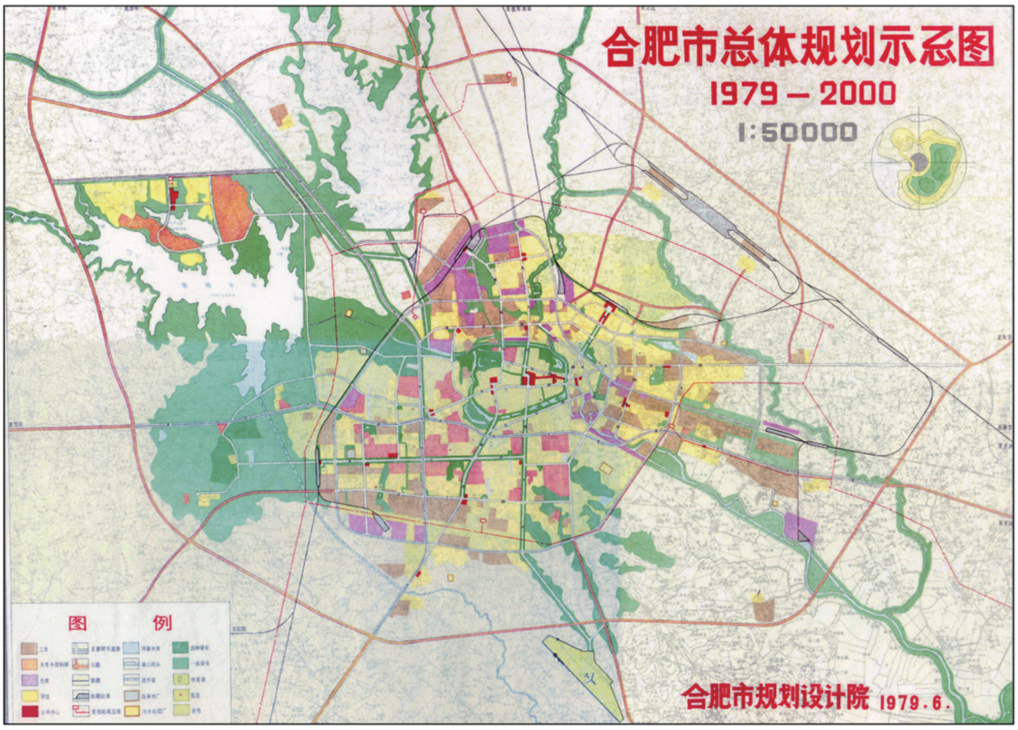


Figure 3.11: Hefei Master Plan 1979-2000 (data source: Hefei Planning Bureau (2013))

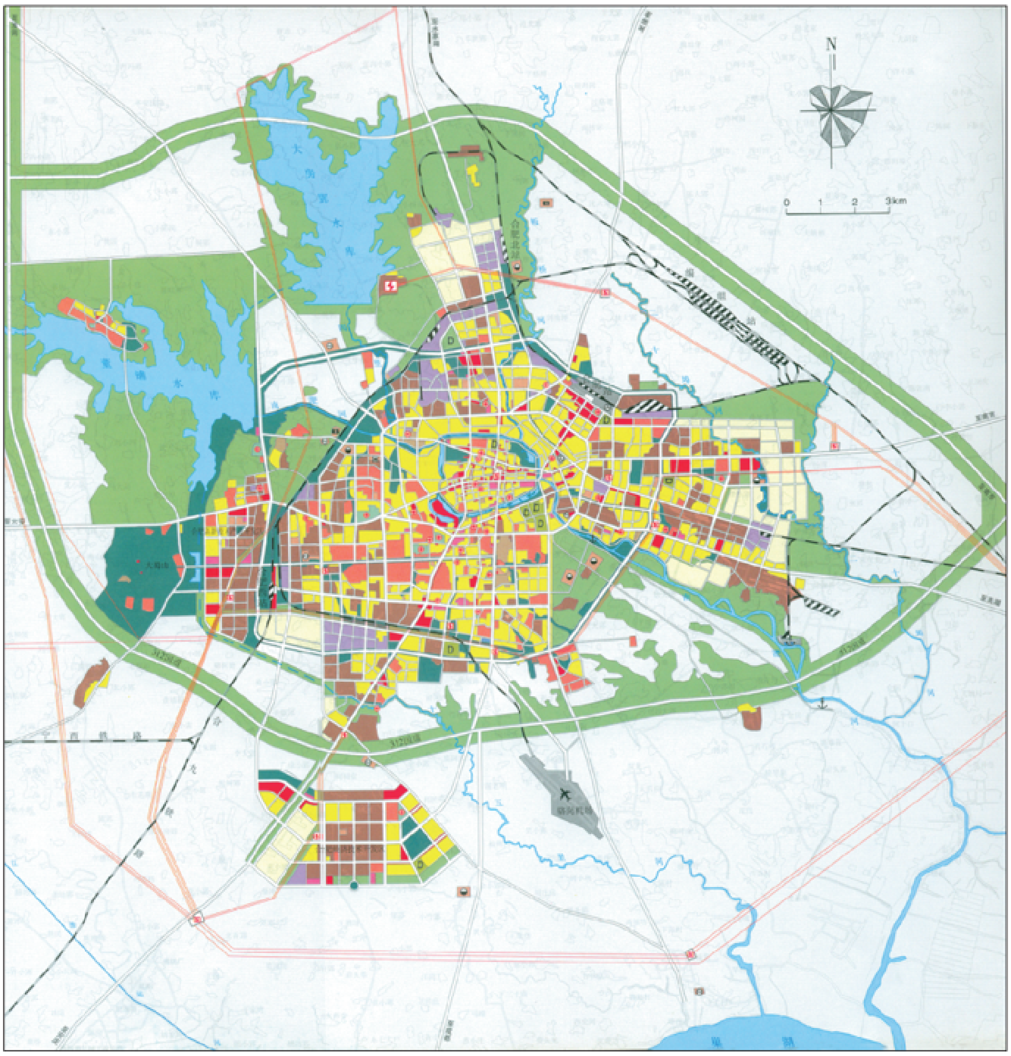


Figure 3.12: Hefei Land Use Plan 1995-2010 (data source: Hefei Planning Bureau (2013))

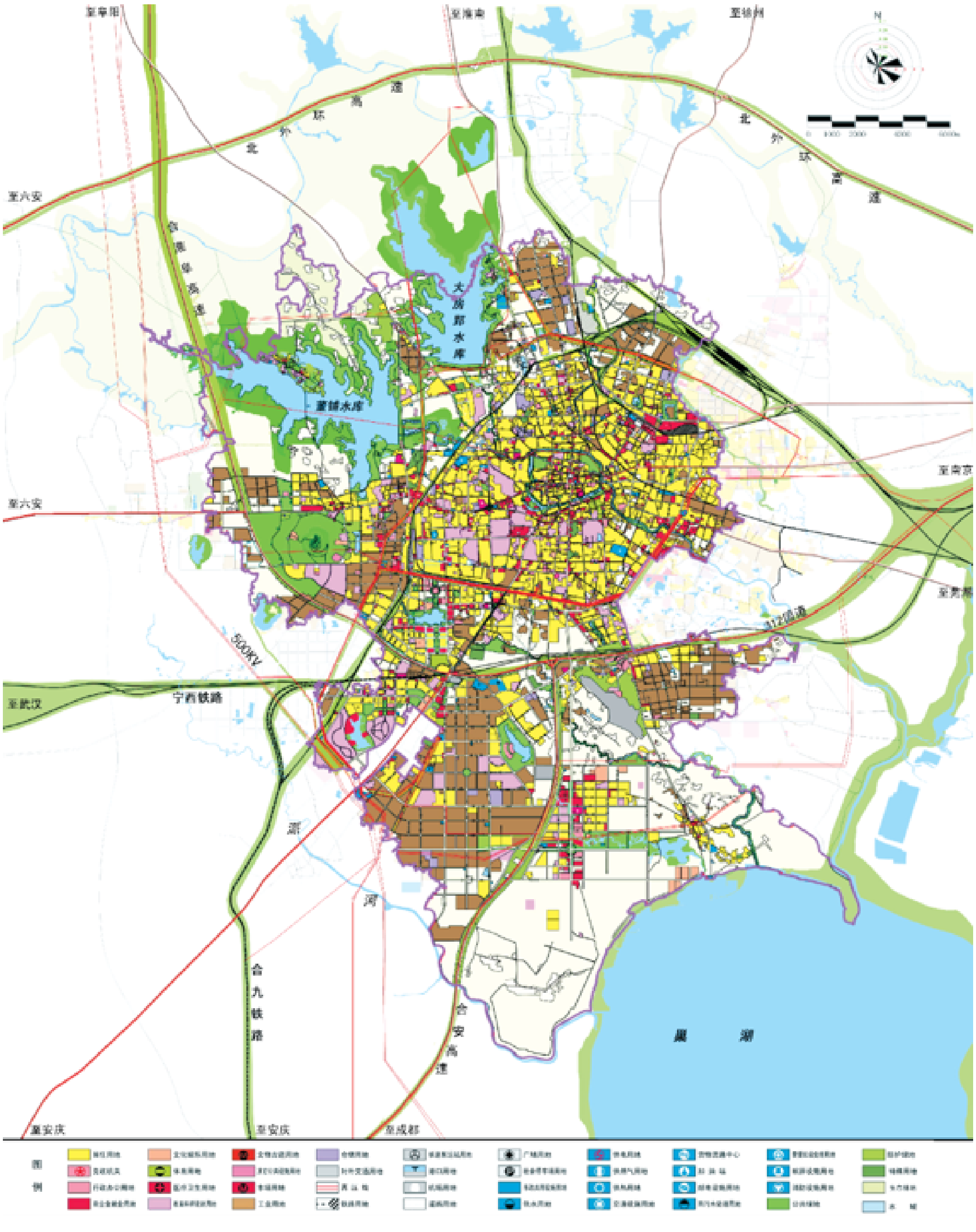


Figure 3.13: Hefei Land Status Map 2010 (data source: Hefei Planning Bureau (2013))

Figure 3.14: Hefei Land Use Plan 2011-2020 (data source: Hefei Planning Bureau (2013))

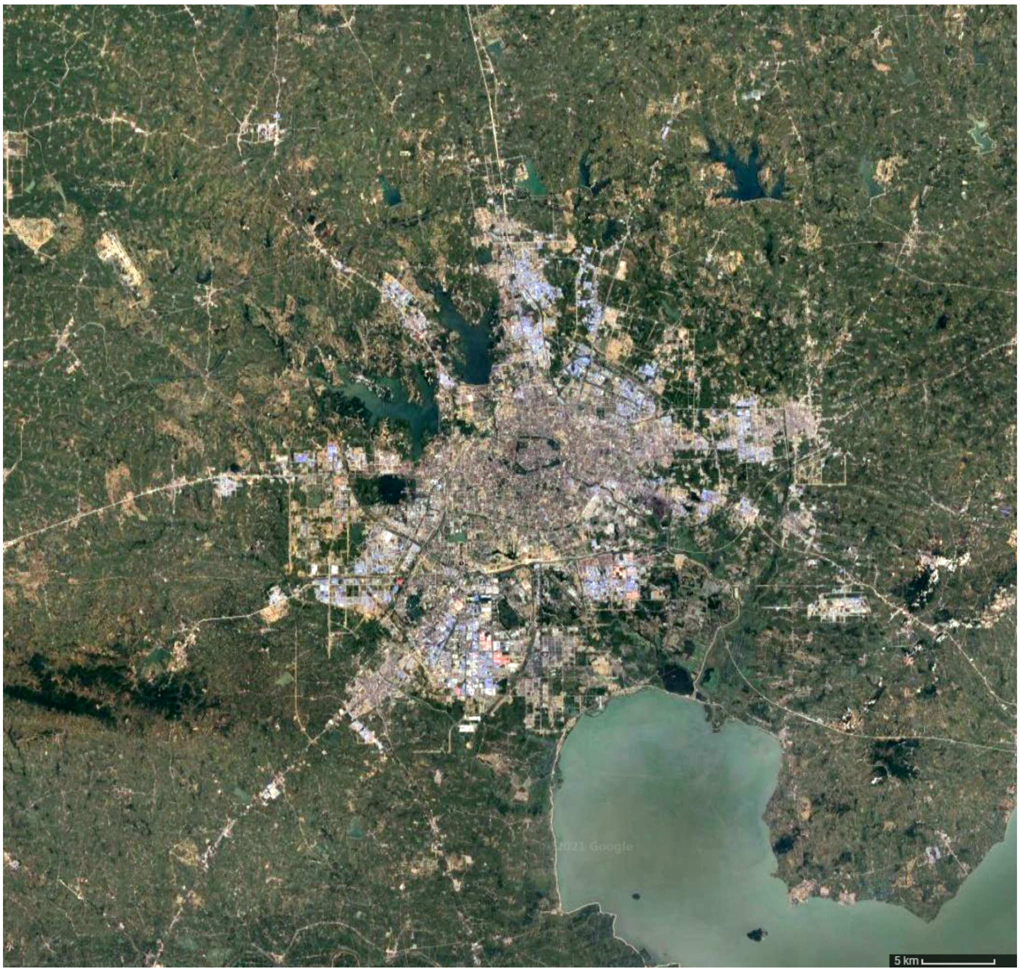


Figure 3.15: Hefei Satellite (data source: Google.com (2021))

3.4 Hefei Old Town and AMS Danwei Compound

The Hefei old town is located within the Huancheng Park, which was built above the remains of the old city walls, and covers an area of 5.9 square kilometres (Figure 3.16). It had been the core of the city's mono-nuclear structure. The old town area mainly contained Danweis with functions such as government and related public agencies, public services and commerce. Industrial production, universities, and other large-scale, resource-intensive or polluting Danweis are mostly arranged outside the old town. Now, the old town mainly comprises commercial, public services, residential and office functions. To present a pictorial perception of the study area, Figure 3.17 provides photographs of the neighbourhoods, public facilities and cityscape of the Hefei old town.

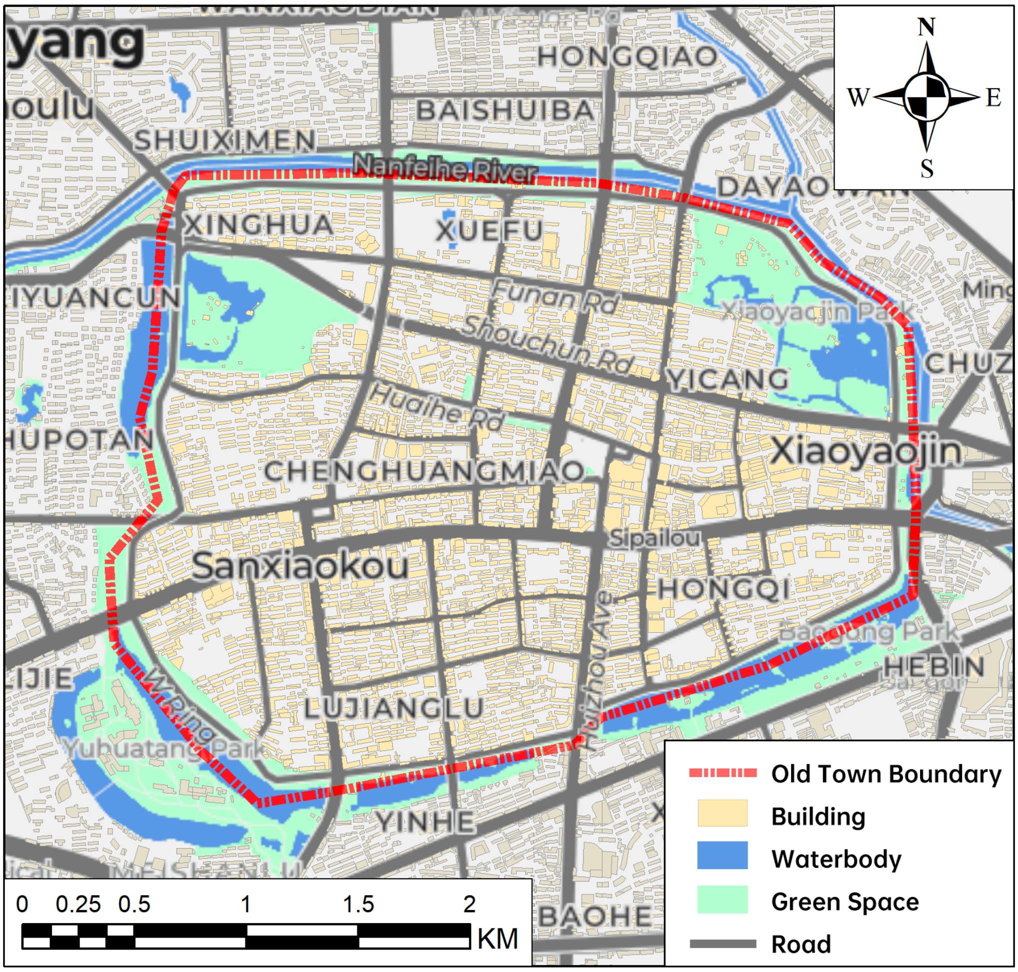


Figure 3.16: Map of Hefei Old Town (Data Source: Mapbox.com, Amap.com)

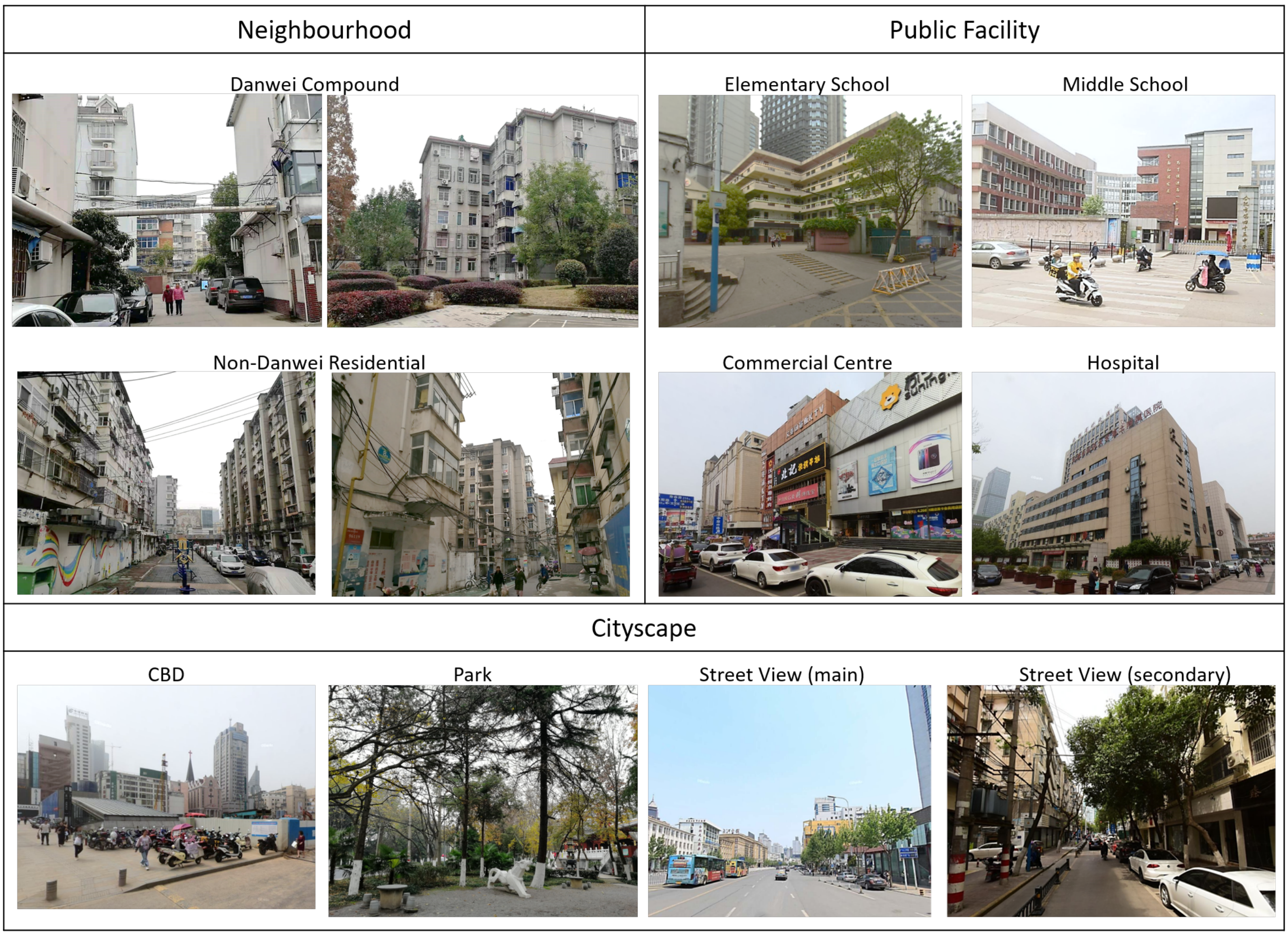


Figure 3.17: Photos of Hefei Old Town (Photo Source: By the Author, Baidu Map (Baidu.com))

The AMS Danwei compound is located in the southwest part of the Old Town Area of Hefei city (Figure 3.18). This compound has an area of about 34,500 square meters (in 2018) and around 900 residents. It has a university to the east, a high school to the north and a large water body to the south and west. As shown in Figure 3.18, the area is also not far from everyday facilities such as shopping streets. This compound contains several Danweis in the public health system. The leading Danwei in this compound was the Centre for Disease Control and Prevention (CDC) of Anhui Province before 1980. At present, the biggest Danwei in the compound is the Anhui Academy of Medical Science, subsequently referred to as the AMS compound in this study. For convenience, all Danweis in the current AMS compound will be referred to in this study as AMS Danweis. To present a pictorial perception of the study area, Figure 3.19 provides photographs of the public spaces of the AMS compound.

