Working Paper

Methodology of Community Survey in Beijing Metropolitan Area: spatial typology, sampling methods and questionnaire design

Cecilia Wong, Miao Qiao, Wei Zheng
with Richard Kingston, Lei Wang and Somayeh Taheri

Spatial Policy & Analysis Lab, Manchester Urban Institute, The University of Manchester

Overall sampling strategy

A robust management model of eco-urbanisation has to be underpinned by scientific understanding of the relationships between the behaviour of urban residents, resource consumption, policy control measures and environmental change in typical neighbourhoods. The survey is an essential step to explore the key variables of urban development and interactive effects on environmental impacts and to rescale the discussion to neighbourhood level to provide micro-level evidence. More explicitly, the survey is to find out patterns of living style and behavioural change in association with urbanisation to develop trajectories of change into the area-based model of the impact of urbanisation on resource consumption. This means the purpose is to extract insightful information to understand different neighbourhood groups' behaviour as well as how urbanisation changes the dynamics (e.g. floating population becomes full urban residents; in-situ urbanisation of rural population; middle class becomes more environmental conscious; rich elites becomes more resource extravagant).

The participants will be chosen on the basis of a *multi-stage, spatial cluster* sampling approach. A *spatial typology* of the case study region, the Beijing Metropolitan Area, was first created by classifying land-use form, demographic variables, and transport accessibility at the township-level administrative unit. Based on the typology of three area groups and further consultation with experts from Peking University, typical township-level units were then chosen from each area group as case study areas. A total of 8 townships of Beijing were chosen and socio-economic profiles were compiled to provide pen pictures of these townships in terms of their local planning framework, economic activities, transport connectivity, public service infrastructure, local culture, education, and other types of amenity.

The third stage involved the selection of local neighbourhoods in each township. Based on the targeted sample size of 0.2% of the total residential population of the 8 townships (i.e. 2260 out of 1,129,995) and a built-in attrition rate of 15%, a sample of 2,600 participants was targeted. Since a valid sampling frame of individuals/households at the township level was not available, a pragmatic decision was made that 120 participants (with built in attrition rate) would be recruited from each local neighbourhood. This meant that a total of 21 neighbourhoods would be selected on a pro-rata basis from the 8 townships according to their population size bands. The sampling frame of the township neighbourhoods was based on the National Statistics Bureau's 2014 sample of neighbourhoods in Beijing townships. After the 21 neighbourhoods were identified, 120 participants were approached in each neighbourhood with a non-probability quota sample - based on age and gender plus a filter question of whether they have any physical and mental health conditions that may affect their participation of the survey).

In addition, a township from Hebei was also included in the study as it is located at the border of Beijing (adjacent to one of the case study neighbourhood) where a lot of residents commute daily to work in the central zone of Beijing.

One of the research goals of this study is to identify areas where rapid and deepened urbanisation will bear ecological consequences: at macro level – urban form, land-use and infrastructure; and at household level - energy, water and waste. The survey data, triangulated with other spatial data and qualitative assessment data, was used to provide more grounded analysis.

Spatial typology of Beijing Metropolitan Area

The main sample strategy was to select participants based on a spatial typology of the city-region. Due to practical reasons, township-level administrative unit was used as the basic unit of the spatial classification. The result of the spatial typology provided spatial statistical criteria for selecting case study townships and the multi-stage sample frame for the selection of neighbourhoods and survey participants. The methodology of the spatial typology is explained below.

Initial data collection and assessment

Three stages of data collection and assessment were conducted to identify, collate and assess appropriate datasets for this research.

First of all, census data of total/urban registered and resident population, GDP, urban land, urban green rate (total and per person), urban/rural resident income, and energy consumption (total and per GDP) were collected. The spatial scale of these data varies for different areas: county level administrative units for Beijing and Tianjin and the prefecture level administrative unit for the Hebei region. The crude spatial scale of the data was deemed as not suitable for the study, as the data did not capture the variations within the large spatial unit. Therefore, other sources of data were identified in the second stage by exploring data at the township level administrative unit for Beijing metropolitan area only.