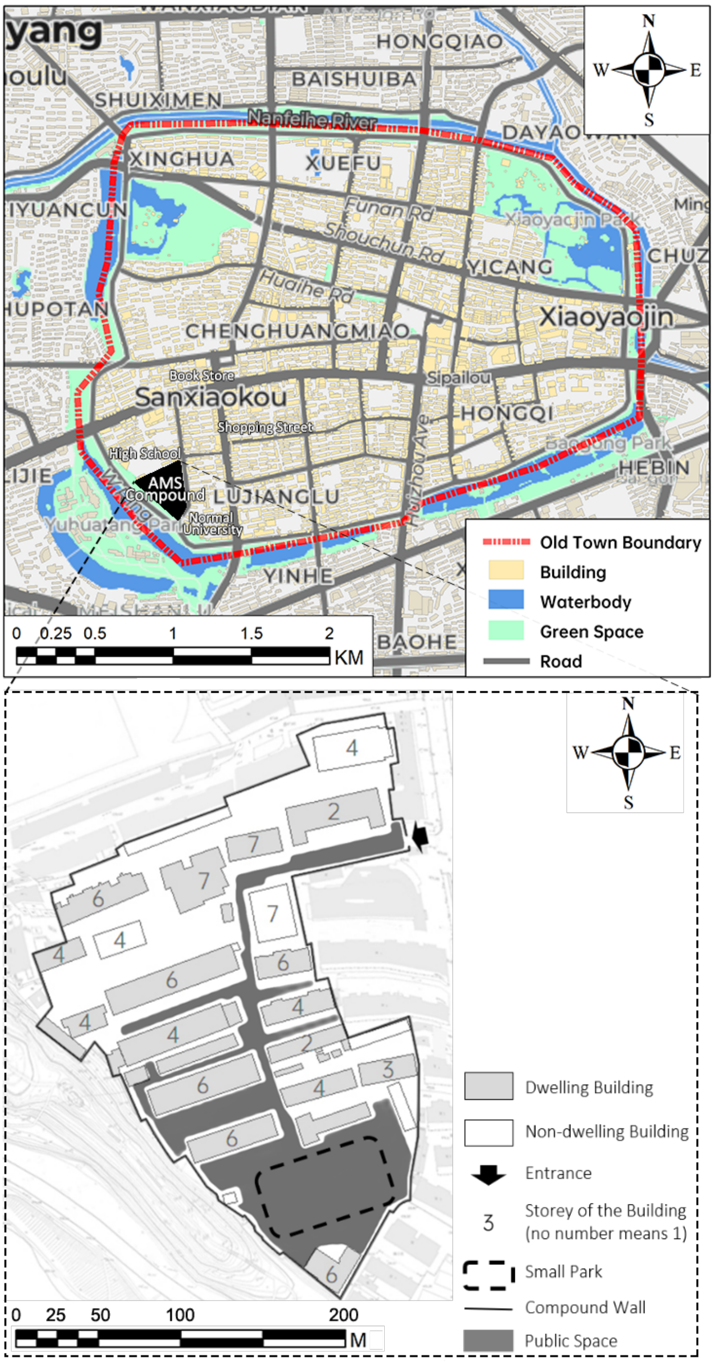


Figure 3.18: Map of Hefei Old Town and the AMS Danwei compound

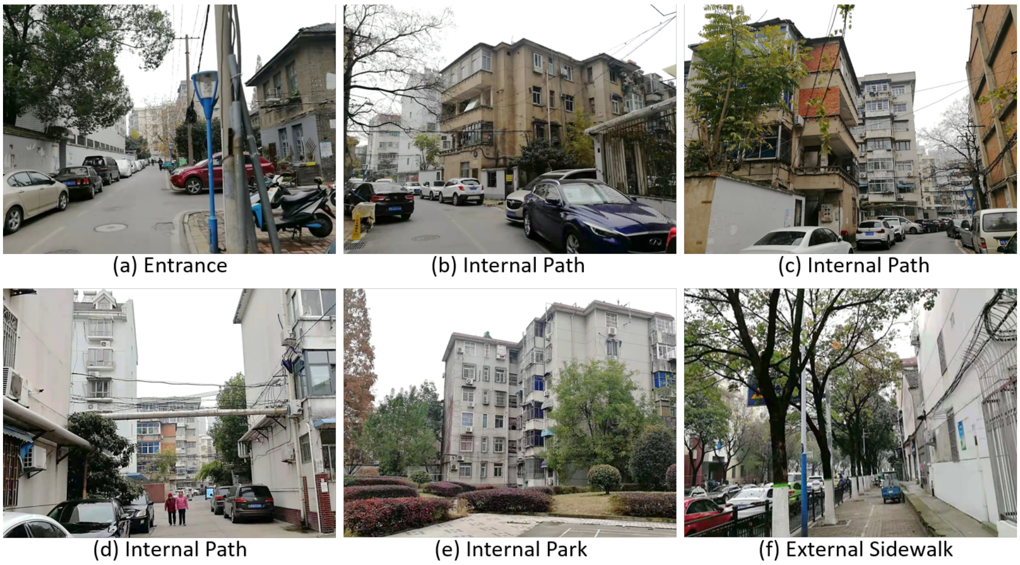


Figure 3.19: Photos of the AMS Compound

Chapter 4

Research Methodology

4.1 Literature Review

4.1.1 Literature Source

The literature used and referenced in this study was obtained from different resources. Firstly, literature about Danwei in Chinese language was reviewed. Baidu Scholar (xueshu.baidu.com), CNKI (cnki.net) and other platforms were used as search tools, and physical book resources from libraries in China were used in the field. From these literature, the social background, development history and spatial pattern of the Danwei system were understood. Through these documents, literature on theories related to local communities, economic crisis, social reform and economic development in China were searched and researched. Secondly, Google Scholar, web of science and other platforms were used to search for Danwei related researches, to understand the current status of international academical view on Danwei. Thus research gaps that can be further investigated were identified. Thirdly, literature of Hefei city was read to get the overview of the research target. Fourthly, literature about the methods planned to be used was reviewed to make the following methodology structure of the research. Mainly include spatial distribution, socio-spatial changes, and neural networks.

4.1.2 Grey Literature

To obtain detailed background information of Hefei city, some grey literature was reviewed. For example, historical statistical data of Hefei city, e.g. population and GDP, was collected from National Data website (National Data, 2020) and Hefei City Statistical Yearbooks (Hefei Municipal Bureau of Statistics, 2020).

4.2 Case Study

In the field of urban study, case study has been a basic method. Case studies are naturally used extensively in urban studies in order to study urban phenomena and to test theories, and since the urban discipline is a practice-oriented discipline, the cases used in research are projections of the theories in the real world. It can even be argued that urban research can only be conducted in conjunction with case studies. For this study, Hefei city was chosen as the main case. Specifically, the old town area of Hefei was chosen to study the spatial distribution of Danwei compounds and their accessibility to public facilities; the Academy of Medical Science Danwei compound in the old town area of Hefei was chosen to study the socio-spatial changes; the built-up area of Hefei was chosen to study the sensory approach to the distribution of commercial facilities, while Nanjing and Shanghai were used as reference cases.

Hefei was selected as the research target area due to the following reasons: (1) it was severely damaged during the wars, the current city of Hefei was built from scratch after 1949, which means that its urban development process coincides with the development of Danwei system and Danwei compounds. In other words, most of the urban neighbourhood in Hefei old town were Danwei compounds, which makes it a suitable case for the study; and (2) Although older with stable boundaries for over 800 years, most developments in the city were emerged from the old area after 1949.

4.3 Methodology in Chapter 5

Chapter 5 examines the spatial distribution of Danwei compounds in the Hefei old town using pedestrian sheds of public facilities as the basis of the analysis. It addresses the research question: (1) what is the current spatial distribution of the Danwei compounds in Hefei old city? and (2) what spatial features differ between the Danwei compound and other residential sites?

In order to answer the first research question, a quantitative study of the distribution and location status of the Danwei compounds in the old town of Hefei was conducted. Raw data was collected from current land use map, Open Street Map API, Amap.com API and a previous study of the authors. Spatial analysis of mapping, plot ratio and building density, and pedestrian shed analysis was done in ArcGIS software. Further statistical analysis was done in IBM SPSS software (version 22). To answer the second question, non-Danwei residential sites were used as a control group against the Danwei compound.

The term Non-Danwei residential site, as used in this study, refers to all residential sites in the old town except the Danwei compounds. It includes social housing neighbourhoods formed before the 1997 reform and real estate sites built after the 1997 reform. The word site is therefore used to refer to "Danwei compound" and "Non-Danwei residential site". A site's "type" will be used to refer to whether it is a "Danwei compound" or "Non-Danwei residential".

For the research propose, the workflow was separated into three stages of data collection, data processing and data analysis (Figure 4.1). From the above mentioned data sources, four main categories of geo-spatial information of Hefei old town and surrounding area was collected. They are urban land use conditions, road network conditions, location of public facilities, and building conditions. All the raw data was then processed to fit the need for data analysis. Additionally, spatial analysis of pedestrian shed of public facilities, plot ratio and building density of each Danwei compound and non-Danwei residential sites were done in ArcGIS software. The accessibility analyses of sites to public facilities, land occupation, plot ratio, building density of each Danwei compounds and non-Danwei residential sites were recorded. The recorded data was collated and analysed in IBM SPSS software using descriptive statistics and binary logistic regression.

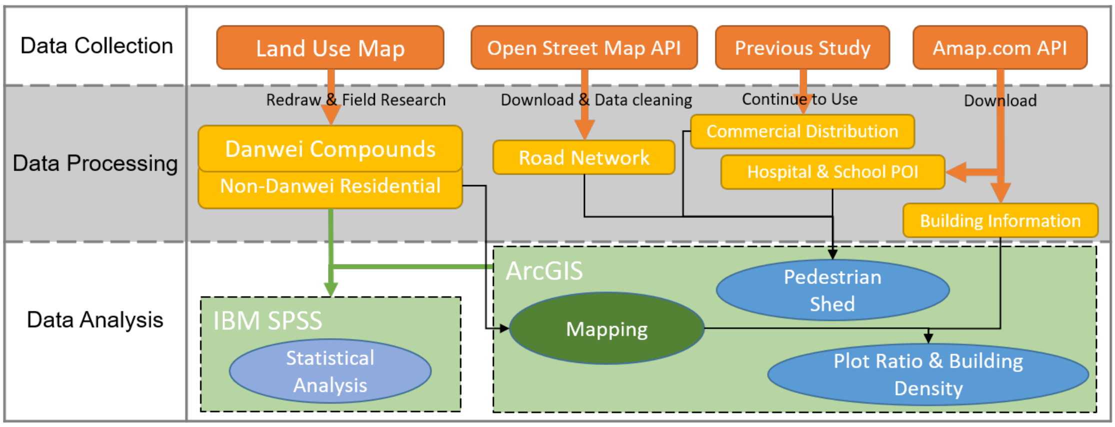


Figure 4.1: Chapter 5's Workflow

4.3.1 Data Collection and Processing

Four kinds of data were collected and processed. First, the current land use map of the old town area of Hefei, which was provided by the Hefei City Planning

Bureau. A digital map was processed from this data. Due to the limited amount of information on the map, a field visit was undertaken in the old town area in August 2018 to manually marked all the residential sites by type: Danwei compounds and non-Danwei residential units. The distinction between Danwei compounds and non-Danwei residential sites were identified from the land use map the names of most sites. Typically, the name of a Danwei compound is attached to a public Bureau, company, or institution (e.g. Anhui Academy of Medical Science Compound, Hefei City Government Compound) while non-Danwei residential sites are generally identified by their names in addition to the common suffix new village (新村) or community (街道or小区) (e.g. Guangming New Village/Xiaoyaojing Community) or even no identifiable name. To check for accuracy, local residents residing in those areas were interviewed to confirm the classification.

Second, the road network map of Hefei was collected from the open street map website API. The data was imported into ArcGIS and cleaned to remove irrelevant information.

Third, data on commercial centres, schools and hospitals were selected as the referencing facilities. Hefei city commercial distribution data was obtained from a study by the first author (Ye et al., 2019) and is present later as Chapter 7. The distribution data of schools and hospitals was obtained by Point-of-interest (POI) data from the Amap.com API. POI refers to a specific point location that a person may find in online maps, which often include schools, stores, museums, hotels and so on (Ren et al., 2017b). In this study, only the POI data of schools and hospitals was used. For schools, elementary schools and middle schools were selected and processed separately. All the position data of public facilities was imported into ArcGIS.

The fourth data was building information data. The Amap.com provides building data of each building with its location, outline and floor numbers. It therefore allows for the estimation of each building's foot area and floor area in ArcGIS.

Finally, to ensure the accuracy of the analysis and also meet the local authority's confidentiality restrictions on the use original maps received from the public entities, maps were redrawn and all data marked using the coordinate system provided by the open street map as the reference frame.

4.3.2 Data Analysis

Pedestrian Shed: Accessibility to Public Facilities

For the study purpose, the concept of Pedestrian Shed, also known as "5-minute walk", is used in this research to measure the accessibility to public facilities. It is the distance people are willing to walk before opting to drive. In recent years, it has become a commonly used method for accessibility analysis in urban road network analysis. Based on the average walking speed, a "5-minute walk" is represented by a radius measuring 1/4 of a mile or about 400 meters (City of Ventura Government, Sep 15, 2016; Morphocode, Nov 8, 2018). It is a benchmark often used in the field of urban research and city design (Mehaffy et al., 2010; Vale, 2015). Nonetheless, some studies also adopt a 10/15-minute walk (800/1200 meters) as the measure radius (Zhou and Xu, 2020).

For commercial facilities, only the most stringent metric of 5-minute Pedestrian Shed of the city commercial centres is used in this study to evaluate the sites for clarity and better differentiation. The rationale for this is due to the fact that old town of Hefei is the centre of the whole city, with an area of only 5.2 square kilometres, and consequently unsuitable for the 10/15 minutes benchmark walking (Ye et al., 2019). More so, Hefei city's urban retail sector is still underdeveloped, and a considerable part of the small businesses are individual grocery stores of low quality (Mao, Zhonggen and Lin, yanjin, 2017). Hence, city residents are more likely to go to large commercial centres for their daily shopping if they exist within walking distance. For schools, the elementary and middle schools are used for the pedestrian shed analysis separately. Moreover, all the hospitals are used for the pedestrian shed analysis. The focus on hospitals rather than low tier health facilities is due to the fact that, in China, there are few clinics and the major suppliers of health service are hospitals, even at local neighbourhood scale.

Further, Pedestrian Shed analysis was executed using the grid analysis function of ArcGIS, based on the position data of public facilities. We carried out separate Pedestrian Shed analysis for commercial, schools and hospitals based on the following four assumptions:

(1) the "5-minute walk" is used as the basic analysis unit for the Pedestrian Shed; (2) the average human walking speed is 80m/min, which translates into a 5-minute walking distance of 400m; (3) the roads are isotropic; (4) 4. the accessibility between the public facilities and the roads facing it is extremely

high.

After the Pedestrian Shed analysis, we marked each site with its accessibility to different kinds of public facilities. With reference and modification to the classification criteria of Lotfi et al. (Lotfi and Koohsari, 2009), the accessibility was measured in four levels of "Very Good, Good, Moderate and Poor". Because of the different coverage of different kinds of public facilities, these four levels were defined slightly differently for each kind of public facility to make the results clearer and differentiated. For school and hospital, the sites with most of its land inside the 5 minutes Pedestrian Shed will be marked as "Very Good", sites with most of its land inside the 5-10 minutes Pedestrian Shed will be marked as "Good", sites with most of its land inside the 10-15 minutes Pedestrian Shed will be marked as "Moderate", sites outside the 15 minutes Pedestrian Shed will be marked as "Poor". For commercial facilities, the sites with all of its land inside the 5 minutes Pedestrian Shed will be marked as "Very Good", sites with most of its land inside the 5 minutes Pedestrian Shed will be marked as "Good", sites with some of its land inside the 5 minutes Pedestrian Shed will be marked as "Moderate", sites outside the 5 minutes Pedestrian Shed will be marked as "Poor".

Statistical Analysis

Statistical analysis was undertaken using 6 key steps (Figure 4.2). First, the area of each site digital map prepared in ArcGIS with its own Calculate Geometry Attributes function. Second, by binding the previously prepared building information data to the sites in the digital map via ArcGIS' Spatial Join function, the total building foot area and total floor area of each site were obtained to calculate the plot ratio and building density of each. Third, site area, total building foot area, total floor area, plot ratio, building density and accessibility level to different kinds of public facilities were recorded. This data was further analysed in IBM SPSS. Fourth, basic statistical analysis of the site area, plot ratio, building density was recorded in addition to plotting box chart for all sites in IBM SPSS. Fifth, in order to study the similarities and differences between Danwei compounds and non-Danwei residential sites in terms of accessibility to public facilities, we cross-tabulated the type of site and its accessibility to public facilities by total site area, total floor area and count for all sites in IBM SPSS. Finally, a binary logistic regression was implemented in IBM SPSS, with the site type (Danwei compound or non-Danwei residential) as the dependent variable; while site area, plot ratio, building density and accessibility to commercial, hospitals, elementary and middle schools as covariates.

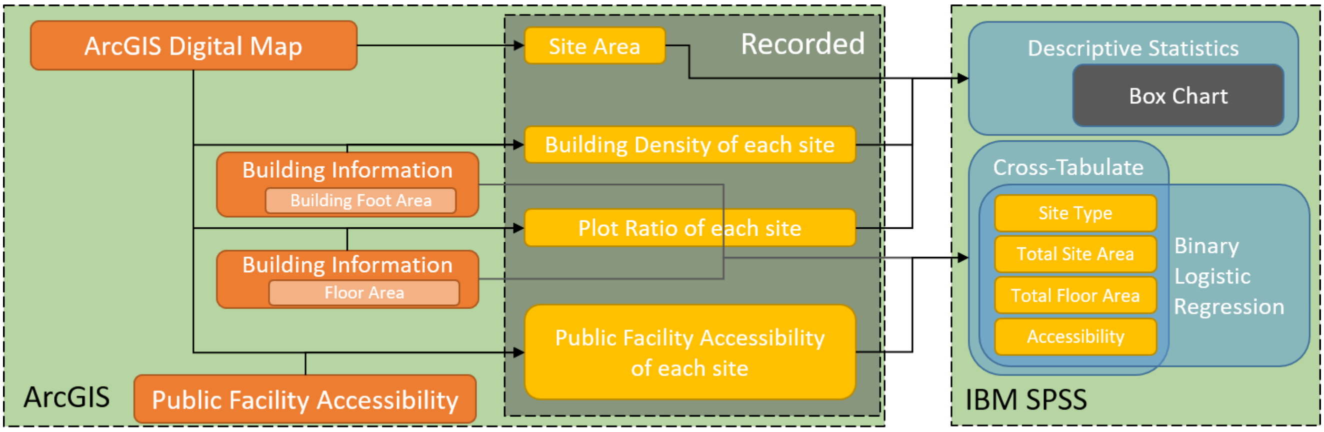


Figure 4.2: Statistical Analysis Flowchart

4.4 Methodology in Chapter 6

Chapter 6 focuses on the AMS Danwei compound to analyse socio-spatial changes before and after the two reforms. It addresses the research questions of: what are specific social and spatial changes in Danwei compound after the reforms. For this research question,both qualitative and quantitative content analysis were employed. As shown in Figure 4.3, a multi-method data collection approach was used to study the socio-spatial features of the AMS Danwei compound both before and after the reforms, for a comparison in a time domain. In this framework, (a) the changes in physical space, including public space and buildings, and (b) the management of the AMS compound, then (c) the changes in the residents' use of public space were described. Subsequently, combining the above results with the relevant literature, we tried to discuss the causes, mechanisms and impacts that produce the above changes. Finally, we discuss the planning and design measures that should be adopted in the transition period of such Danwei compounds.

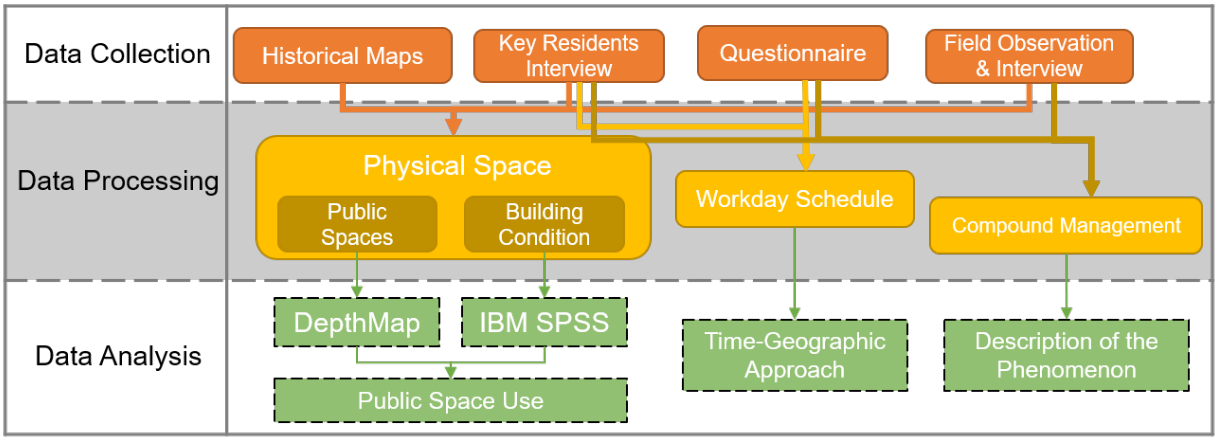


Figure 4.3: Chapter 6's Workflow

4.4.1 Data Collection

In order to achieve comparisons in a time domain, two main time frames were selected. The sampling time points for social related data were set for 'before the reforms' (before 1997) and 'after the reforms' (current situation). The reasons for using this time sampling is (i) the reforms lasted over a long period of time and it was until the Urban Housing reforms of 1997 that the effects became clear; and (ii) and the reliance on interviews for lack of objective data such as historical records. We therefore have to rely on key person interviews for past information, and it is difficult for individual memory to recall the conditions of the social context clearly. For pure spatial data, the sampling time points were set for 1961, 1975, 1987, 1999 and 2018 due to the availability of maps for these years. The data of 1961, 1975, 1987 are considered to be 'before the reforms', while 1999 and 2018 are considered to be 'after the reforms'.

In this study, socio-spatial changes are analysed from the perspective of both physical space changes and social life changes. Limited by publicly accessible data, four elements were selected. Buildings and public spaces were selected as spatial study aspects. In terms of social elements, management of the compound and the usage of public space were selected. Different data collection methods were used for different research aspects in different time periods (Table 4.1). The methods involved are described below.

Mapping: The original paper maps were sourced from the Hefei City Bureau of Geomatics gallery. The surveying and mapping years were obtained for 1961, 1975, 1987 and 1999. These maps are at a scale of 1:500 and show the

Table 4.1: Data Collection Methods for Different Research Aspects

Socio-Spatial Elements	**Before the Reforms**	**After the Reforms**
Public Spaces	KP, MA	MA, FO
Building Features	KP, MA	MA, FO
Usage of Public Spaces	KP, MA	MA, FO
Workday Schedule	KP	QN, FO
Compound Management	KP	FO

MA: Mapping. KR: Key Residents Interview.
FO: Field Observation

enclosure walls, the outlines of the buildings, the building storeys and the building materials. The authors redrew these maps in AutoCAD. The map of 2018 was drawn based on field research, satellite photos and the 1999 map. All the digital maps were imported into ArcGIS and DepthMap software for further analysis.