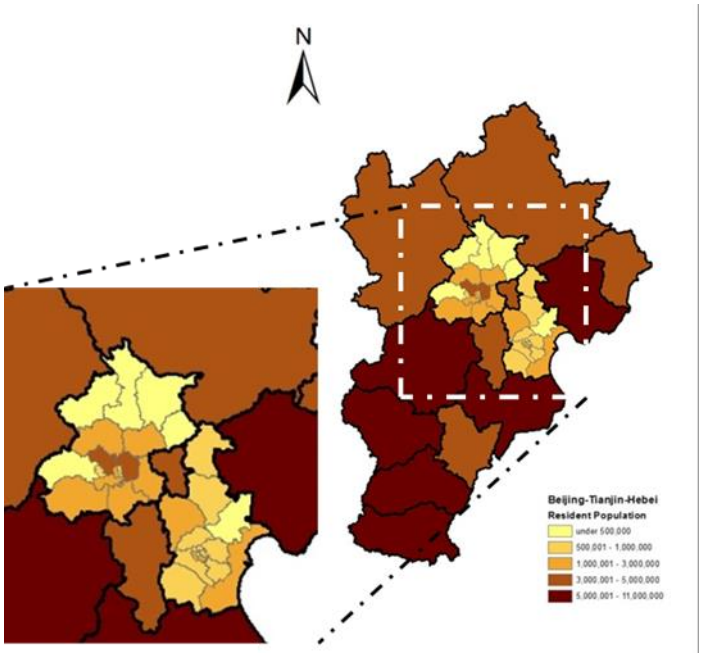


Figure 1 Resident Population of Beijing-Tianjin-Hebei Metropolitan Area
Data source: Beijing, Tianjin, Hebei Statistical Year Books (2016)

The data search process focused on 4 main data sources: Open Street Map, urban form data (wudapt.org), online property agencies, and Baidu Maps. From these resources, only the urban form data specially supplied by Dr. Chao Ren from the Chinese University of Hong Kong was found suitable for the research. Unlike the experience in the UK and other European countries, the point data (including schools, hospitals, bus stops, metro stations, businesses, and industrial areas) and the street networks of Open Street Map were found incomplete and inaccurate for Beijing when validated with local knowledge. This is probably due to the sheer amount of services and facilities required to meet the needs of the large population size in Beijing and local residents do not have the culture of posting data online to Open Street Map. Baidu Maps is an alternative as it is a desktop and mobile web mapping service application providing street maps and location of services and facilities in China. However, this data source's APIs are with restricted access for downloading information from their website. Finally, the online property websites also have restricted access to information to avoid major data extraction.