Key Residents Interview: The main informants were selected through a snow ball method. The first author contacted a retired employee (informant I) of the AMS Danwei compound who provided a list of six potential respondents for further interviews based on the criteria of the person being a long term resident of the AMS compound and very familiar with social and spatial aspects of the neighbourhood. After initial contacts, three of the six listed persons were available for interviews. Our final four key informants selected all have lived in the AMS Danwei compound for over 50 years, including a retired employee of one Danwei in the compound (informant I), a university professor (informant II), a government specially honoured architect (informant III) and a retired middle-level manager of one Danwei in the compound (informant IV). In all of the interviews with informants, the key persons were first shown maps of the compound from 1961, 1975, 1987 and 1999 obtained from the Hefei City Bureau of Geomatics and asked to recall and describe the areas based on the maps. Additionally, informants were asked to indicate on the map the location of social activities before the reforms. Generally, the interviews covered both social and spatial aspects such as building functions, public space usage, maintenance of public facilities and residents social life. The interviews were conducted face-to-face and lasted about one and a half hours on average. All interviews were conducted by the first author in Chinese and transcribed in English.

Given the historical nature of the informant interviews, we applied the descriptive validation to improve the credibility and validity of the responses (Byrne, 2001; Okumah et al., 2021). That is, all interviews were reviewed with a retired Danwei director (validator I), highly recognised an expert of the AMS Danwei compound. Any suggested in consistences in the responses were reported back to informants to clarify narratives and address any issues lapses in recollecting old events. Although such informal interviews on historical events can be subjective or constrained by romanticising of the past, studies show that they enrich the diversity of data sources and accord long-term residents as relevant sources of knowledge (Aptekar, 2017; Jeanneret Brith et al., 2021; Thomas, 2004).

Questionnaire: During May to August, 2018, face-to-face interviews were used to collect questionnaires in the AMS compound. A total of 104 valid questionnaires were collected. This accounts for about 10% of the total population of the AMS Danwei compound. The questionnaire included questions about basic personal information, social relationships within the compound, space and time information about daily activities, and perceptions of the AMS compound.

Field Observation: During May to August, 2018, observations of socially relevant activities and building/space features were conducted in the AMS compound. Transect walk method was chosen and implemented by the first author across the compound to observe the buildings, streets, public spaces and residents' activities. The observations were sometimes combined with incidental conversation with the garbage collectors, compound cleaners, public facility users, and commuters to and from work, which provided additional information about compound management and residents' attitude toward current AMS compound.

4.4.2 Data Processing and Analysis

The physical space of the AMS compound was mapped in the digital maps and marked by the information provided by Key Residents Interview and Field Observation. From the digital maps, basic information about the boundaries and the area of the compound could be easily obtained. Following this, the study highlighted the public space. The concept of 'Public Space' in this study includes common spaces, transportation spaces, greening, and some other open spaces in the AMS compound. The public space of the AMS compound was mapped in the digital maps. From the digital maps, it was easy to obtain basic information about the compound outline, area and other data.

For the further analysis of the public space, spatial syntax analysis was applied using DepthmapX software. As a method of quantitative spatial analysis, space syntax is able to highly relevant insights in the analysis of both long-term changes in urban space (Hallowell and Baran, 2020) and public space (Bendjedidi et al., 2019; Garau et al., 2020). The Visibility Graph Analysis approach in DepthmapX was chosen for the neighbourhood-scale public space analysis. A grid of 1x1 meter covering the whole compound was made as the basic analysis units. From the analysis result, three kinds of frequently used indicators were selected, including Visual Step Depth, which measures the visible depth of the cell from the entrance; Connectivity, which calculates the strength of the connection between all cells in the internal space; and Scatter Plot of different years, composed of Connectivity value and Metric Step Shortest-Path Length (a kind of Spatial Depth value, showing the length of the shortest path from the entrance to the cell), reflects the general character of the public space.

For the analysis of building features, the number of storeys, materials and functions of each building in each period was annotated in ArcGIS, based on the information provided by Key Residents Interview and Field Observation. Then, the area calculation function in ArcGIS was used to obtain the footprint area of each building, which allows for further calculations, such as floor area and compound plot ratio. The attribute tables in ArcGIS were then exported to IBM SPSS for descriptive statistics of the building related changes.

For the analysis of the household's workday daily schedule, a time-geographic approach was used to mark the time-space trajectories of the members of a typical core household during a typical workday. The pre-reforms data was obtained from the Key Residents Interview and the post-reforms data from the questionnaire.

In the analysis of the management of the compound, an attempt was made to locate the key actors, including initiators, funders, and participants. The Key Residents Interview as well as the Field Observation provided information on the pre/post-reforms periods respectively.

In addition to the above analysis, we also tried to reconstruct some of the patterns of residents' use of public space before and after the reforms, based on information obtained from the Key Residents Interview, mapping and Field Observation.

4.5 Methodology in Chapter 7

In order to accurately identify the spatial distribution of urban commercial areas needed in chapter 5, a neural network-based system for perceiving urban commercial areas was developed. The methodology is explained here and the result is shown as Chapter 7. The structrue of this system can be seen in Figure 4.4. The detail process in each section will be explained in the following section.

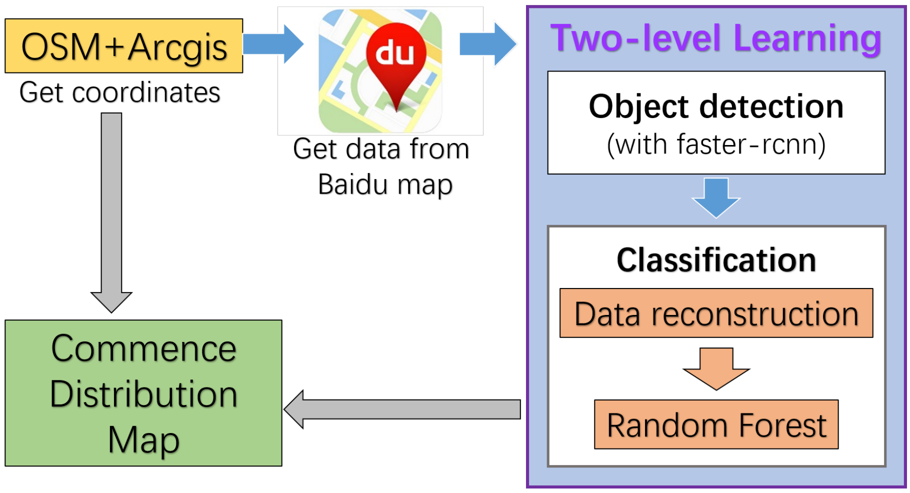


Figure 4.4: Work flow of Chapter 7

4.5.1 Street View image acquisition

The Street View image in this study came from the Baidu Map open platform (http://lbsyun.baidu.com/). We apply the following steps below to download the Street View image and create a dataset:

(1) The urban road network information are selected and obtained by using the rectangular frame within its scope through open street map (openstreetmap.org);

(2) The road network obtained in the previous step is sampled by the CreatePointsLines plugin of the ArcGIS software, and the density of sampling point is set to 20 meters. The coordinate of all sample points are saved;

(3) In order to get images perpendicular to the road, the angles of the road are calculated and the vertical directions (both left and right) of each sampling point are obtained.

(4) Downloaded 2 images (both left and right) through the Baidu Map API (viewing angle 90 degrees, picture size 800x500 pixels) for each sampling points;

(5) The points in the data retain the following information: the sequence number of the point; the sequence number of the street to which the point belongs; the geographic information coordinates of the point. Figure 4.5 demonstrate the

structural of the data recording.

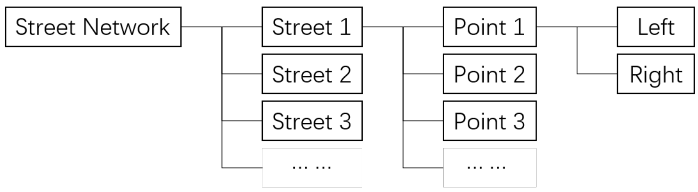


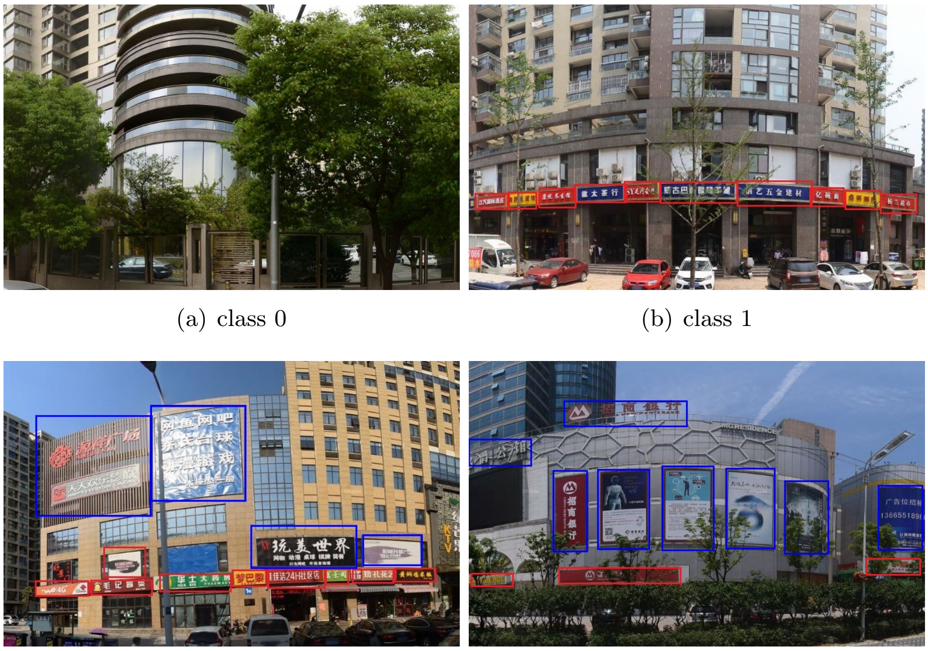
Figure 4.5: The structure of data recording.

4.5.2 Dataset

All the pictures are divided into four categories, and labeled as Class 0, 1, 2, 3 respectively. The following is the definition of these four types of images. (1) *Class 0*: The image with no commercial signage, which often indicates no commercial activities. (2) *Class 1*: The image of one storey small business. (3) *Class 2*: The image of medium scale multi-storey shops, which often indicates community centre. (4) *Class 3*: The image of shopping malls and other big shops, which often indicates city commercial centers (see Figure 4.6).

It should be noted that class 0 occupies about 70% among the total 400,000 images. So in the data selection, for the class 0, we selected some representative images (For example, street view without signages, underground passages, buildings without signage, large areas of greenery and sky in the field of vision, etc.). For the three categories with signage, the selected images cover the various districts of the city (not only in business districts). We selected 1638 Street View images captured by Baidu Map, manually marked the data through the standard above and named the dataset *'Streetscape datasets of Major Cities in the Pan-Yangtze River Delta region (SMCPY)'*. SMCPY included 500 images from class 0, 460 images form class 1, 400 images from class 2 and 278 images from class 3.

For object detection, we aim at searching for signages. The signages are classified into two categories, shop sign (a small signage directly above the entrance to the store) and signboard (a signage with a certain propaganda function that is usually higher than shop sign). (see Figure 4.6). We build a new data set named SMCPY-OD according to the format of PASCAL VOC. Then 1000 images which are not in SMCPY are selected and all the signages are manually marked (the total number of shop sign and signboard are 2917 and 1385 respectively).



(a) class 0 (b) class 1

(c) class 2 (d) class 3

Figure 4.6: Example of SMCPY and SMCPY-OD (With boxes contain signages. Blue boxes mean signboard and red mean shop sign.)

4.5.3 Object detection

The purpose of this step is to find the signages in each image. We observed that almost 100% of commercial establishments (shops, shopping centers, restaurants, hotels, etc.) have signages in their vicinity, and large commercial establishments often set up multiple signages. Although some non-commercial organizations also set signages, the number of these organizations is rather small. Therefore, our recognition target is the signages of commercial establishments. In this study, "signage" "signboard" and "shop sign" only refer to the signage of commercial establishments.

For the depth model of object detection, yolo(Redmon et al., 2016), ssd(Liu et al., 2016) and faster-RCNN(Ren et al., 2015) are commonly used. In this study, the detection object signages are of small size so the faster-RCNN is applied.

Network architecture

The VGG-16(Simonyan and Zisserman, 2014) model is adopted as the pre-training model for the network. As shown in Figure 4.7 an input image was processed by the convolution blocks (Conv1-Conv5) to produce feature maps. We remove the last pooling layers (pool5).

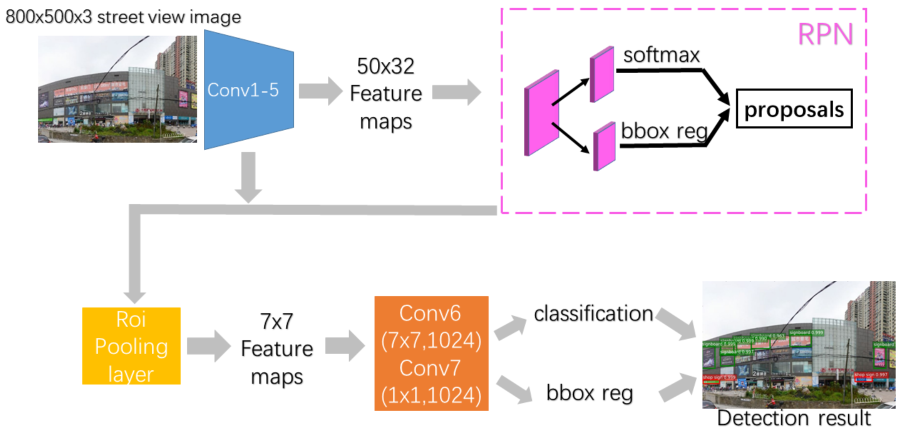


Figure 4.7: Flowchart of the signage detection algorithm.

The next part is a region proposal network(Ren et al., 2015) analyzing the feature maps and proposing candidate signages regions. It estimates the probability of signage/non-signage on a fixed set of anchors on each position of the feature maps. Meanwhile, the position and size of each anchor obtained by bounding box regression are fine-tuned. After investigating the sizes of the bounding-boxes for signage, we use three anchor scales (64,128,and 256) and three anchor ratios (1:2, 1:1, and 2:1) in this study.

The feature maps and the signage proposals are sent to a region of interest (Roi) pooling layer afterward, which will turn all feature maps in proposal into a fixed size (7X7 in this study). These feature maps are fed into two convolution layers, Conv6 and Conv7. We replace the 4096D fully-connected layers in original VGG-16. Conv6 consists of 1024 7x7 filters with zero padding and stride 1. Conv7 consists of 1024 1x1 filters with zero padding and stride 1. The 1024D feature vector in Conv7 are sent to two FC layers to predict the bounding box regression for further fine-tuning and the confidence scores for each signage proposal. Nonmaximum suppression (NMS)(Ren et al., 2015) is applied to the bounding boxes to decide the final predictions. The intersection-over-union (IoU) thresholds for NMS are 0.7 and 0.3 for training and testing, respectively.

Implementation details

We use the SMVPY-OD for training. 70% of the images are used for training, 10% of images are used for validation, and 20% of images are used for testing. The proposed algorithm is implemented using Keras(Chollet, 2015) with Tensorflow backend(Abadi et al., 2016) in Python 3.6. The weights in Conv1 to Conv5 are initialized with the ImageNet(Deng et al., 2009) pretrained VGG-16 model, and all the other layers are randomly initialized. Compared with the four-step strategy in the original faster-RCNN implementation, this end-to-end joint training is more efficient. Each mini-batch has two images. The number of region proposals per image for training is 128. We adopt the SGD and set the base learning rate to 0.001, and then reduced it a factor of 10 at 10000 iterations. The network executed total of 20000 iterations. During training, we also use data augment operations such as flip, pan, contrast adjustment, etc..

4.5.4 Image classification

Based on the object detection module, we got two types of boxes which contained the signages for each image. Due to the fact that Street View images of different roads are taken from different distances to the street facade. The images did not share the same field of vision. Some have small vision field because they are taken near the facade while some have large vision field when they are taken far away. Therefore the commercial condition of the street could not be shown simply by counting the number of boxes in the images. Additional information are necessary to classify the images.

Data reconstruction

In order to train the classifier, we need to convert the information of the boxes in each image into a fixed dimension. For one image, we record the information of shop sign and signboard respectively. We record the number and coordinate information of boxes, and calculate the mean, variance, and median of the boxes' width and height. For the image that no box is detected, all data will be recorded as 0. After this process, one image will be converted into a 23-dimension data.

Classification

SMCPY is used to train the classifier. Similarly, 70% of the images are used for training, 10% of images are used for validation, and 20% of images are used for testing. All the images are firstly processed with the faster-RCNN to produce the reconstracted data. And then, we try Random Forest (RF)(Liaw et al., 2002) and Xgboost(Chen and Guestrin, 2016) as classifier. We use sklearn to realize the program. For RF, we set 300 subtree, using information gain as critic and the max depth is 8. For Xgboost, the max depth is 5 and the objective function is softprob. Other values which are not indicated are default. Logistic Regression(LR)(Hosmer Jr et al., 2013) and SVM(Suykens and Vandewalle, 1999) are also tried but they do not get good results. We also set up a comparative experiment that directly uses DCNN (DenseNet and ResNet) for classification.

4.5.5 Heat map drawing

Kernel density analysis can effectively reflect the distribution and aggregation of points in space, and heat map is a commonly-used visual representation of kernel density analysis. All sampling point images are processed by the trained faster-RCNN and the classifier, in order to get its predict label. Then we use the coordinate information of the points saved in A section in Chapter III, and use the ArcGIS software to draw the urban commerce distribution heat map. The results of the analysis are presented in C section in Chapter IV.

$$f_h(x) = \frac{1}{n}\sum_{i=1}^{n} K_h(x - x_i) = \frac{1}{nh}\sum_{i=1}^{n} K(\frac{x - x_i}{h}) \tag{4.1}$$

For regular Kernel density analysis in function (1), K_h is the kernel function based on the quartic kernel function described by Silverman (Silverman, 2018). h is the bandwidth which has a big impact on the estimates obtained and mean intergrated squared error(Swanepoel, 1988) is usually used. n is the number of sample points.

$$Density = \frac{1}{(Radius)^2}\sum_{i=1}^{n}\left[\frac{3}{\pi}\cdot pop_i\left(1-\left(\frac{\text{dist}_i}{\text{Radius}}\right)^2\right)^2\right] \tag{4.2}$$

$$Radius = 0.9 * \min(SD, \sqrt{\frac{1}{\ln(2)}} * D_m) * n^{-0.2} \tag{4.3}$$

In this study, we used the Kernel density analysis method that is integrated in the ArcGIS software, the coefficients and details are slightly different. pop_i is the population field value of point I, which is an optional parameter. $dist_i$ is the distance between point i and the (x, y) location. D_m is the (weighted) median distance from (weighted) mean center. SD is the standard distance (Arcgis.com).

4.6 Limitation of the Study

In spite of the methodology design above, this study has some limitations. Although this study hopes to provide a comprehensive picture of the role and status of Danwei systems and Danwei compounds in urban planning and construction from different levels from macro to micro perspectives, it is limited by factors such as data collection, data analysis and other objective constraints to achieve these goals perfectly. Firstly, there are only a few cases used for the study. Thus there may be shortcomings in the coverage and persuasiveness of the conclusions. Secondly, the data sources are limited. Some data, such as specific demographic and detailed historical maps, are black literature and cannot be obtained. Meanwhile, due to limited research manpower and time, the amount of field work such as questionnaires, interviews and observations could only meet the basic analysis needs, resulting in a limited depth of the study. Finally, due to the covid-19 epidemic, it was not possible to conduct secondary research and add secondary content to the thesis. This prevented us from further refining the thesis. Below is the limitation in the specific research directions.

For Chapter 5 which studies the spatial distribution of Danwei compounds, three limitations could be identified. First, this study does not provide comparative historical analysis in line with the spatial distribution of Danwei compounds due to the unavailability of historical maps. Second, a comprehensive characterisation of the development and decline process of Danwei compound and Danwei system was not considered. Third, an improved evaluation of the spatial location of a residential site might consider the accessibility of various public services, including public transport and other facilities which could not be undertaken due to time and resource constraints.

For Chapter 6 which studies the socio-spatial changes of the AMS Danwei compound, limitations are: First, the restricted sample size of key person interviews is relatively small, and might not account for the general situation of the Danweis other than the AMS compound. Second, the object of this study is limited to the socio-spatial elements within a single Danwei compound, lacking comparisons with other compounds and non-Danwei settlements. Moreover, from a dialectical point of view, the findings of this chapter seem to indicate that the two reforms only had a negative impact on the Danwei compound. However, besides the socio-spatial environment inside the Danwei compounds, they had obvious positive effects on other aspects such as social economy, freedom of the people and indoor housing conditions.

Although the latest technology has been used and innovative methods such as two-step learning and multiple scenario comparison have been adopted to improve the accuracy rate, Chapter 7 still has many natural limitations concerning deep learning and street view images. For example, the limitation related to street view images includes but is not limited to: (1) the analysis results are limited by the clarity, accuracy and selling price of the images provided by the web map services; (2) in some special road sections (e.g. very narrow roads with a width of less than 3m) the view of street view images is too narrow to reflect the surrounding conditions; (3) the spatial location of the street view images is discrete and there is spacing between the sampling points, which leads to the inability to reflect street conditions in some extreme conditions (e.g. tree covered roads). In addition, the deep learning technique itself has a number of limitations, such as sample sensitivity, poor interpretability, the possibility of retraining and fluctuating accuracy when used in other cases, etc.

Chapter 5

Spatial Distribution of Danwei compounds in Hefei Old Town

5.1 Introduction

The urban neighbourhood constitutes the basic unit of the urban living environment, and critical focus on urban planning and policy initiatives in both the developed and emerging world (Cotterrell, 1997). In China, emphasis on the urban neighbourhood emerged at the beginning of the urbanisation process, particularly in the establishment and adoption of the "Danwei system". It is a unique community-level socio-spatial system which emerged after the founding of the People's Republic of China (PRC) in 1949 and developed during the early period of socialist construction (Tian, 2014).

The Danwei system, which originated in the middle of the 20th century, is a grassroots urban community structure with strong organisational and mobilisation capacity and administrative power (Chai et al., 2007). Generally, a "Danwei" could be understood as a publicly owned institution, e.g. a school, a hospital, a weather forecasting station, etc., while "Danwei system" is the social-political system built on the "Danweis" (Tian, 2014). Based on the "Danwei system", a number of "Danwei compounds" (also called "Danwei communities" or "Danwei compound communities") were established as the spatial unit of the Danwei system. Basically, "Danwei compound" refers to a compound enclosed of walls with one or several gates for access. The interior is often a mixed-use spatial environment of offices, dwelling and public facilities and hence, includes all the working, living, and relaxing spaces and facilities of a Danwei (WANG, 2010).