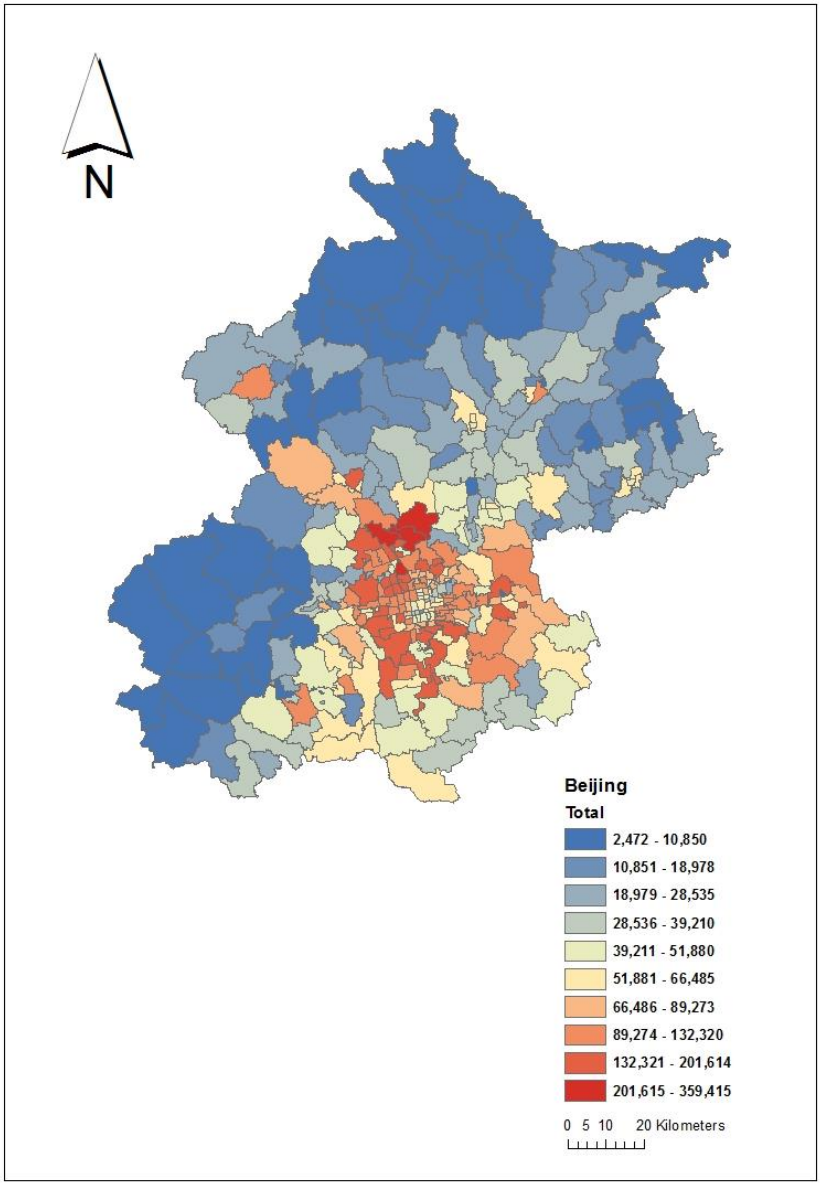


Figure 2 Population density of Beijing (at Township level)

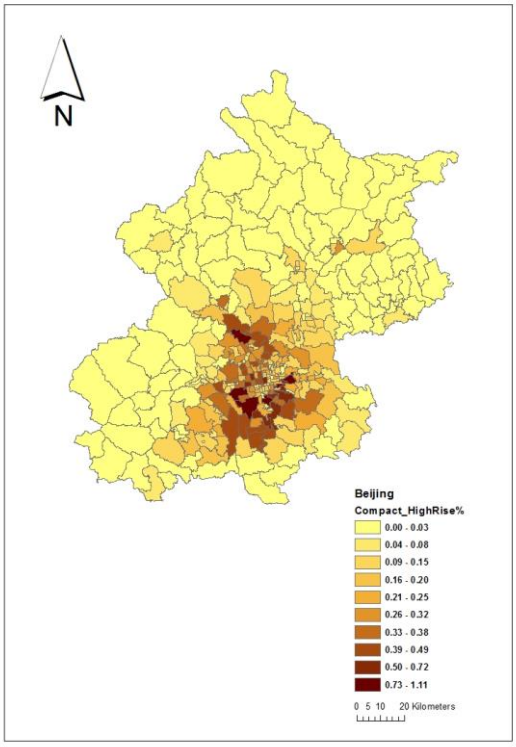


Figure 3 The percentage of compact high rise land-use in Beijing (at township level)