Danwei compounds dominated China's urban development when urban development was almost equivalent to the construction of new Danwei compounds before the 1980s (Li, 2016). It has been argued that the noticeable decline of the Danwei system occurred after the 1997 Urban Housing System reform (Chai, 2014), which permitted land transactions between legal persons, and housing transactions between natural/legal persons. Consequently, most of the new rural–urban migrants tended to live in other types of residential areas, such as real-estate housing and government-provided affordable housing (Zhang and Song, 2003). This urban spatial reconfiguration has meant that Danwei compounds have become purely residential while market-led development has been expanding old city boundaries and urban life beyond the walls of old neighbourhoods.

Given the above, a number of studies have been conducted to comprehend the process and its underpinnings. Within the broader context of urban studies, and specifically urban planning, a large number of studies on Danwei compounds has focused on historical analyses or case studies of individual Danweis (Li, 2016; Qiao, 2004; Zhang, 2004). Zhang (Zhang, 2004) analysed the historical process of the Danwei compounds' decline and found that the decline and decomposition of the compound is an inevitable consequence of social development. He suggested reorganisation of the Danwei compound in terms of improving the social security system, encouraging the subdivision of compounds by government fiscal policy and the marketisation of land. In another study, Qiao (Qiao, 2004) investigated the spatial design features and history of Danwei compounds in Beijing. His results indicated that the Danwei compounds still had a significant influence on the existing spatial structure of Chinese cities. More recently, Li (Li, 2016) focusing on spatial typology analysis illustrated the formation and link between Danwei compounds and the city of Nanchang.

While these studies provide useful understanding of the Danwei system and the spatial aspects of the urban living environment, there is still limited understanding on the current state of Danwei at the city level in terms of their spatial distribution and spatial features. Are Danwei's still a major component of the urban spatial configuration? Moreover, as the land and housing reforms triggered a boom in private real estate development, and associated public facilities, recent research has not engaged a comparison between the old Danwei's and new residential units in Chinese cities in terms of spatial characteristics. How do the old Danwei compounds compare with non-Danwei sites in terms of spatial features such as plot ratio, building density and access to public facilities? Underlying these two questions is the fact in the international scholarly literature, little is known of Danwei as part of China's urban system since most of the research outputs have been published in Chinese [see (Chai et al., 2007; Li, 2016; Qiao, 2004; Tian, 2014; WANG, 2010; Zhang, 2004) etc.]. Hence, quantitative and spatial research on the state quo of Danwei compounds, including studies on the current distribution of Danwei compounds is scarce, especially in English language. In the international scholarly literature, most of the discussions on Danwei system and Danwei compound are focused on political economy (Bian, 2005; Bray, 2005; Lü and Perry, 1997), and a few on urban spatial studies about Danwei compounds (Peiling, 2014). For example, the book edited by Lü and Perry (Lü and Perry, 1997) provides a series of analysis of the Danwei from perspectives of historical development, international comparisons and reforms. Bray (Bray, 2005) investigated the Danwei compound and Danwei system and described them as neighbourhood social space and local governance of China. He identified enclosed walls as the distinctive ' of the compound. In another study, Bian (Bian, 2005) introduced the Danwei system of China by exploring different kinds of industries and enterprises promoted by such a system. Peiling's recent study (Peiling, 2014) provided a comprehensive survey of Jingmian Danwei compound in Beijing through micro-space analyses. He identified that the most serious issue in Jingmian compound might be residents' dislocated identity of whether they are socialist workers, rural farmers or modern citizens.

Therefore, this chapter focuses on two questions: (1) what is the current spatial distribution of the Danwei compounds in Hefei old city? (2) what spatial features(e.g. plot ratio, building density and accessibility) distinguish Danwei compounds and other residential sites? By doing this, this chapter aims to contribute to the existing literature in two ways. First, we provide an empirical understanding on the distribution of Danwei compounds as an entry for future in-depth analysis on their conditions and socio-spatial transformation; and secondly, to provide insights at the city scale on accessibility to public facilities in terms of the reshaping of the urban environment following recent housing reforms (e.g. The 1997 Urban Housing Reform).

5.2 Spatial Distribution of Danwei Compounds and Non-Danwei Residential Sites in The Old Town of Hefei

The distribution map of Danwei compounds and non-Danwei residential was developed in ArcGIS (Figure 5.1). The land use map shows that the Danwei compounds are still the main land use type in the old town of Hefei. As shown in Figure 5.1, Danwei compounds are widely distributed over the old town of Hefei, except the northeast corner which functions as the central business district and a city park. Twenty-seven percent of the land in the old town is occupied by Danwei compounds, much higher than the 8.3% of non-Danwei residential units. If the estimated road occupancy of 10%-20% is considered, the Danwei compound accounts for more than 30% of the available land in the old town of Hefei. The remaining sites locate public facilities such as parks, hospitals, schools, and commercial areas. It should be noted that all the land in the old town is either public or semi-public.

In order to identify the area value numerical distribution pattern of the sites, site area box chart (Figure 5.2) was developed and presented with the corresponding specific values (Table 5.2). Some outliers above the maximum value can be observed for extremely large Danwei compounds. A non-linear scale on the y-axis is used in Figure 5.2, due to the presence of two enormous extreme values in the Danwei compound. From Figure 5.1 and Table 5.1, it could be observed that Danwei compounds are superior in both quantity and average area over non-Danwei sites. In addition, Figure 5.2 and Table 5.2 indicates that individual Danwei compound areas are significantly larger than non-Danwei sites in terms of median, maximum and minimum values. Also, there are two outliers where the Danwei compound with the area size far exceeds that of the other Danwei compounds and non-Danwei sites, at 136,430 m^2 and 94,760 m^2 respectively.

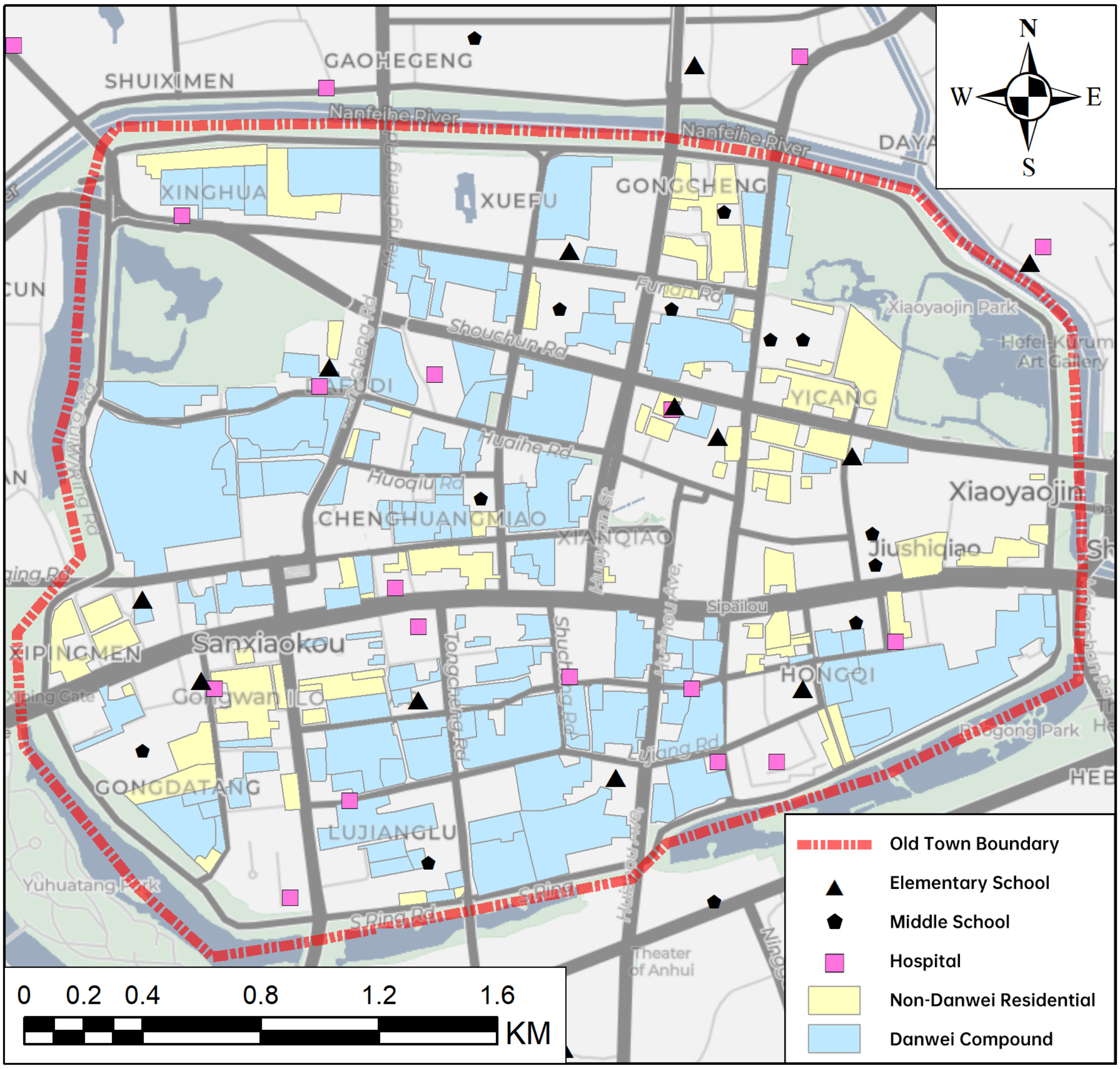


Figure 5.1: Distribution of Danwei compounds and non-Danwei residential in Hefei old town (Data Source: Mapbox.com, Amap.com)

Table 5.1: Quantity and area of residential sites in Hefei Old Town area

Site Type	Quantity	Total Area(km^2)	Proportion of Old Town area	Average Area(m^2)
Danwei Compound	115	1.34	25.70%	11690
Non-Danwei residential	63	0.43	8.30%	6810
Total	178	1.77	34.00%	9959

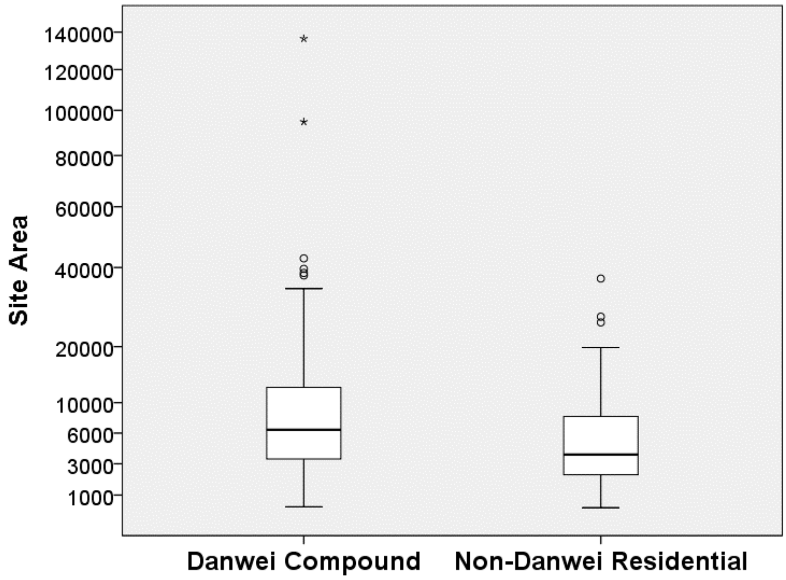


Figure 5.2: The Site Area box chart by Site Type

Table 5.2: Key values of Figure 5.2

Site Type	Maximum Area	Minimum Area	Median Area	Inter Quartile Range
Danwei Compound	1136430	530	6380	9070
Non-Danwei residential	36790	490	3790	6000
Total	1136430	490	5380	8800

5.3 Plot Ratio and Building Density

In order to compare the spatial condition inside the two kinds of sites, we calculated the plot ratio and building density of each site. The larger the plot ratio and building density, the more crowded the site is, and the less open space it tends to have (Figure5.3,5.4, Table 5.3). The results indicate that the non-Danwei residential sites tend to have a higher plot ratio and building density than the Danwei Compounds in all dimensions. This suggests that non-Danwei sites are more crowded than Danwei compounds. Due to the state-owned land system in Chinese cities (Huang et al., 2017), the non-built part of residential areas is overwhelmingly public space. Hence, the average plot ratios (Danwei compound: 2.065, non-Danwei site: 2.338) and the average building densities around 0.4 (Danwei compound: 0.390, non-Danwei site: 0.411) indicates that each square meter floor area in Danwei compounds shares $0.295m^2$ of public land, which is

17.1% more that non-Danwei sites' 0.2525 m^2.

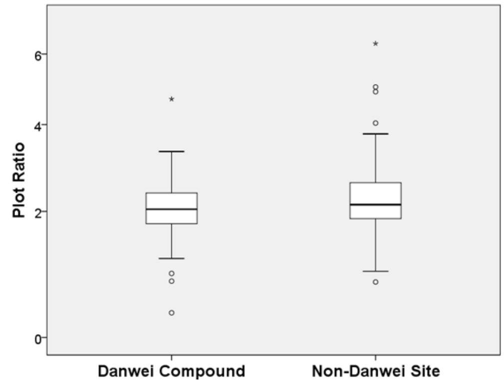


Figure 5.3: The Plot Ratio Ratio Box Chart

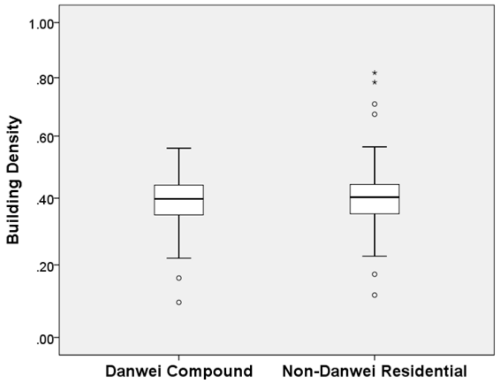


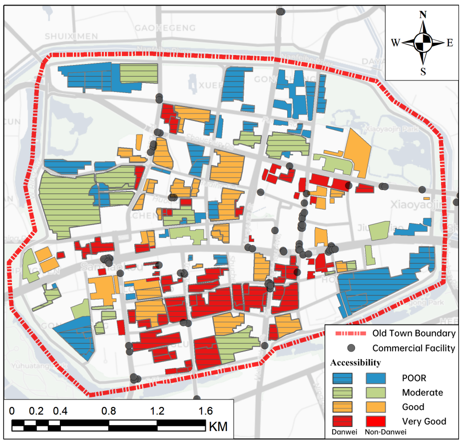
Figure 5.4: The Building Density Box Chart

Table 5.3: Key Values of Figure 5.3,5.4

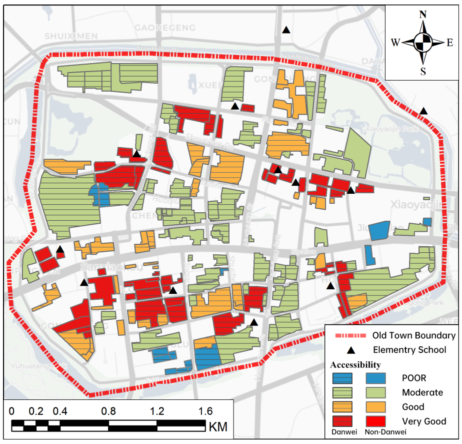
	Site Type	Average	Maximum	Minimum	Median	Inter Quartile Range
Plot Ratio	Danwei Compound	2.065	4.686	0.307	2.044	0.634
	Non-Danwei residential	2.338	6.326	0.748	2.137	0.771
Building Density	Danwei Compound	0.390	0.560	0.095	0.398	0.094
	Non-Danwei residential	0.411	0.817	0.115	0.403	0.094

5.4 Accessibility to public facilities in Danwei and non-Danwei compounds

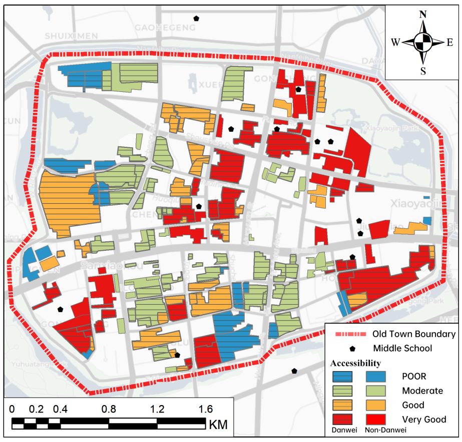
This section presents the results of the accessibility of Danwei and non-Danwei residential units to commercial centres, hospitals and schools (Figure 5.5) based on the pedestrian shed as explained in the methodology section. As can be seen from Figure 5.5, the accessibility to the selected public facilities varies considerably across the city. However, none of the public facilities achieved full service area coverage.



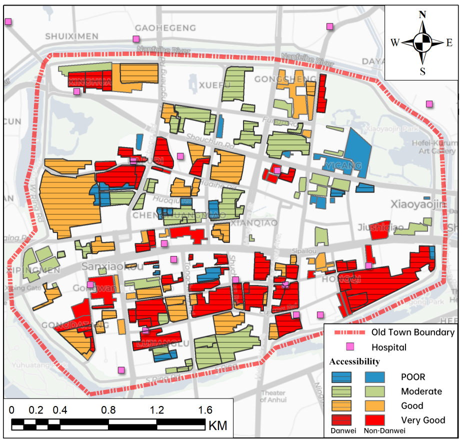
(a) Accessibility to Commercial Facilities



(b) Accessibility to Elementary Schools



(c) Accessibility to Middle Schools



(d) Accessibility to Hospitals

Figure 5.5: Accessibility to Public Facilities

Based on the results of the pedestrian shed analysis above, a cross-tabulation of the area and count of sites for each type and accessibility to public facilities was developed (Table 5.4). The results show that 50 Danwei compounds (area of 435,400 m^2) have a "Very Good" level of access to commercial facilities compared 19 for non-Danwei residential sites (area of 75,220m^2). While 45 Danwei compounds (area of 645,120m^2) have "Very Good" level of access to hospitals compared only 14 is recorded for non-Danwei residential sites (area of 137,010m^2).

Meanwhile, Danwei compounds' accessibility to elementary and middle schools was mainly concentrated in the "Moderate" level, with 53 and 46 sites respectively, while non-Danwei sites were more evenly distributed at all levels.

Table 5.4: The number and total area statistics by site types and accessibility to public facilities.

Accessibility	**Site Type**	**Poor**		**Moderate**		**Good**		**Very Good**		**Total**	
		Count	**Area (m^2)**	**Count**	**Area (m^2)**	**Count**	**Area (m^2)**	**Count**	**Area (m^2)**	**Count**	**Area (m^2)**
Commercial	Danwei	30	415690	14	441530	21	339190	50	435400	115	1631810
	Non-Danwei	23	188150	6	103300	15	153950	19	75220	63	520620
	Total	53	603840	20	544830	36	493140	69	510620	178	2152430
Elementary School	Danwei	10	71820	53	889800	25	342870	27	327320	115	1631810
	Non-Danwei	5	32980	21	224350	15	91570	22	171720	63	520620
	Total	15	104800	74	1114150	40	434440	49	499040	178	2152430
Middle School	Danwei	14	197240	46	496080	27	455100	28	483390	115	1631810
	Non-Danwei	8	70090	25	110620	6	49290	24	290620	63	520620
	Total	22	267330	71	606700	33	504390	52	774010	178	2152430
Hospital	Danwei	18	88020	25	376580	27	522090	45	645120	115	1631810
	Non-Danwei	9	92820	25	177630	15	113160	14	137010	63	520620
	Total	27	180840	50	554210	42	635250	59	782130	178	2152430

5.5 Binary Logistic Regression: Which Spatial Features Distinguish Danwei Compounds From Non-Danwei Sites?

Acting as a synopsis of this study, a binary logistic regression was used to bring all the spatial features studied above together to comprehend the main difference between Danwei compound and other residential sites in terms of spatial features.

The binary logistic regression model has a Cox & Snell r^2 of 0.0119 and the Nagelkerke r^2 of 0.164, demonstrating a good fitting effect. The confusion matrix is shown in Table 5.5. The model shows a good precision in the prediction of Danwei compounds (87.0%). For non-Danwei residential sites, the precision is not satisfactory (34.9%). Overall, the model has an accuracy of 68.5%, which is sufficient as a reference for the analysis.

Table 5.5: Confusion Matrix of the Binary Logistic Regression Model

			Predicted		
			Type		Precision(%)
			Danwei Compound	Non-Danwei Residential	
Actual	Type	Danwei Compound	100	15	87.0
		Non-Danwei Residential	41	22	34.9
	Accuracy(%)				68.5

Therefore, the correlation and significance between the corresponding spatial features and compound types can be determined by reading the "B" and "Sig." columns in Table 5.6. Collectively, Danwei compounds and non-Danwei sites differ significantly in the spatial features of accessibility to commercial facilities, accessibility to elementary schools, and accessibility to hospitals. Danwei compounds have higher accessibility to commercial facilities and hospitals, whereas non-Danwei sites have higher accessibility to elementary schools. It should be noted that, due to the small sample size, the results of this regression analysis are only statistical conclusion about the old town but not entire city area of Hefei.

Table 5.6: Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1	commercial	-0.29	0.14	4.26	1.00	0.04	0.75	0.57	0.99
	elementary school	0.41	0.18	4.88	1.00	0.03	1.50	1.05	2.16
	middle school	0.06	0.17	0.13	1.00	0.72	1.06	0.77	1.47
	hospital	-0.35	0.17	4.34	1.00	0.04	0.71	0.51	0.98
	Site_Area	0.00	0.00	3.22	1.00	0.07	1.00	1.00	1.00
	plot_ratio	0.44	0.28	2.47	1.00	0.12	1.56	0.90	2.71
	building_density	-0.03	2.22	0.00	1.00	0.99	0.97	0.01	75.23
	Constant	-0.97	0.92	1.12	1.00	0.29	0.38		

* For the dependent variable of this model, "0" stands for Danwei compounds and "1" stands for non-Danwei sites.

5.6 Discussion

5.6.1 Danwei Compounds Dominate in The Spatial Organisation of The Hefei Old Town

The spatial distribution of the residential units shows that Danwei compounds dominate the old city of Hefei's built environment. While the major reforms in the urban land and housing sector, coupled with market led urban development (Yeh et al., 2015) have indeed led to a boom in the private estate (Chen and Wen, 2017; Glaeser et al., 2017) and social housing (Wang and Murie, 2011) residential units, this situation has not diminished the predominance of old Danwei compounds as some studies assert (Chai and Zhang, 2009; Chai et al., 2007; Mao and Chai, 2013; Ta and Chai, 2010). This is apparently due to the fact the Danwei compound, the main spatial unit of the Danwei system, has not declined in tandem with the Danwei system—the socio-political structure (Lü and Perry, 1997). This notwithstanding, Danwei compounds have experienced functional changes from an integrated space for "work, life, and housing" (Tian, 2014) into purely residential spaces. Although these changes have emerged as inevitable consequences of earlier reforms, it is suggestive that their existing function as residential space needs particular attention from local government and planning authorities in terms of improvement in spatial conditions and urban functions and preservation. Indeed, evidence from similar cases in other East Asian cities (Kusakabe, 2013) suggest that locally based spatial improvement strategies that are integrated into urban developments plan with community involvement can enhance the attractiveness old neighbourhoods.

5.6.2 Public Space in Danwei Compounds Provides the Basis for Community Building

The lower plot ratio and building density of Danwei compounds indicate the existence of more public spaces in comparison with non-Danwei residential sites. Historically, this could be due to the abundant supply of land and space in the early years of Danwei construction and development, where compounds were designed to be more open and less dense (DU et al., 2012). Given the observation that public spaces in Chinese cities are in a gradual decline (Wang, 2017b), the case of non-Danwei compounds offers potential for restoring the public realm, community and social interactions in urban China (Tian, 2012). Thus, these public spaces can play a positive role in the reconstruction of community (Ding, 2008), social capital (Curley, 2010) and reinvigorating a sense of belonging in the community (Francis et al., 2012). It is suggestive that these spaces can be used to organise community events, build common facilities to increase social engagement and interaction opportunities for local residents.

5.6.3 Uneven Distribution of Public Facilities in Hefei Old Town

Among the different spatial features studied, results also show that the main element that significantly distinguishes Danwei compounds from the non-Danwei site is accessibility to commercial centres, elementary school and hospitals. In particular, the poor accessibility to elementary schools from Danwei compounds. As basic education facility, the lack of good accessibility to elementary schools has a significant negative impact on an urban community (Bonaiuto et al., 2003). This has ramifications for the overall quality of the living environment as Bonaiuto et al.'s earlier study asserts that elementary schools in a community have a beneficial effect on the residents' sense of belonging and vitality (Bonaiuto et al., 2003). Furthermore, the difference in the accessibility of public facilities between Danwei compounds and non-Danwei sites means that some residents are unable to access some public services within walking distance, which is detrimental to global and local agenda's of urban sustainability, especially with regards to compact and walkable neighbourhoods (Gao et al., 2016; UN, 2020). This situation requires a response from the local planning authority to improve the coverage of public services and better community planning and design that enhances the pedestrian environment. Clearly, this informs better collaboration with residents and educational, health and commercial service providers in spatial planning.

CHAPTER 6

Social-Spatial Changes in the AMS Danwei compound

6.1 Introduction

The 'Danwei' system, also known as the 'working unit', is a unique community-level socio-spatial system which emerged after the founding of the People's Republic of China (PRC) in 1949. The Chinese word 'Danwei' is the collective term for non-natural person entity unit of human society. 'A Danwei' could refer to, for example, a school, a hospital, a government institution, a factory, etc. The Danwei system was established to obtain the national mobilisation ability to rebuild the economy and industrialised productivity (Skocpol, 1979). It is generally considered that this system contributed enormously to the physical shape of Chinese cities, in addition to the economic, political, social and spatial structure of modern China, particularly during the 20th century. In spatial terms, the Danweis are physically identified as Danwei compounds: a gated work-life mixed neighbourhood enclosed by walls (Bray, 2005). The interior is often a mix of offices, residential and public facilities with various spaces and facilities for the employees' working, housing, catering, and even recreation, sports, fitness, and basic medical care. For a long time after its establishment, it had been the basic unit of urban neighbourhood construction (Wu, 2016).

However, after the 1990s, some changes began to occur in the compounds due to the decline of the macro socio-spatial system it was based on. This decline was fuelled by two of the most significant Chinese reforms of the second half of 20th century—the Reform and Opening Up (1978) and the Urban Housing Reform (1997). On the one hand, the Reform and Opening Up, which began in 1978, loosened the economic and social structure base of the Danwei system with significant effects on space, society and economy (ChuangLin, 2009). Prior to this reform, China implemented a planned economy system in which most public goods were rationed (Wen, 2013). In this planned system, the entire society was de-monetised and hence had no free market in which goods could be bought and sold freely with money. Thus, urban residents were required to be part of a government-recognised organisation or institution (a Danwei) in order to get access to industrial or agricultural products (Liu, 2000). This system tied all citizens onto the same social system, forming a single community of interest. However, this so-called class-neutral planned economy led to a low level of productivity and other social problems, such as the urban-rural dualism, and hence necessitated the need for reforms (Tian, 2014). As a result, The Reform and Opening Up was launched in 1978, which among other things, led to the reversion of private ownership, and the use of currency to buy and sell goods (Wen, 2013). On the social front, the notion of China as one original 'single community' was dismantled, allowing the population to have free mobility across the country. Consequently, social organisations independent from the Danwei system proliferated after 1978. However, due to historical inertia, a slow integration of market-based society and the apparent contradiction between the goal of the reform and the local realities, the Urban Housing reform was not introduced until 1997.

The Urban Housing reform, on the other hand, is considered to have particularly impacted the spatial base of the Danwei compound. It was a top-down reform of housing and urban land-use. Before this reform, all urban land and housing resources belonged to the State and could not be traded (Li and Dai, 2009). Typically, the government would allocate the rights of land use to Danweis, while the ownership and title to the land remained with the State. A Danwei would build a compound and thus control the land and houses. After the Urban Housing reform in 1997, the property rights of the residential houses in the Danwei compounds were distributed to individual occupants, leading to the gradual loss of the Danwei's (organisational entity) control over its territory. Expectedly, this resulted in the creation of a new real estate market, permitting individuals to own homes as assets (while land ownership remained with the State) (Li and Dai, 2009). While the above reforms contributed to rapid economic growth, they have also unleashed a fundamental transformation of the social and spatial structure of Chinese cities (Zhang, Chun & Chai, Yanwei., 2009). Unfortunately, the constituent changes in Danwei compounds' socio-spatial system impacted by these reforms have not attracted relevant empirical attention in the scholarly literature. Previous studies of Danwei system and Danwei compound have looked at historical (Bian, 2005; Tanigawa, 1999), political (Tian, 2014), economic

(Zhou, Yihu. and Yang, Xiaomin, 2002) and social (Zhang, Chun & Chai, Yanwei., 2009) aspects of the Danwei. However, most of these studies focus on the city-wide scale rather than the micro level of the neighbourhood or compound. The few studies that focus on the micro-level do not provide a historical context for socio-spatial changes. For example, Peiling (Peiling, 2014) studied the micro-level features of the Jingmian Danwei compound in Beijing, which revealed dislocated identities in the socio-spatial relationships among residents without engaging the historical context of the reforms. This is also true for the study of Zhang et al. (Zhang, Chun & Chai, Yanwei & Zhou, Qianjun, 2009) on the spatial changes of a Beijing Danwei compound by analysis its maps between the 1990s and 2006.

To fill the research gap of socio-spatial change studies of Danwei compounds, this study uses a time domain comparative approach. The study is guided by the question of: what are specific social and spatial changes in Danwei compound after the reforms. By comparing the socio-spatial elements of a Danwei compound at different time periods, the study clarifies the changes which have taken place within the compound. This study assumes that such analysis can shed useful insight on challenges and potentials for effective community level planning at this critical stage of urban development in old Chinese cities. From the perspective of urban planning — and in the context of China's current urban transformation and rapid urban renewal planning of old city cores — effective locally oriented planning and spatial development warrants analysis of the socio-spatial changes that have emerged due to the reforms have shown their imperativeness and necessity. This study is therefore, an extension of earlier studies on Hefei city and Danwei compounds by the authors (Ye et al., 2019, 2021).

6.2 Physical Space Changes

6.2.1 Boundary and Density

Figure 6.1 shows the changes in the physical boundary (1961-2018) of the AMS. The result show two significant boundary changes in the history of the AMS compound. The first change occurred between 1961 and 1975 (before the reforms), when walls were built to clarify boundaries with the surroundings, turning the compound from an open neighbourhood to a gated one. The second change occurred between 1987 and 1999, when a part of the land was allocated to another Danwei (Danwei C, Figure 6.1). Such land transaction between Danweis was decided by the city government in an integrated consideration of urban planning, community conditions and economic circumstances.

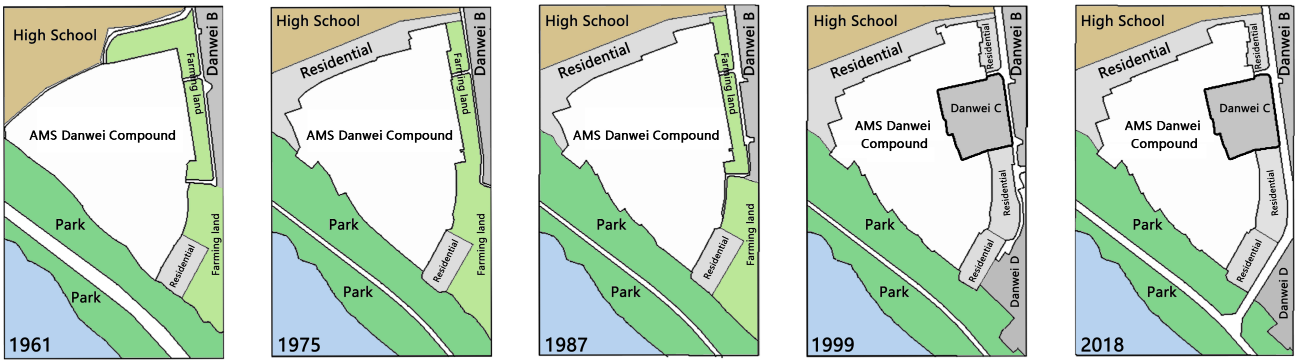


Figure 6.1: Boundary of the AMS Danwei Compound and Surrounding Land Usage

Table 6.1 shows the basic indicators of building density and plot ratio in the AMS compound. Building density increased steadily till 1999 and remained stable since; the plot ratio had increased rapidly from 1961 to 2018. The compound had been getting denser.

Table 6.1: Building Density and Plot Ratio of AMS Compound

	1961	**1975**	**1987**	**1999**	**2018**
Building Density	20%	27%	42%	48%	48%
Plot Ratio	32%	47%	77%	149%	151%

6.2.2 Public Space

Based on the digital maps, the public spaces in each period were drawn (Figure 6.2) with their areas and occupancy calculated (Table 6.2). It could be seen from Figure 6.2 that the public space in the AMS compound gradually declined, from a block form in 1961 and 1975 to a net form in 1987. After the 1997 reform, it shrank further into a tree-like spatial structure. In specific numbers, the area and ratio of public space declined rapidly, most notably between 1975 and 1999, from 25,870 square metres (65%) in 1975 to 9,690 square metres (28%) in 1999. During the same period, the building density rose rapidly from 27% to 48%, and the plot ratio more than tripled from 47% to 149%. From the above data, it can be seen that the public spatial system of the AMS Danwei compound before and after the reforms has drastically altered. According to the key residents and field observation, the decline in public space after the reviews was due to the increase in residential housing promoted by the urban housing reforms and the growing car ownership without accompanying parking.

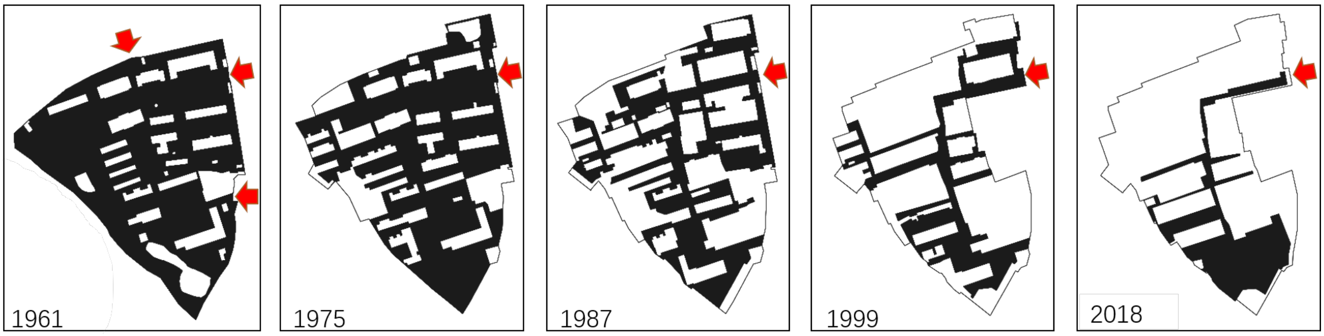


Figure 6.2: Public Space Map of the AMS Compound (1961-2018)

Table 6.2: Basic Spatial information of AMS Compound

	1961	**1975**	**1987**	**1999**	**2018**
Public Space Area(m^2)	29740	25870	17060	9690	8200
Public Space Ratio	75%	65%	42%	28%	24%

6.2.3 Spatial Syntax Analysis

DepthMapX software was used for a spatial syntax analysis on the public spaces. The value obtained from the Visual Step Depth analysis stands for the turns needed to walk from the entrance to that point. As evident in Figure 6.3, the proportion of area with high visual spatial depth kept increasing since 1961. In 1961, with two turns from the entrance, 99% of the public places in the compound could be seen. Such accessible space decreased significantly to 49% in 1975, 42% in 1987, 27% in 1999 and 12% in 2018. Field observations revealed compound had becoming increasingly difficult for outsiders to walk through.

Figure 6.3: Visual Step Depth of the AMS compound (1961-2018)

Connectivity values refer to the strength of the connection between the cell and all other cells in the public space (Figure 6.4). In a residential environment, a place with a higher connectivity value has better potential as a social or common space. From 1961 to 1999, the analysis showed that the overall connectivity in the AMS compound decreased significantly. In 2018, the connectivity remained poor, except for the new emerged common space (a neighbourhood park) in the south end.

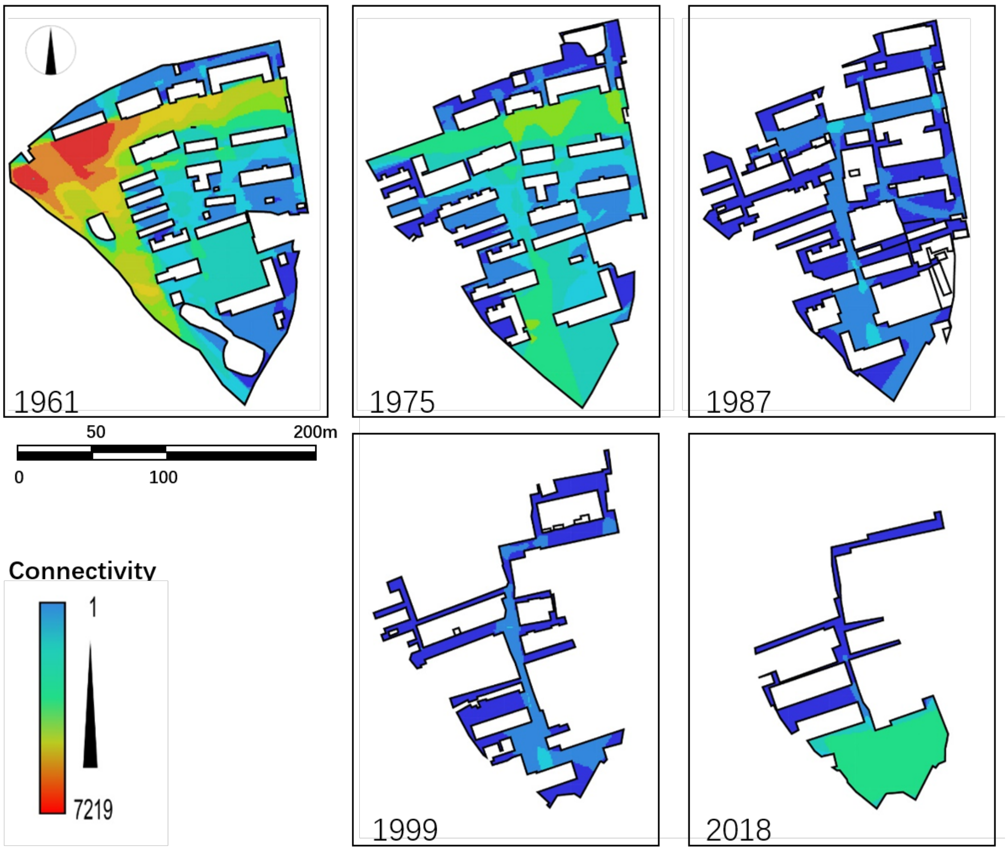


Figure 6.4: Connectivity of the AMS compound (1961-2018)

By the scatter plot with the x-axis represents the Connectivity value, and the y-axis represents the Metric Step Shortest-Path Length, Figure 6.5 presents a relatively visual representation of the public space spatial characteristics of different years. Each point in the scatter plot stand to one 1x1 meter cell in the compound. In the earlier years (1961 and 1975), the cells tend to have higher connectivity and low Metric Step Shortest-Path Length. Meanwhile, the points laid in an organic pattern, suggesting that there were large public spaces existing with a regular patch shape. After the 1997 reform, in 1999 and 2018, the points tend to have deficient connectivity and much higher Metric Step Shortest-Path Length, with the points forming a linear pattern, suggesting there were few public spaces, albeit narrow and linear. In general, over the years, public space had degenerated from an organic, blocky, low depth pattern to a linear, striped, large depth pattern.

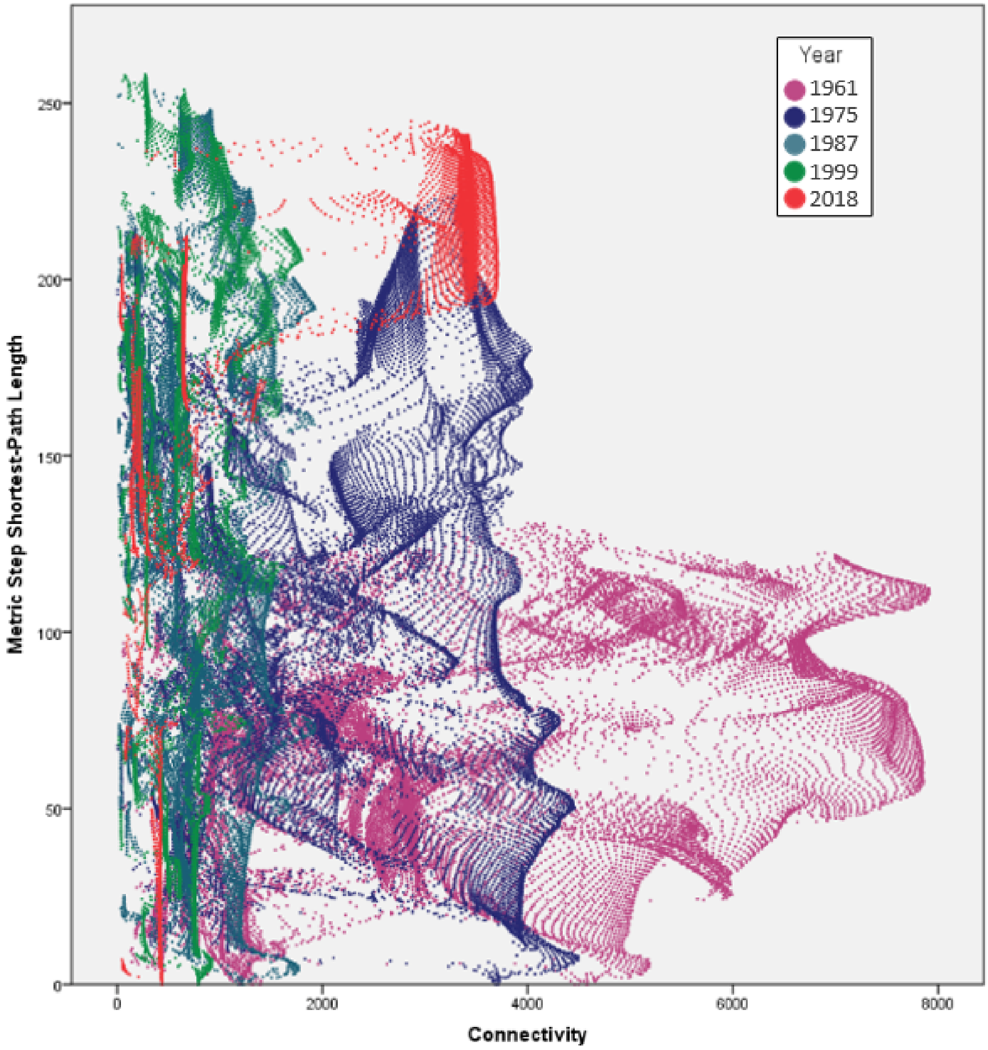


Figure 6.5: Scatter Plot by Connectivity and Spatial Depth of the AMS Compound

In summary, the data of 1961, 1975 and 1987 shows that the public space in the AMS compound had been shrinking before the reforms, but maintained a reticulated spatial form with relatively moderate spatial depth and connectivity. The data from 1999 and 2018 shows that, after the reforms, the public space in the AMS compound shrank into a tree-like structure and experienced issues such as excessive spatial depth and low internal connectivity. These results suggest that after the reforms, the public space in the AMS compound had largely lost its function as a space for public activities and was only capable of basic transportation.

6.3 Building Features

As shown in Table 6.3, before the reforms, the total floor area and average building area increased significantly. Before the 1997 reform, the total area of buildings in the compound grew from 12,699 square metres in 1961 to 31,032 square metres in 1987. Around the time of the 1997 reform, the floor area in the compound grew rapidly, reaching 51,386 square metres in 1999. After the reforms, the floor area within the AMS compound has remained largely unchanged, at 51,862 square metres in 2018. The AMS compound has also been experiencing a consistently high building renewal rate. In particular, in 1999, new construction accounted for more than half of all floor space. According to the residents, the high building renewal rate was premised on improvements of indoor living and working environment, thereby increasing interior floor area and overall building quality. The quantity of buildings within the compound has remained roughly the same (39 in 1961 and 36 in 2018), while the size of the individual buildings has continued to increase (326 square metres in 1961 and 2096 in 2018). Note that the change in 1987 and 1999 was because of the construction of a large number of temporary earthquake resistant shelter.