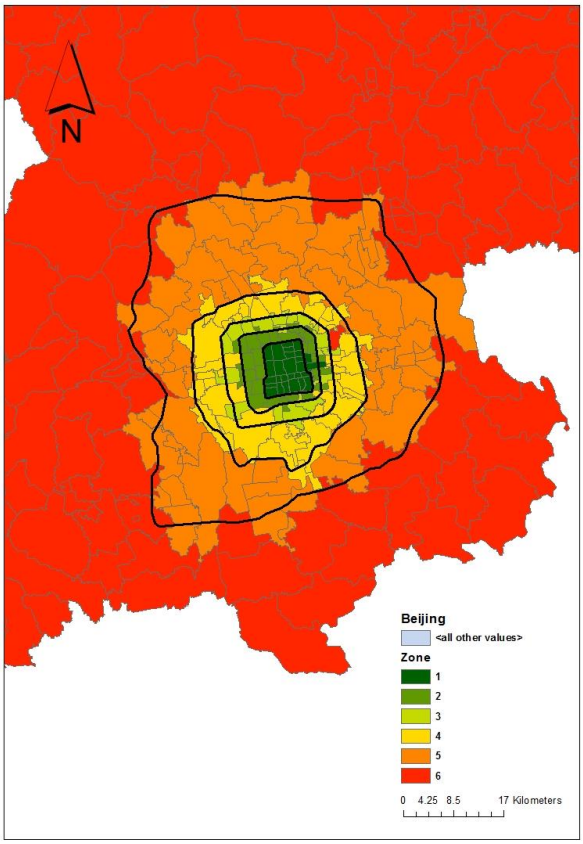


Figure 4 Zones defined by five main ring-roads in Beijing

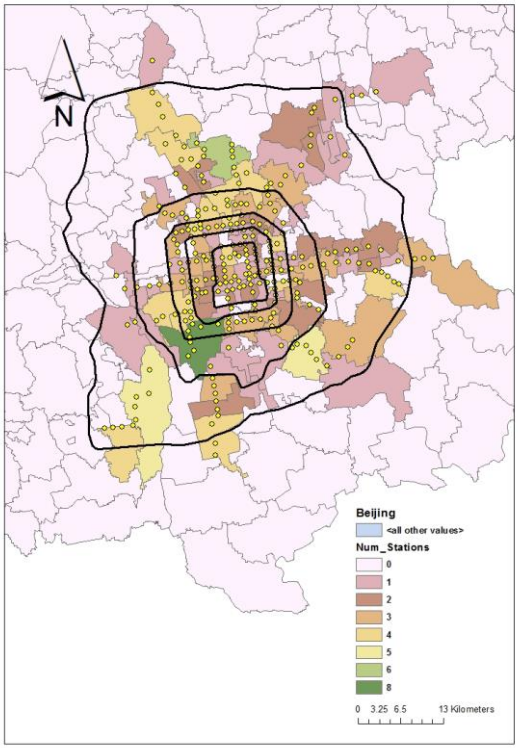


Figure 5 The location and distribution of Beijing Metro stations

The third stage turned to explore data from Google Maps, Beijing City Lab, and the SPA Lab's research networks in China. Google Maps were used to identify and map Beijing's city zones, shopping centres and metro stations. Beijing City Lab was contacted to supply data on bus stops, and other researchers in China were approached for special tabulated data on population, gender, age, and GDP at township level for Beijing.

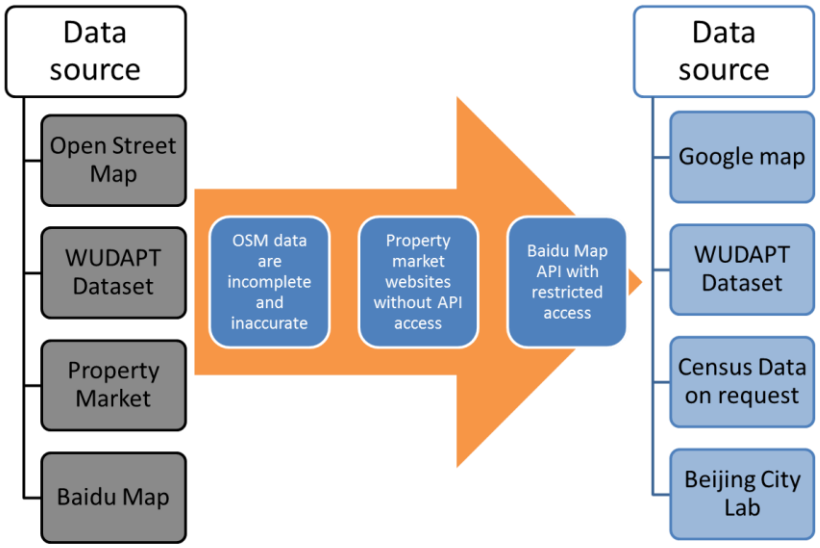


Figure 6 Data mining process

Data compilation and computation of key variables

Data was compiled for township level administrative units, which is used as the basic analytical unit. The dataset consists of three types of variables: urban form data, demographical data, and transport accessibility data.