Table 6.3: Building Area and Quantity in the AMS compound (1961-2018)

	1961	**1975**	**1987**	**1999**	**2018**
Total Building Area (M2)	12699	18543	31032	51386	51862
In Which: Retention Area (M^2)		11001	17736	23054	39287
In Which: New Build Area (M^2)		6180	13973	26626	12574
Average New Building Area (M^2)	326	247	318	634	2096
New Build/Total Area Ratio		33%	45%	52%	24%
Total Quantity	39	41	75	78	36
In Which: Retention Quantity		16	31	36	30
In Which: New Build Quantity		25	44	42	6

In the AMS Danwei compound, the field survey and key residents interview revealed nine main functions (Figure 6.6, Table 6.4). Building functions include: Mix-use buildings which usually have office-residential-warehouse functions, with the residential unit as the biggest part, (exist due to the lack of sufficient buildings to accommodate the different functional requirements); Animal House refers to the building that breeds public health experimental animals; and Earthquake Resilient Shelter refers to the temporary residential shelters which appeared after the Tangshan earthquake.

Figure 6.6: Building Function Map of the AMS Compound

Table 6.4: Building Area and Proportion by Function

Building Area by Function (M^2 | %)	1961		1975		1987		1999		2018	
Office	2388	19%	3250	18%	10086	32%	14118	27%	6940	13%
Residential House	5643	44%	8565	46%	15323	49%	34605	67%	42782	82%
Mixed-Use Building	3598	28%	4670	25%	997	3%	0	0%	0	0%
Warehouse	79	1%	841	5%	1308	4%	1558	3%	752	1%
Public Service Facility	346	3%	848	5%	961	3%	129	0%	1387	3%
Farming House	277	2%	51	0%	0	0%	0	0%	0	0%
Toilet	57	0%	47	0%	51	0%	0	0%	0	0%
Animal House	311	2%	270	1%	270	1%	203	0%	0	0%
Earthquake Resilient Shelter	0	0	0	0	2051	7%	789	2%	0	0

Most of the buildings in the AMS compound were offices and residential houses, with other buildings of supporting functions. Before the reform, offices and residential houses in the compound had been growing rapidly. Along with the continuous construction of new buildings, mixed-use buildings were rapidly decreasing. For example, in 1961 (before the reforms), the predominant building functions were office (19%), residential house (44%), mixed-use building (28%), with a small number of warehouses (1%), public services(3%), farming houses (2%) and animal houses (2%). With the construction and the renewal of the buildings, in 1987, the predominant building functions were only offices (32%) and residential houses (49%), while other functions decreased, except for the addition of a new function of Earthquake Resilient Shelter (7%). These earthquake resilient shelters were built by the residents themselves for the possibility of a major earthquake. The AMS compound of this period was a typical mixed function work-residential neighbourhood.

After the reforms, the building functions saw considerable changes. Specifically, residential house had become the dominant building function, increasing to 67% in 1999 and 82% in 2018. The change in floor area by functions shows a rapid decline in office and ancillary functions such as warehouse. The reformed AMS compound reflects a strong tendency towards pure residentialisation. This period has also seen a regrowth in public service buildings. In 1999, the area of public service facilities had fallen to only 129 square metres; by 2018, it had rebounded to 1,387 square metres, or 3% of all buildings, due to the rising demand for elderly care.

6.4 The Use of Public Spaces and Public Facilities

The Danwei compound had been a common living space, where public facilities, such as water supply and toilet, have a direct influence on daily life. Before the reforms, such facilities were communal as they were not available within existing residential housing units in the AMS compound. For example, tap water was built near residential buildings as a shared facility by several households residing in surrounding buildings (Figure 6.7). Similarly, there were three public toilets that were communally used by all households within the compound. Without drainage facilities, waste water was indiscriminately disposed into surrounding vegetation. According to interviews, communal and shared use of facilities created strong social bonds among residents. Long-time residents disclosed that several social groups were formed around shared facility usage (e.g. shared tap water) as neighbours would often socialise on a daily basis through interactions and conversations about the facilities, conditions and maintenance.

However, this socialisation around shared use began to change in the late 1970s, following the construction of the first apartment building with indoor tap water and toilets in the compound. Specifically, in the late 1980s, the city government embarked on housing renovation in the Danwei compounds with particular emphasis on the installation of housing facilities such as tap water and toilet within each housing unit. By the early 1990s, the water supply and drainage system had been completely interiorised in the AMS compound. Consequently, the residents' shared use of public utilities and corresponding social interactions and communalisation that came with them gradually disappeared (Figure 6.8).

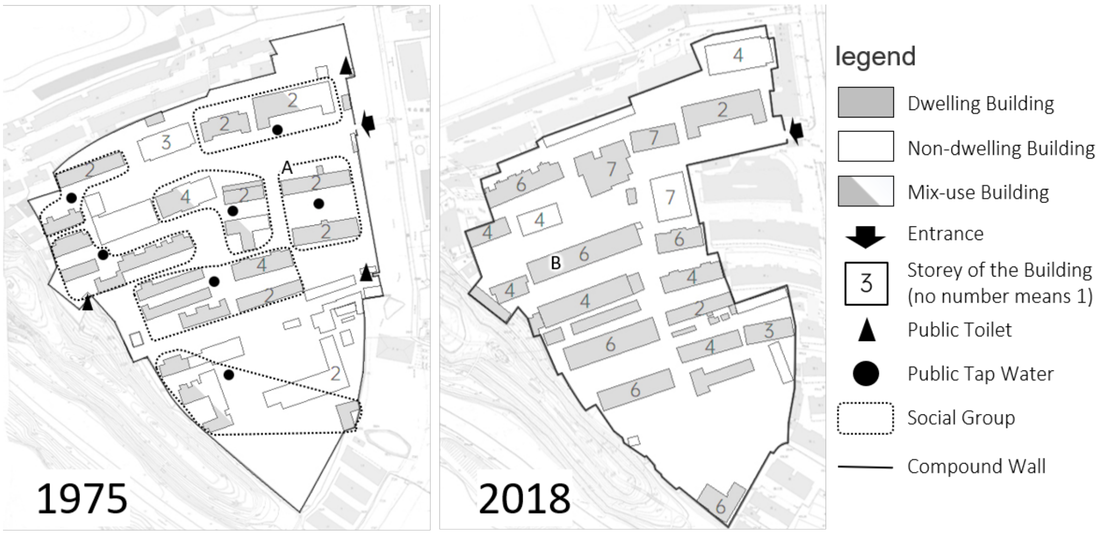
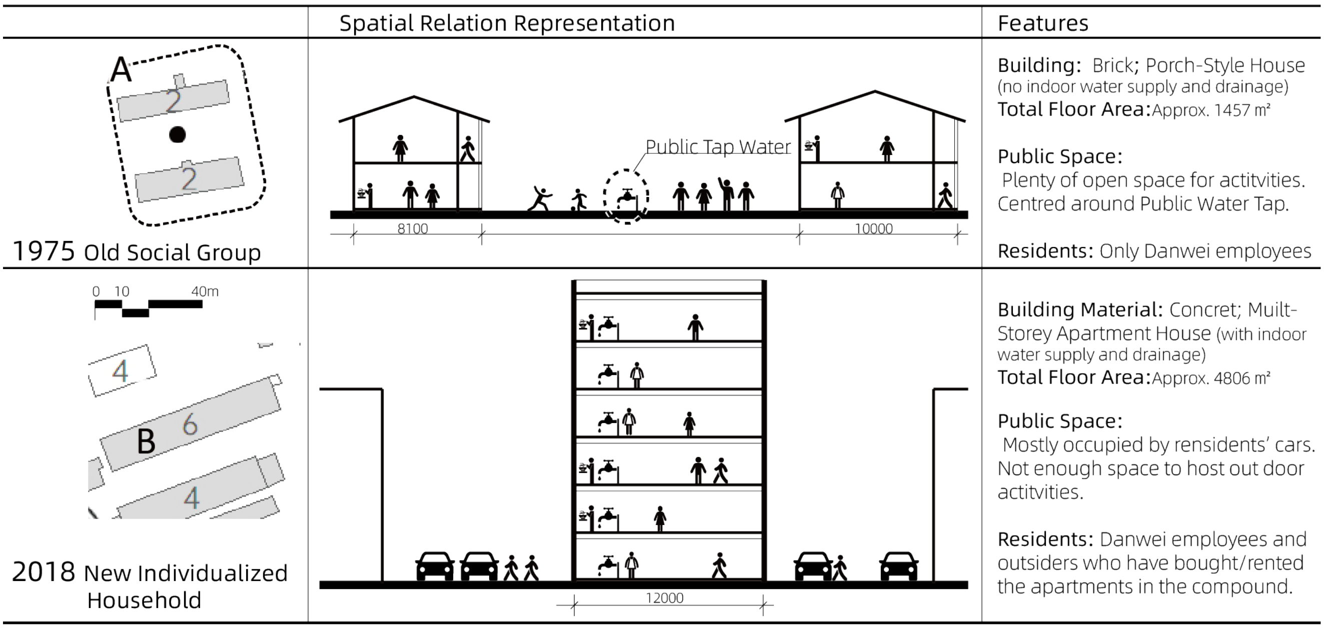


Figure 6.7: Public Water Supply, Toilets and Buildings of the AMS Danwei Compound



A,B represent the building and public space marked by A,B in Figure 6.7

Figure 6.8: Living Environment Conditions

6.5 Typical Nuclear Household Workday Daily Life Schedule

In order to comprehend the 'before and after the reforms' everyday life in the compound, a time-geography technique was used to analyse the typical daily life schedule of a typical Chinese nuclear family household, i.e., a family of three with two working parents and a school-age child (Figure 6.9). Given that before the reforms, residents of Danwei compounds were all employees working in the AMS compound and the families, their daily activities were of similar patterns. After the reforms, the questionnaire and interviews revealed that the majority of the new households in the AMS compound were also nuclear families, with a few share-houses units of young working people and a very small number of single households. The workday schedules of the shared-houses and single householders were similar to the parents in nuclear families. Therefore, only the workday schedules of the nuclear households are plotted in this study (Figure 6.9b).

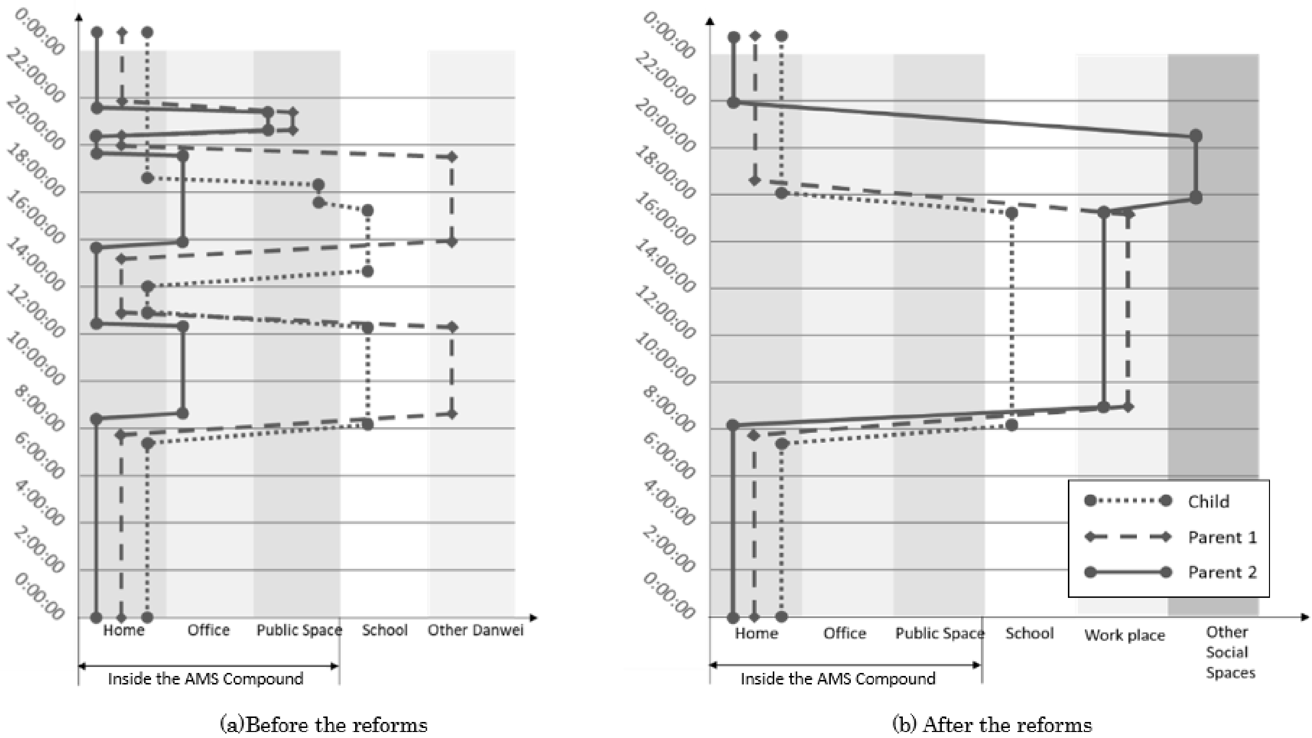


Figure 6.9: Typical Nuclear Family Workday Schedule (By Time-Geography)

As shown in Figure 6.9, working time before the reforms was usually 7:30-11:30 and 13:30-19:30, and the single commuting time was only 5-20 minutes as most residents' workplace were either within the AMS compound or nearby. At noontime, residents usually cooked at home. Children would often return to the compound from school at around 17:30, where they would usually play with their friends until returning home at sunset. Since all the residents of the compound were employees of the Danweis and the offices were located within the compound, there was a steady number of people in the compound throughout the day. Thus, key residents reported that this created a strong 'defensible space', conducive for children to play freely. Dinner was mostly at home due to the absence of eateries or restaurants at the time. Interviewees usually spent evening time in group strolls or socialising in and around the compound. For the most part, everyday life was constrained within the compound.

Table 6.5: Demographic composition of AMS compound (Data source: questionnaire)

Residents' Affiliation	**How long have you lived in this compound?**					**Total**
	<1 Year	**1-3 Years**	**3-10 Years**	**10-20 Years**	**>20 Years**	
Employee of the Danweis or family	1	2	9	16	37	65
Not Employee of the Danweis	16	15	6	2	0	39
Total	17	17	15	18	37	104

However, interviewees reported considerable changes after the reforms. For example, the changes in building functions, particularly office relocations outside of the compound and construction of new residential houses (estate developments) has meant fewer residents are employees of AMS Danweis (Table 6.5). Hence, commuter time increased significantly (Figure 6.10).For about 18 percent of interviewees in 2018 suffered a more than an hour one-way commute (Figure 6.10). Meanwhile, Hefei authorities introduced the 9:00-17:00 working schedule after the year of 2000, cancelling the long break at noon. Additionally, figure 6.11 shows the time points at which questionnaire respondents leave and return home during the working day. It indicates that most residents go out at 7:00 or 8:00 and return at 18:00 or 19:00, with the most frequent time combination being 7:00 and 18:00 (21 out of 104). As a result, most of the residents had stopped going home for lunch (Figure 6.9b). With fewer local employees, longer commuting time and longer working hours, it can therefore be observed that The AMS Danwei compound has gradually transformed from a full time living-working space to a 'dormitory settlement' as the residents' time in the Danwei compound has decreased considerably.

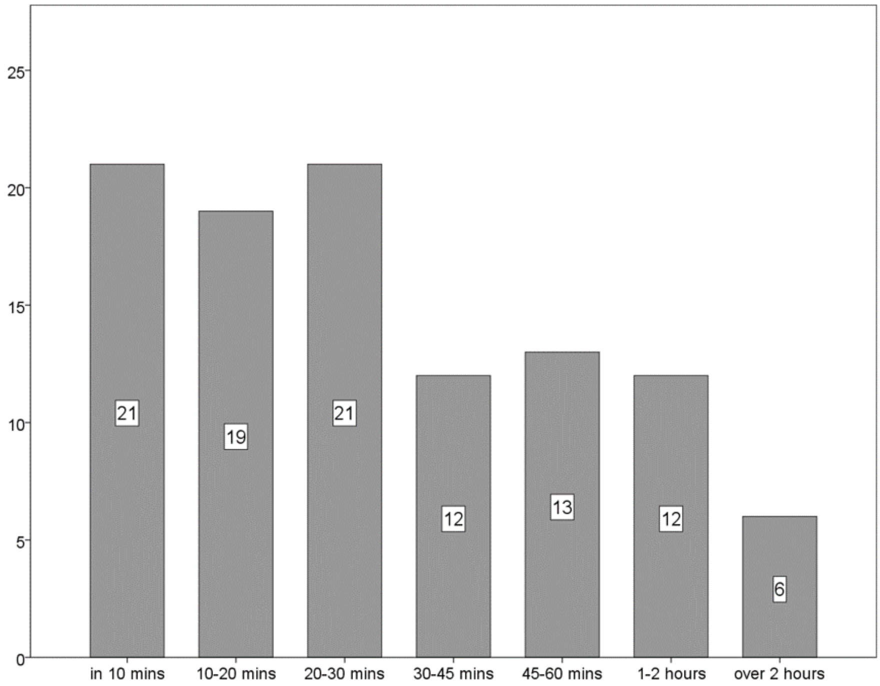


Figure 6.10: One-way Commute Time of AMS Compound Residents (Data source: questionnaire)

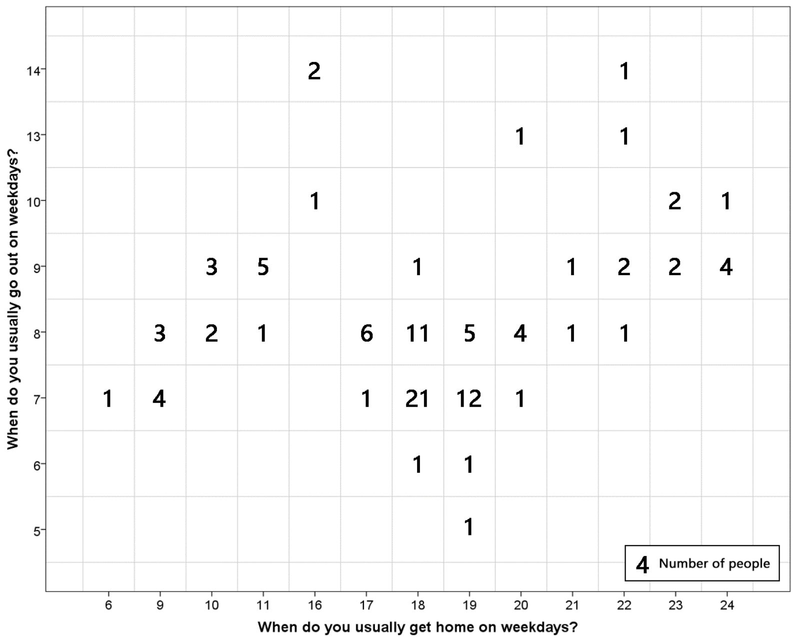


Figure 6.11: Distribution of Workday Commute Time Points (Data source: questionnaire)

6.6 Compound Management

This part of the study analyses the actors for the management and maintenance of public facilities in the AMS Danwei compound. As earlier mentioned, most facilities were commonly shared before the reforms and thus the responsibility of the AMS Danweis to manage and maintain. After the reforms, the changes in compound management emerged as a result of the changes in communalisation. Interview with key persons indicated that there were three main aspects of management and maintenance, including (i) the origin of a proposed idea or action, (ii) the source of funding and (iii) the workers or person responsible for executing the maintenance action. Further, four public services or facilities were identified as the basis for analysing. These are garbage collection, compound cleaning, facility/equipment maintenance (e.g., street light and water pipe maintenance), and human excreta disposal. These public services or facilities are selected because they were the most common resident-related. The results (Table 6.6) indicate that, before the reforms, the AMS Danweis held the responsibility for the maintenance of the compound since they owned the land and properties within the compound. More so, the Danwei employed professional electricians, plumbers and cleaners to undertake necessary facility repairs and maintenance. These professionals (shown as 'Employee' in Table 6.6) were full-time employees who lived in the compound. During this period, general residents were more actively engaged in daily maintenance activities such as compound and building cleaning.

Table 6.6: Main Actors in the Compound Maintenance

Maintenance activities	Actors	Period	
		Before the Reforms	After the Reforms
Garbage Collection	Initiators	Government	Government
	Funding	Danwei	Government
	Participants	Employee	Employee
Compound Cleaning	Initiators	Danwei	Resident
	Funding	Danwei	Resident
	Participants	Employee, Resident	Resident
Facility/Equipment Maintenance	Initiators	Danwei	Resident
	Funding	Danwei	Government
	Participants	Employee	Employee
Human Excreta Disposal	Initiators	Danwei	-
	Funding	-	-
	Participants	Outsider	-

Due the 1997 Urban Housing reform, the ownership of the housing units in the AMS Danwei compound was distributed to the residents, while other estates such as office buildings and public facilities remained under the control of the AMS Danweis'. From the view of property rights, the management and maintenance of the compound became a joint responsibility and obligation of the AMS Danweis and the residents. However, the residents could not establish a neighbourhood organisation, legally and operationally, to continue compound management. Hence the residents and the government have to take over some of the management works after the reforms. Key residents revealed that with the decline of the Danweis' economic situation, the management and maintenance become chaotic since AMS Danweis could not provide competitive remuneration. As shown in Table 6.6, in terms of facility maintenance and garbage collection, for example, the professionals employed by the Danwei's continued to handle maintenance activities, while whose funding is from the government after the reforms. Meanwhile, it is necessary to note that although Table 6.6 shows that post-reform compound cleaning was mainly carried out by the residents, this does not mean that the residents formed a community organisation to carry out regular or effective cleaning. In the field observation, it was found that residents only cleaned the compound randomly, with low frequency and intensity. This has led to the gradual deterioration of physical conditions inside the Danwei compound. Consequently, Government have taken over technical aspects of management and maintenance work in the AMS. Nonetheless, this has probably not improved conditions as 81.1 percent (30 out of 37) of long-term residents reported in the questionnaire that compound conditions as significantly worse compared to before the reforms. Figure 6.12 depicts the frequency on compound

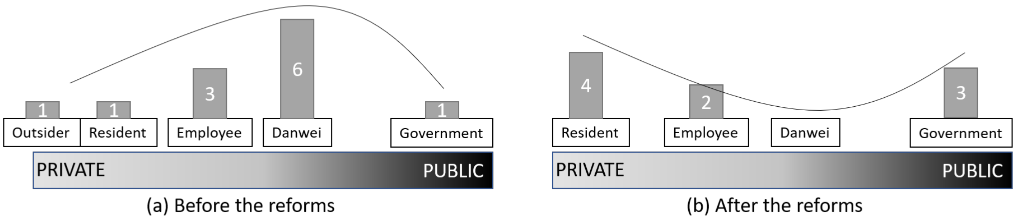


Figure 6.12: The Public-Private Spectrum of Management Actors

management activities by actors in Table 6.6 along a public-private spectrum. The most frequent management actor before the reforms was the 'Danwei', with six occurrences, and the most frequent after the reforms was the 'resident', with four occurrences. The Danwei, that once played an important role in the management of the compound have disappeared, and the management actors show a clear separation of public and non-public actors.