1. Urban form data (the WUDAPT level 0 data and product of Jing-Jin-Ji region) was provided by Dr. Chao Ren's research team of the Institute of Future Cities of The Chinese University of Hong Kong (wudapt.org)[1].
2. Demographical data were extracted from official Population Census data.
3. Transport accessibility data were compiled by the MUI team by calculating accessibility measures to major ring roads and metro station with GIS.

Steps of creating the spatial typology

The clusters were created through a series of methodological steps to examine the statistical distribution, multicollinearity, underlying dimensions, sensitivity to different clustering methods and visual validation of distribution patterns with SPSS and ArcGIS.

(1) Correlation analysis: correlation analysis of the variables were examined and the general patterns suggest that compact urban forms (e.g. high rise and mid rise) are highly correlated, so are the open urban forms.

(2) Factor analysis: PCA was performed to examine the underlying dimension of the variables and the findings show that all the urban form variables group together and then the low density forms group together.

(3) Standardisation of all variables into z-score.

(4) Testing different cluster models with different combination of cluster variables with the two-step methods in SPSS. The findings show an over-dominance by the zone variable[2], so it was excluded; urban forms that do not have many residents e.g. sparsely built, large low rise and industrial) were also removed; and the next iteration showed the domination by compact vs open spatial form (which means that we focus on the compact high rise and open low rise as the cluster variables for urban form.

(5) Perform different cluster analysis of the variables until a preferred model emerged with the 2-step methods, which was then validated by performing the analysis via a different classification method (k-means non-hierarchical). The final cluster chosen is based on the 2-step method which combines the hierarchical and non-hierarchical methods and for ease of interpretation. The final model's cluster quality is deemed as 'Good' by the Silhouette measure of cohesion and separation **(+0.5** in the scale of -1 to +1).

(6) Through the mapping of the cluster with Google maps, the spatial forms and typographies and spatial relationships were checked. Outliers for each cluster was checked and confirmed the

[1] The Local Climate Zone (LCZ) data classifies land-cover in to 17 zone types shown in **Error! Reference source not found.**

[2] We delimit Beijing into 6 zones according to the major ring roads (see Figure 4).

classification was appropriate e.g. outliers in the cluster are largely related to unusual land use e.g. airports, military use, universities and institutional use of land.

The result of spatial typology

Based on the 2-step cluster analysis, the township level units of Beijing were classified into three categories (see Figure 7).

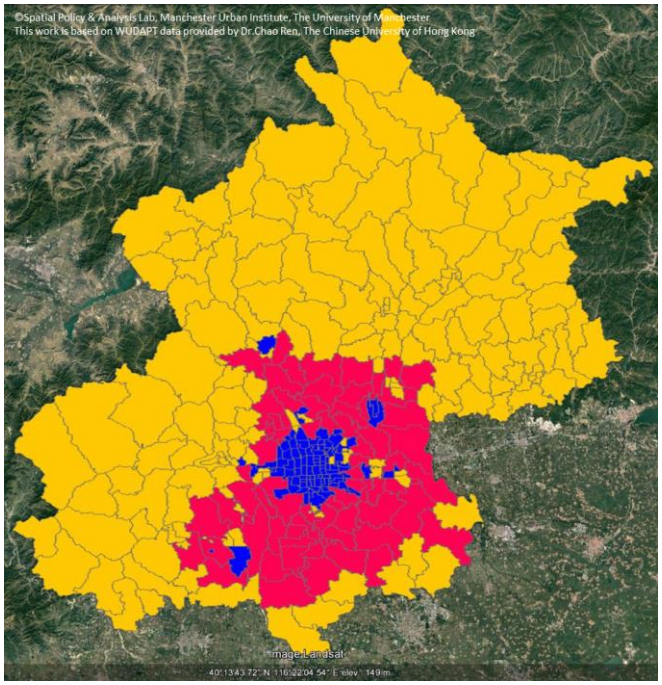


Figure 7 Spatial typology

The profile of each category is distinguished by a set of indicators identified by cluster analysis run on SPSS (2-step method) (see
Figure **8**):