6.7 Discussion

The findings of this study reveal the social and spatial aspects of changes in the evolution of urban neighbourhoods. In the context of old Chinese cities and emerging cities generally, the results correspond with the summary of major changes in socio-spatial schema in urban neighbourhood studies presented in Table 2.1, section 2.7. Furthermore, by positioning the results within the framework in Figure 2.3, the study reveals how the dynamics of two major policy reforms influence socio-spatial changes at the urban neighbourhood level.

In terms of physical changes in the Danwei compound, the study found that after the reforms, the AMS Compound has lost most of its public space, gradually eroding the spatial context for urban public life. For example, the size of available physical space for public activities has declined from 25870 square metres in 1975 to 8200 square metres in 2018. Indeed, the loss of public space has been widely recognised in recent urban development in China, and its causes are believed to be related to the end of communal land ownership system and the commercially driven land development process in a quasi-capitalist framework, which significantly boosted the real estate developments in the city centre (Wang, 2017a). These kinds of reform driven spatial changes are similar to those reported in studies by He and his colleagues (He, 2013; He and Wu, 2007) and in other Chinese cities such as Shanghai and Guangzhou. This situation could be detrimental to the quality of the neighbourhood living environment as studies show that public spaces are of high significance to urban residents' sense of belonging to a community and their self-evaluation of urban quality of life (Bonaiuto et al., 2003; Francis et al., 2012).

Another important finding is related to changes in boundary and density of the Danwei compound. Contrary to recent research (Abu Hatab et al., 2019; Coq-Huelva and Asián-Chaves, 2019; Wang et al., 2020) that point to outward physical expansion, especially in Asian and other cities in the emerging world, the AMS Danwei compounds have rather seen physical readjustments in land use and housing densification since 1999. As shown in Figure 2.7, the differences in socio-spatial changes between city level and urban neighbourhoods may be due to the fact that the impact of reforms on urban space are mediated by other economic forces such as the real-estate market and planning support systems. From an eco-city perspective (Roseland, 1997), this could be a potentially positive spatial change if the dense and compact developments make room for mixed uses while the old neighbourhoods preserved for socio-spatial continuity. However, in the AMS compound our study only finds an increase in density, while the community function degenerated from a mixed-use one towards a purely residential one.

The study findings also point to a shift in the spatial concentration of residents' daily activities from within the Danwei compound to outside of the compound (city and its outlining areas). Specifically, the change in building functions (office relocates to the outer city) has meant daily activities has extended beyond the compound. As the residents' time in the Danwei compound has decreased considerably, the AMS Danwei compound has gradually transformed from a full time living-working space to a 'dormitory settlement'. About 18 percent of residents spend more than an hour on a one-way commute. Besides the recent discourse in urban planning and design that promotes shorter commuter times as part of sustainable urban communities (Agyeman and Evans, 2003; Sun et al., 2016), it could also be deduced that the long commuting times also depriving residents of their community and social life within the neighbourhood (Aguilera and Mignot, 2004; Costa et al., 1988; Sandow, 2019). This calls for urban planners and policymakers to pay particular attention to planning and design initiatives or regulations that promote compactness and efficient use of space at both the neighbourhood and city level.

Relatedly, the analysis shows that shared or common use public facilities (e.g. shared tap water) that used to be the converging point for resident's interaction and social life (social groups) before the reforms have gradually disappeared. This phenomenon is similar to the case of Izmir, Turkey, studied by Eranıl et al., where the introduction of high rise housing led to a reduction in social interaction among residents (Eranıl Demirli et al., 2015). On the one hand, this marks improvements in indoor housing conditions after the Urban Housing Reform. On the other hand, they also suggest that the material components of the neighbourhood that support vibrant social and communal life have been lost. As earlier studies that show that shared use or the presence of common public facilities often contribute to social vibrancy in public or community spaces (Lu et al., 2019; Tumlin, 2012), this warrants a call to action to define and identify new elements in the urban socio-spatial system that can enhance social and communal life of the compound.

In terms of social changes, two key issues were identified: compound management and usage of public space. These two topics correspond to the findings of Eranıl et al. (Eranıl Demirli et al., 2015), Gür Enön (Öymen Gür and Enön, 1990) and He (He, 2013). With regards to compound management, the study findings show a major change of management actors in the Danwei compound. For example, before the reforms, the Danwei solely initiated, funded and employed personnel for compound maintenance and management activities (e.g. garbage collection, facility maintenance and cleaning). However, the reform-induced private house ownership and the decline of Danwei economic situation means compound management is now in the hands of Danwei employees, residents, and government—a much chaotic situation than before the reforms. This is contrary to some studies in the East Asian context which show that well organised communities and grassroot organisations can collaborate with public and private agencies to support better compound management, such as the Chonai-kai in Japan (Nishimoto, 2018) and thus, should be given attention in improving compound maintenance and management activities. In the context of Danwei compound it suggests the need for a well-developed communication regime between the residents and the local government (Tian, 2012).

In summary, the above reforms did not adequately take into account the acceptability and sustainability of local communities. It could even be argued that these reforms have completely reshaped the political and economic framework of Chinese society, which in turn has led to a complete overhaul of local communities. Yet, because of the rapid economic development and material and material improvements brought about by these reforms, the side effects of these transformations did not result in the destabilisation or collapse of local communities. In the words of a common expression for China's modern reforms, 'the problems from the development shall be solved in the development'.

Chapter 7

Spatial Distribution of Urban Commercial in Hefei City

7.1 Introduction

Commerce is one of the most important feature of cities. It can reflect many aspects of a city, such as economic and living conditions. For instance, Jacobs pointed out that small business is an important node of street vitality (Jacobs, 1961); different researchers have proved the positive role of commerce for the community by different perspectives (Bonaiuto et al., 2003; Pothukuchi, 2005). Moreover, the distribution of urban commercial space has always been an important part of commerce studies. Such researches have provided basic references for urban researchers, planners, policy makers and business sectors, especially retail companies, to understand the condition of cities. As a kind of raw data, it can also be combined with other data to conduct various urban studies, such as wild birds distribution research (Ortega-Alvarez and MacGregor-Fors, 2009), mechanism of urban development(Yuming, 2018), etc.

Currently, the most common used data and tool for commercial distribution analysis is Point-of-interest (POI) data and Geographic Information System (GIS) software (Chezhi et al., 2019; Pujiang, 2018; Yang et al., 2019; Yuan et al., 2012). POI means a specific point location that someone may find useful or interesting in online maps, which often stand for stores, museums, hotels and so on (Ren et al., 2017a). However, we face some imperfections in practices while using POI data: (1) some small shops are not labeled as POI points; (2) many POI points suffer from wrong geographical coordinates; (3) the difference in POI data from different sources is significant; (4) the POI date are points on a Point on a two-dimensional surface and do not contain enough information to reflect the real world; (5) at the microscopic scale, POI data is difficult to match with specific roads, and therefore causing confusion for planners and policy makers to use it accurately.

Recent years, the online map services such as Google Map and Baidu Map (Baidu.com; Google.com) provide an alternative data of POI in their public GIS databases. They are called the Street View image. They provide a service that virtually displays the surrounding environment, with millions of panoramas on the streets all across the city. In major cities, the Street View service almost covers every single street. Thanks to the development of deep learning and public GIS databases, now we have the raw data (Street View image API) and tools (deep learning) to carry out studies based on large scale Street View image. There have already been researches based on this data and method (Liu et al., 2017) (Kang et al., 2018). However, there has not been any study on commercial space that is carried out by this method.

In this study, we aim at analyzing urban commerce distribution by Street View images. We collect the street network in the range of central urban areas and download the street view images via an open web API. For three cities in China (Hefei, Nanjing and Shanghai), we download around 400,000 Street View images. All these images are used for analyzing. All the images are classified by the commercial facility types. However, it is difficult to discriminate their categories by simply using the DCNN models (like in Liu et al.'s paper (Liu et al., 2017)). To solve this problem, we choose signages as our initial identification target and analytical reference. The signages, which often stand for shops (The New York State Small Business Development Center, 2004), play significant roles in modern commerce. The work by Tsai et al. (Tsai et al., 2014) shows that finding the signages of shops using Street View images is possible. Therefore, we design a two-level learning method for image classification. In the first step, we choose an algorithm which is based on a regional convolutional neural network (faster-RCNN (Ren et al., 2015)) for object detection of signages. Faster-RCNN performs well on some common data set (PASCAL VOC (Everingham et al., 2010), COCO (Lin et al., 2014)). For each image, detected signages will constitute a distribution. The characteristic of signages distribution varies from one commercial facility types to another. Therefore, it is possible to classify images by this method. In the second step, for each image, signage distribution information classified by the first step is converted into a fixed dimension. We name this process as data reconstruction which will generate the new format of data for each image. Then, the images are classified by a Random Forest classifier trained by new format of data. In addition, the heat maps of cities are drawn by the total classification results. We also verify our heat map with the results of other researchers. By all these steps with the more advanced algorithms, we aim at a higher accuracy of the image classification and higher efficiency of the total workflow than existing researches in this field.

Our innovation is summarized as below:

- By using and modifying deep learning technology in a traditional research field, which is urban (commercial) spatial distribution, a cross-boundary research is achieved.

- By using the two-level learning mode of object detection and classification, the recognition accuracy is improved.

- A new commercial sensing method based on the simulation of human visual perception is realized. The highly efficient feature of deep learning technology helps to achieve the large-scale research which is difficult to achieve with traditional methods.

In this study, Hefei was the research target city, while the city of Nanjing and Shanghai was selected as reference cities because they are the major provincial capital cities which locate in the middle and lower reaches of the Yangtze River Basin. Due to the financial and computing power limitation, it is difficult to conduct research on the whole city region. So the research area is limited to the urban center.

The research area of Hefei City is about 106.3 square kilometers (Fifure 7.1), with 49,140 sampling points. The research area of Nanjing is about 151.4 square kilometers (including some Yangtze River water-body), with 59,420 sampling points. The research area of Shanghai is about 120.6 square kilometers (including some Huangpu River water-body), with 55,998 sampling points.

7.2 Object Detection Analysis

The results of the test set were represented by the Precision-Recall(PR) curve (see Figure 7.2). Through the PR curve, we found that the model achieved good results on the shop sign, with an Average Precision(AP) value of 0.888. But compared to shop sign, the result of the signboard class is at a lower recall rate. This may be because that the number of signboard is less than shop sign, and some samples are really difficult to discriminate. Despite some losses, the trained model achieves the purpose of finding two kinds of signages. Through the PR

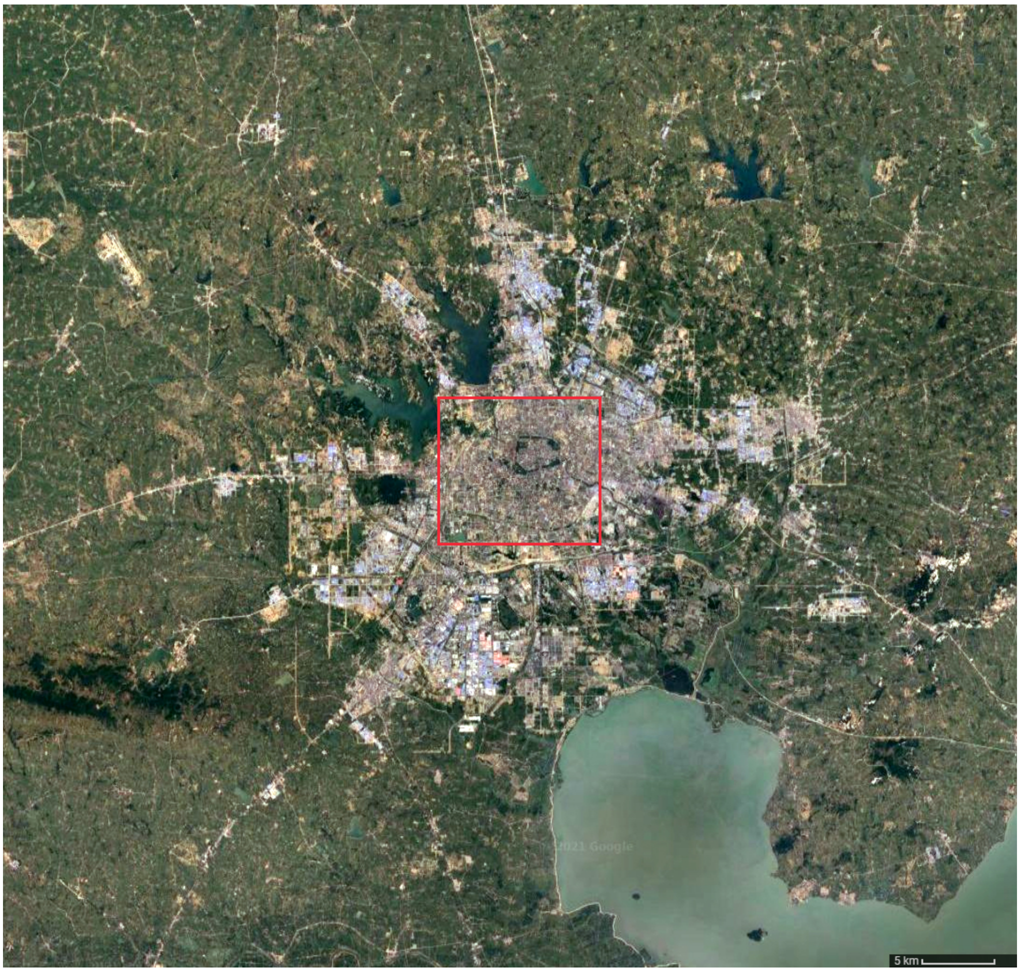


Figure 7.1: Research Area in Hefei City.

curve, we also find that the detection of the two targets would have high precision and recall values at the same time with the confidence over 0.9. Therefore, in object detection section, we only reserve the bounding box with a confidence over 0.9 for each image.

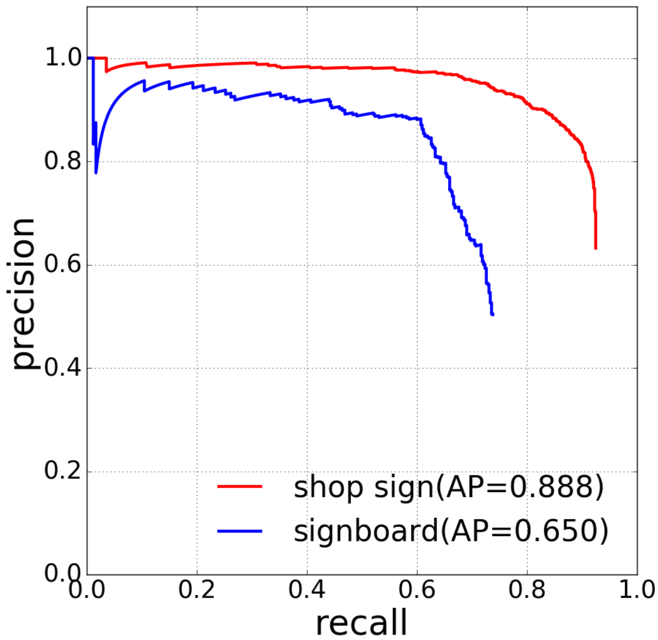
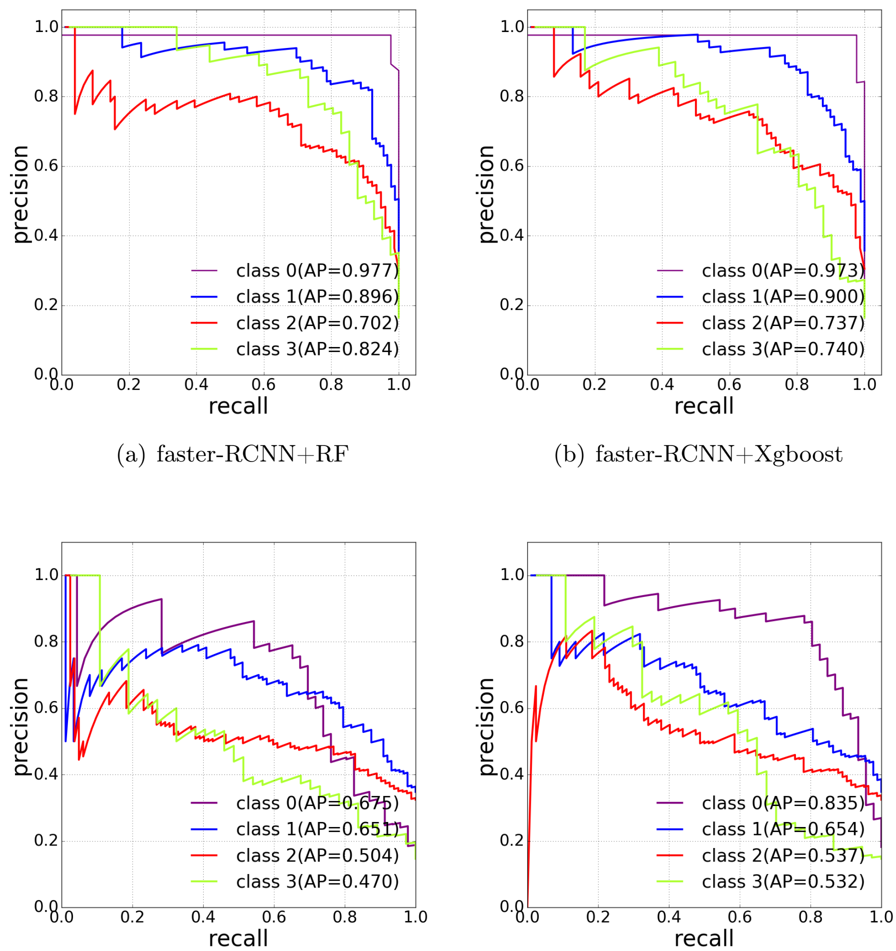


Figure 7.2: PR curve of test set for object detection.



(a) faster-RCNN+RF

(b) faster-RCNN+Xgboost

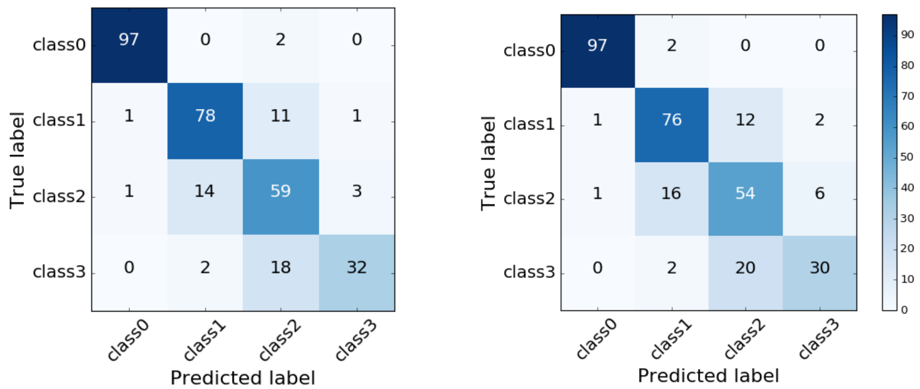
(c) ResNet-101

(d) DenseNet-121

7.3 Classification Analysis

We list the results of Xgboost(Liaw et al., 2002) and RF(Chen and Guestrin, 2016). For comparison, we also add the classification results directly using the DCNN, which is the method used by Liu et al.(Liu et al., 2017). The results of PR curve are shown in Figure 7.3.

From the results, we see that it is difficult to distinguish four types of images simply by using DCNN. Through our two-level learning method, average precision values for all four kinds have been improved. On mAP, the highest score was obtained by using RF as the final classifier of 0.850. Therefore, RF is chosen for the classification section. From Figure 7.3 we also find that the AP of class 2 is significantly lower than other three categories. This means that in our model, the images of class two do not show obvious characters. For class 0, the ideal result for object detection should be no box. But there are some objects that are not signage being misdetected. This leads to errors in the classification after data reconstruction. The confusion matrix of our method which tell specific results is also shown in Figure 7.4.



(a) faster-RCNN+RF (b) faster-RCNN+Xgboost

Figure 7.4: Confusion Matrix of our method in test set

By remarking the classification result back onto the map, we can get the distribution map of commercial facilities on both sides of the street network of a city. Here is an example of the city of Hefei (Figure 7.5). The granularity of this data depends on (1) the density of the street sampling points; and (2) the sampling density of the Street View images provided by the online map provider.

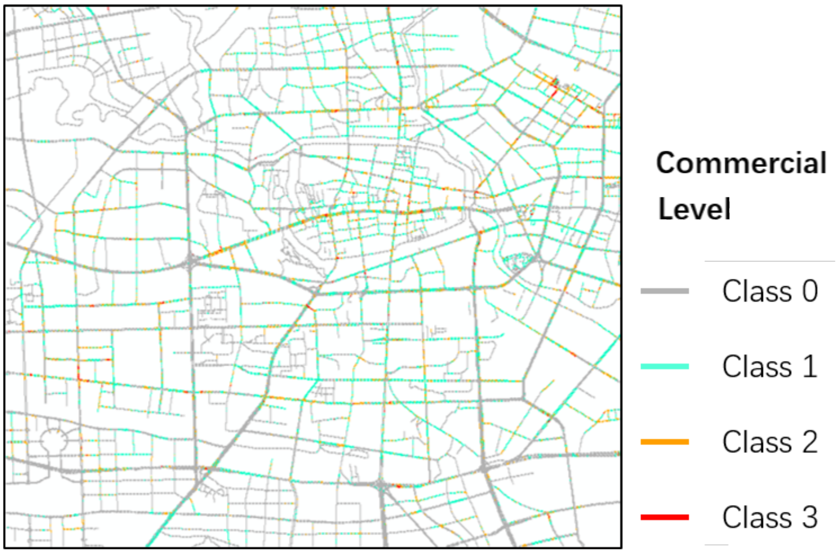


Figure 7.5: Commerce distribution map of Hefei.

7.4 Heat maps and Analysis

According to the results of classification, we draw the heat maps of the three cities as shown in Figure 7.6. Since kernel density analysis actually counts the number of points within a certain range and clusters according to their spatial distribution, these heat maps directly show where the shops (signages) in the city are concentrated.

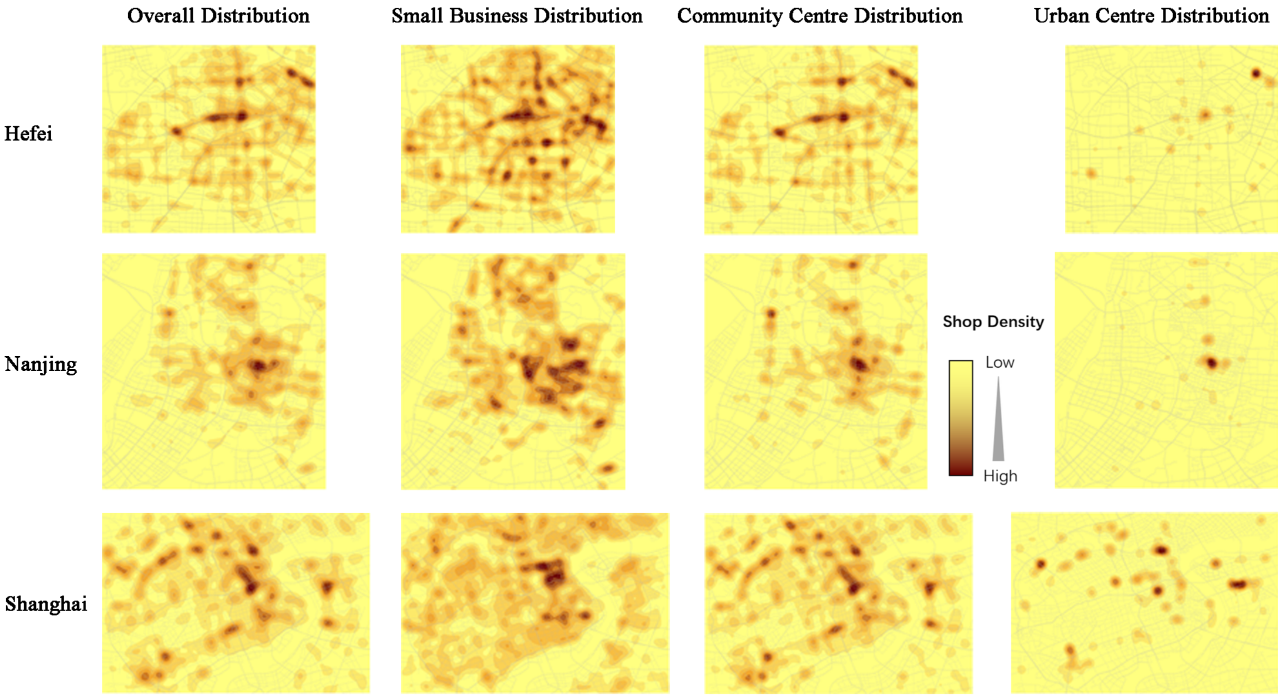


Figure 7.6: Urban commerce distribution heat map

By observing and analyzing these heat maps, we could observe the following characteristics of shop distribution in each urban central area. Hefei: (1) Commercial distribution are highly related to road network system. Most commercial districts locate along the main roads separately; (2) The center points are scattered, showing obvious Voronoi diagram distribution; (3) Business is concentrated in old urban areas, and commercial facilities are scarce in urban fringe areas (south and northwest corner); (4) The distribution of small businesses and large commercial centers is more uniform; (5) Community business centers have obvious multi-core cluster characteristics.

Nanjing: (1) All levels of commerce area are centered and highly concentrated around Xinjiekou; (2) Old urban areas are generally high-continuity and high-density commercial areas as a whole; (3) The distribution of small businesses in the central area of the old city is uniform and has high-density, which forms a large number of community business centers, but these centers are neither large-scale nor continuous (a large number of community business centers have been optimized and deleted by the streets); (4) Business is highly concentrated in the old urban areas, and there is little commerce distribution in the new southern urban areas, including those along the Yangtze River; (5) There are relatively fewer shopping malls.

Shanghai: (1) Business is widely and evenly distributed, with high commercial coverage and density in Puxi District but relatively low in Pudong; (2) The concentration of Commerce on the same street is low, and it distributes evenly in the whole city (after street optimization, the overall commercial coverage is significantly reduced); (3) There is a very clear continuous central business district; (4) Small businesses in the general community are very developed.

As indicated from the analysis above, this method could comprehensively reflect the following characteristics of commercial distribution in cities: (1) Overall commercial distribution; (2) The distribution of small businesses, community center businesses, and city center businesses; (3) Continuity between commercial areas; (4) Shop intensity.

7.5 Verification of accuracy

We find one commerce distribution analysis papers for each of these three cities as the benchmark for verification. Although these studies differ from the POI data in terms of accuracy and actual visual perception, the rough structure in city scale should be consistent.

Hefei: Two core business districts and three secondary business districts can be observed. This is consistent with the commerce distribution characteristics of Hefei City described in the research results by CHENG, et al (2019)(Chezhi et al., 2019).

Nanjing: It is obvious that the Xinjiekou is an absolute single-core commerce area and radiates to other directions except the northeast, which is blocked by Yangtze river. This result is consistent with Yang's, et al. (2019)(Yang et al., 2019) research results on the overall commerce structure of Nanjing.

Shanghai: The Puxi area is almost entirely covered by high-level commercial areas except for the central east portion, while the Pudong area has no core business area except Lujiazui. This is consistent with the results of the Shanghai Commerce Distribution Study by Huang and Du (2018)(Pujiang, 2018).

It should be pointed out that the existing urban commerce distribution results based on POI data have larger granularity and low fineness. In the three papers used as benchmarks, the results of the other two papers were rough in contrast. In

Table 7.1: Coverage of different commerce types in Hefei.

Walking Distance	General Business		Central Business		City Central Business	
	Area(km^2)	Coverage	Area(km^2)	Coverage	Area(km^2)	Coverage
<300m	24.9	23.4%	11.5	10.8%	13.1	12.3%
300-600m	22.8	21.4%	18.1	17.0%	4.6	4.3%
600-1000m	29.1	27.4%	31.1	29.3%	1.8	1.7%
<1000m	76.9	72.3%	60.8	57.2%	19.5	18.3%

these papers some location information of the business district described in their heat maps does not accurately march with the streets or even the blocks. This reinforces that our two-level learning method has high precision and resolution in term of classifying commerce features/analyzing commerce distribution patterns.

7.6 Possible application of this method in Urban Planning Practice

As a large-scale, programmable city-scale analysis tool, the application potential of the research methods applied in this study can be foreseen in the fields of smart cities, urban planning or construction management. Since this method produces a result of commerce distribution of a city, which can be used as input data in other urban researches, we could find a large research field after this.

Here is a list of some major following usage scenarios in our vision: (1) Calculation of accessibility of commercial facilities; (2) Researches on urban spatial structure characteristics based on commerce distribution. If combined with other data, it can provide a wider range of application scenarios, for exmaple: (3) Combining residential area location, population distribution and other data to study urban commercial coverage; (4) Combining mobile phone signaling data to study the interaction between commercial facilities and people; (5) Combining POI data to determine the hidden commerce distribution of the city; (6) Based on the frequency of street view map update, dynamic monitoring of urban business changes may be achieved.

For example, a business accessibility analysis is conducted for Hefei City. The commerce accessibility of various parts of the city is analyzed based on road network data and our business point level data, with the Network Analyst feature in ArcGIS. Here we refer to the relevant requirements of the 15-minute living circle, in which the residents can reach the living service facility within 15 minutes of walking. It could be converted into a distance of about 1200 meters. By the above measure, the service area, which demonstrates the walkable coverage of commercial facilities could be drawn. The results of the analysis are shown in Figure 7.7.

Figure 7.7: Walking range coverage of different commerce types in Hefei.

The result shows that the commerce accessibility of the downtown area is generally good, and the coverage of medium commercial centers is large. Although the city-level central business districts are widely distributed, the range of services outside the old town is very limited. This is presumably due to the lack of a pedestrian transportation system or a low density street network.

Chapter 8

Conclusion and Planning Implication

8.1 Introduction

This chapter concludes the research study. it summarizes the major findings, and introduces policy implications. It also presents the future research direction of this research concerning the findings and the objectives of this research for Danwei compound in Hefei city.

8.2 Summary of Findings

Based on the analyses of previous sections, the major findings have been organized along with three main themes:

The Spatial Distribution of Danwei Compounds

· Danwei compounds still dominate in the spatial organisation of The Hefei old town. This suggests that the spatial system of the Danwei compound did not completely disintegrate with the decline of the Danwei system as the social system.

· Public space in Danwei compounds provides the potential for community building. The lower plot ratio and building density of Danwei compounds indicate the existence of more public spaces in comparison with non-Danwei residential sites.

· Uneven distribution of public facilities in Hefei old town. Quantitative analysis results also show that the main element that significantly distinguishes Danwei compounds from the non-Danwei site is accessibility to commercial centres, elementary school and hospitals.

Social-Spatial Changes in the AMS Danwei Compound

· After the reforms, the AMS Compound has lost most of its public space, gradually eroding the spatial context for urban public life. Moreover, shared or common use public facilities (e.g.shared tap water) that used to be the converging point for resident's interaction and social life (social groups) before the reforms have gradually disappeared.

· Since 1999, the AMS Danwei compounds have seen physical readjustments in land use and housing densification rather than outward physical expansion, which is commonly found in Asian and other cities in the emerging world.

· A shift in the spatial concentration of residents' daily activities from within the Danwei compound to outside of the compound. Specifically, the change in building functions (office relocates to the outer city) and the reduction in time residents spend in the compound has meant daily activities has extended beyond the compound.

· Compound management actors has been shifted from Danwei-leading into the hands of residents and government, which is making a much chaotic situation.

The Spatial Distribution of Commercial Facilities in the Old Town of Hefei

· Building a city commerce distribution sensing system based on Street View image and deep learning with with sufficient accuracy and usability is possible.

· The system built in this study has achieved its theoretical advantages (more realistic reflection of pedestrian visuals on the street) than traditional POI-based urban commerce distribution research. We believe that with more training data, it is possible to further improve the scores.

· A carefully designed two-step learning approach can be effective in improving the accuracy of deep learning models for specific tasks.

8.3 Policy Implications and Recommendations

Today's Danwei compounds are considered 'old' neighbourhoods in Chinese cities. Due to the rapid expansion of cities, Chinese urban planners and policy makers have spent most of their time and energy on building new cities over the last 20 years or so, and have not paid enough attention to the old urban areas and the old neighbourhoods, including the Danwei compounds. This has resulted in inadequate refurbishment of older neighbourhoods in older cities. Based on the findings of this study, the following are some policy implications and recommendations for the urban planning and policy making for old urban areas and old neighbourhoods.

Planners and government need to value and protect public space in urban neighbourhoods. Residential space needs particular attention from local government and planning authorities in terms of improvement in spatial conditions and urban functions and preservation. Open spaces can be used to organise community events, build common facilities to increase social engagement and interaction opportunities for local residents. The need for supportive planning and design policies that improve the public realm of Danwei compounds. Clearly, that the decline of public space in the community represents declines in the quality of social life brought about by the former top-down reforms.

Increase the coverage of all public facilities in order to achieve spatial equality. Uneven distribution of public facilities requires a response from the local planning authority to improve the coverage of public services and better community planning and design that enhances the pedestrian environment. Clearly, this informs better collaboration with residents and educational, health and commercial service providers in spatial planning.

Planners need to understand, analyse and integrate the special needs of Danwei residents in order to plan for them appropriately. This implies opening up the planning and design process to factor the needs and aspirations of residents in the old city core, where most residents reside in Danwei compounds. Additionally, it invites the local government to avoid over-concentration of development of outer areas to improve social and spatial quality inner areas of the old city core. this study recommends structural improvements in the city and regional planning, such as creating more efficient non-motorised transport facilities or implementing more compact city planning principles.

Rebuilding local community organisation with resident participation. This measure could lead to the increasing of the communication intensity between residents, the improvement of basic community services and management capacity. Such organisation could also act as an intermediary layer between residents and the government. This organisation can take the form of an homeowners' or tenants' committee organised by the residents, or a primary administrative service team facilitated by the government, or a combination of these two.

Advance planning intervention as a prerequisite for high density neighbourhood development. The reorientation of the site edge pattern and the high density development of the AMS Danwei compound show the positive side of the development of this urban community. However, the lack of early planning intervention has led to a loss of community function and a failure to create a mixed-use community. This calls for targeted interventions in urban design principles that make room for public facilities and public spaces such as shops, neighbourhood parks and walking system. In a post COVID-19 urban environment, this can encourage enrich the residents' time spent in the neighbourhood and overall community life.

Emphasis should be placed on new means of urban perception brought about by technological advances. Urban data provided by online mapping services, including city road networks, community boundaries, building outlines, building levels, and street view images etc., are used extensively in this study. And GIS, spatial syntax, deep learning and other tools were used to analyse and interpret this data. The information technology has given planners and politicians the ability to quickly perceive large scale urban spaces and can provide a certain level of support for planning and policy decisions. These capabilities are necessary for decision makers at a time when society is evolving and cities are changing more and more rapidly.

Future economic development, policy formulation and social reform should take full account of the sustainability and acceptability of local communities. In general, China is transitioning from a phase of rapid development to a stage of stability, and the future model of urban construction and community development will inevitably shift from the previous rough-and-tumble approach to a fine-grained planning approach. With the help of advanced technology, planners now have more than sufficient capacity to control the development of communities in a more detailed way. With the attention of policy makers who can build a community mindset, Chinese communities would achieve systematic and sustainable development.

By collating the above findings and planning implementation recommendations according to the scales, Figure 8.1 is obtained. From which it is easy to read the problems faced by Chinese urban communities, represented by Danwei compounds, from the community level to the national level, with the corresponding suggestions for improvement.

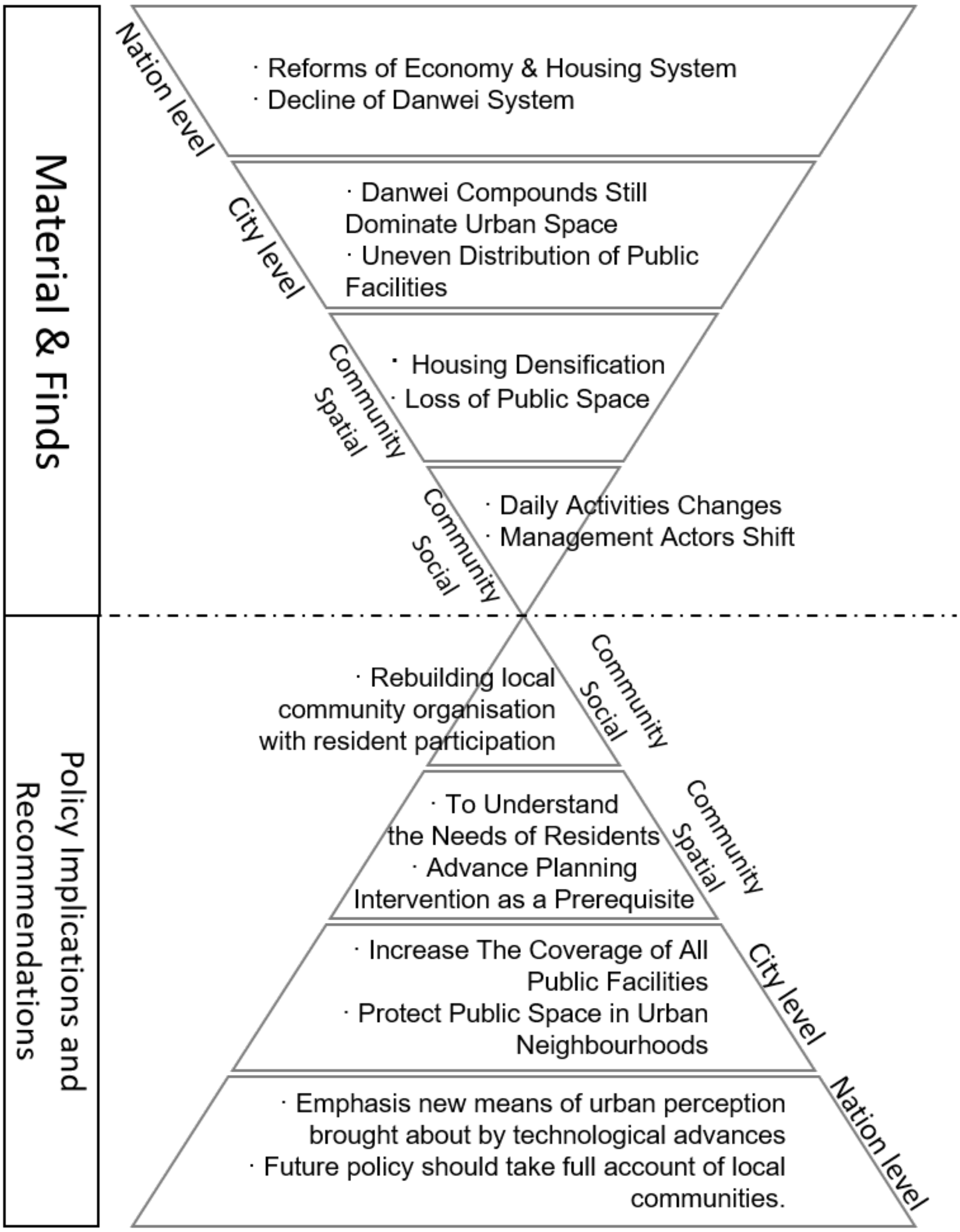


Figure 8.1: Findings and Recommendation at Different Scales

8.4 Future Study

this study has analysed the spatial distribution of Danwei compounds in the old town of Hefei, Anhui province of China; investigated social-spatial changes in the AMS Danwei compound in Hefei, via the situation before and after the 1978 Reform and Opening Up and the 1997 Urban Housing reform; and designed a city commerce distribution sensing method based on Street View image and deep learning. These works and findings coupled with the limitations (see Chapter 4.6), therefore provide entry points for future studies. The initiated future research directions include:

· Access to more and larger scale data. For example, to study the accessibility of various urban neighbourhoods and more types of public services on a larger scale; to study the historical changes of more Danwei compounds from more socio-spatial elements and to compare them cross-sectionally; to use higher computing power to identify various urban facilities with higher accuracy on a larger scale, to comparative analysis different cities, etc.

· The comparison of Danwei compounds in the same urban area across different historical periods. More so, In-depth study of the current situation within one Danwei compound is also a valuable research direction. How many of the current residents in the Danwei compound were newly moved in after 1997? Where did the residents who moved out of the compound go? Why did one leave, and why did one stay? What is the current ownership status of the homestead in the Danwei compound?

· Adding more objective data to the socio-spatial analysis. Examples include the length of internal fences, income of residents, population data, etc. As well as adding objective data based on on-site observations, such as marking the map with data on residents' spatial activities, counting footfall, etc. The inclusion of such data can provide additional direction for analysis and enhance the persuasiveness of the study.

· Aggregate analysis of more structured data. Since the results of the urban commercial distribution data can be used as input data for other urban researches, it could combine with other urban data, to achieve various issues related to urban commerce could be studied.

Therefore, the future research will capture a closer look at the Danwei compound, more Danwei compounds and other types of neighbourhoods, and more in-depth observation and study of urban communities including the Danwei compound.

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Appendix A

AMS Compound Questionnaire

A.1 General Respondent Information

Q1.1 What is your gender?

Male	
Female	

Q1.2 What is your age?

18-35	35-45	45-65	65+

Q1.3 Are you (or were you) an employee or family member of an employee of the Danweis in this compound?

Yes	
No	

Q1.4 How long have you lived in this compound?

<1 year	1-3 years	3-10 years	10-20 years	over 20 years

A.2 Evaluation of the Compound

Q2.1 Do you think the living environment in this compound is better or worse than 10 years ago?

Significantly worse	Slightly worse	No change	Slightly better	Significantly better

Q2.2 Do you think the environment surround this compound is better or worse than 10 years ago?

Significantly worse	Slightly worse	No change	Slightly better	Significantly better

Q2.3 Do you think the environment surround this compound is better or worse than 10 years ago?

Significantly worse	Slightly worse	No change	Slightly better	Significantly better

Q2.4 Do you think the living environment in this compound is better or worse than 20 years ago?

Significantly worse	Slightly worse	No change	Slightly better	Significantly better

Q2.5 Do you think the environment surround this compound is better or worse than 20 years ago?

Significantly worse	Slightly worse	No change	Slightly better	Significantly better

Q2.6 How many acquaintances do you have besides relatives in this compound?

0	1	a little (2-5)	some (6-15)	many (15-)

Q2.7 Do you own a apartment in this compound?

self or family owned	rented	borrow (pay no or little fee)

Q2.8 Do you live alone or with your family?

live alone	with family	share house

Q2.9 Excluding yourself, how many people are living with you?

1	2	3	4	5	6	7	8	9	10+

A.3 Activities

Q3.1 Where would you normally choose to chat with others in the compound?

at home	at door or stage	in front of the building	small public space	on the road	in squares

Q3.2 Where do you most often interact with others (other than your family) in the compound? (mark on the map)

Q3.3 What time do you normally leave for work on a typical weekday? (Please write the time)

____

Q3.4 What time do you usually arrive home on a typical weekday? (Please write the time)

____

Q3.5 Your one-way commuting time is:

in 10 min.	10-20 min.	20-30 min.	30-45 min.	45 min.-1 hour	1-2 hours	over 2 hours

Q3.6 Where do you usually eat lunch on a working day?

at home	at work	at restaurant

Q3.7 (only for respondents who choose ’at restaurant’ in Q3.6) The approximate location of the restaurant you often go to for lunch is (mark on the map):

Q3.8 The places you visit most often on your days off are (mark on the map):


庐阳区大杨
工业园
董铺水库
合肥市现代
农业示范园
合肥植物园
庐州公园
中国铁建·国际
城湿地公园
3号线
半岛公园
庐阳区
三角线桥
天水公园
合肥东站
济民肿瘤医院
新海公园
瑶海公园
生态公园
合肥站
郎溪路立交桥
学林公
万博科技
职业学院
安徽农业大学
杏花公园
古逍遥津
安徽省地质矿产勘
局三二七地质队
花冲公园
瑶海区
西二环长
江西路桥
蜀山区
银河公园
裕溪路立交桥
瑶海湾湿地公
大蜀山国家
森林公园
恒悦国际外商
俱乐部酒店
中国科学技术
大学(东校区)
合肥工业大学
(屯溪路校区)
瑶海区滨河公园
安徽新华学院
合肥市政府
中国科学技术
大学(南校区)
关镇村
合肥绕城高速
徽南立交桥
天鹅湖体育公园
安徽建筑大学
(北校区)
明珠公园
淝河生态公园
G4001
合肥体育中心
小西冲枢纽
安徽医科大学
第二附属医院
沪汉蓉桥
联东U谷
繁华大道
桃花潭公园
安徽省市场
监督管理局
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