- 'Density_sqkm': population density - number of people per square kilometre
  'Open_LowRise%': percentage of land cover defined as 'Open Low Rise' by wudapt.org
- 'Bush_Scrub%': percentage of land cover defined as 'Bush and Scrub' by wudapt.org.
- 'Under15%': percentage of population of the age under 15.
- 'Compact_HighRise%': percentage of land cover as 'Compact High Rise type defined by wudapt.org
- 'Age1564%': percentage of population aged between 15 and 64.
- 'Male%': percentage of male population.
- 'UGS000pop': number of metro station per 1,000 people.

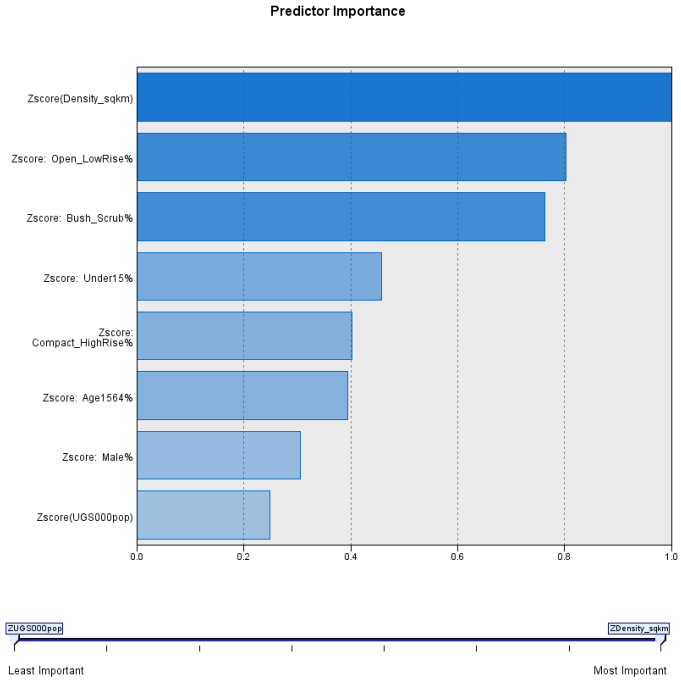


Figure 8 Indicators identified by cluster analysis

Type 1: Inner Metropolitan Neighbourhood (IMN) – in blue

- very high pop density, average open low rise, low on bush and shrub, very low age under 15, very high on compact high rise, higher on age 15-64, low on male pop, very good underground access.

Type 2: Outer Metropolitan Neighbourhood (OMN) – in red

- average pop density, very high on open low rise, very high on bush and shrub, average age under 15, very high on compact high rise, very high on age 15-64, very high on male pop, good underground access.

Type 3: Peri-Urban Neighbourhood (PRN) – in yellow

- very low pop density, low on open low rise, about average of bush and shrub, high age under 15, very low on compact high rise, very low on age 15-64, average on male pop, low underground access.

Selection of case study townships

One case study township was first picked from each of the three typologies to assess their characteristics. They were chosen based on their typical representation, their relevance for understanding the dynamics of urbanisation, and our knowledge of the local area. However, after assessing their distribution and local contexts, it was clear that the sheer spatial area covered by each township included very diverse characteristics. After consultation with experts from Peking University, 8 case study areas were selected for Beijing (see Figure 3). They are:

- Beitaipingzhuang Street, Haidian (Type 1);

- Xibeiwang Town, Haidian; Dongxiaokou District, Changping; Huangcun District, Daxing; Songzhuang Town, Tongzhou; and Doudian Town, Fangshan (Type 2);
- Binhe Street, Pinggu; and Xiji Town,Tongzhou (Type 3);

In addition, a township from Hebei was also included in the study as it is located at the border of Beijing (adjacent to Songzhuang Town of Tongzhou - one of the case study neighbourhood) where a lot of residents commute daily to work in the central zone of Beijing. However, the case of Yanjiao Town from Hebei is intended to be treated as a reference sample to see how administrative status affects urbanisation dynamics. Therefore, Yanjiao Town is not included in the spatial typology.

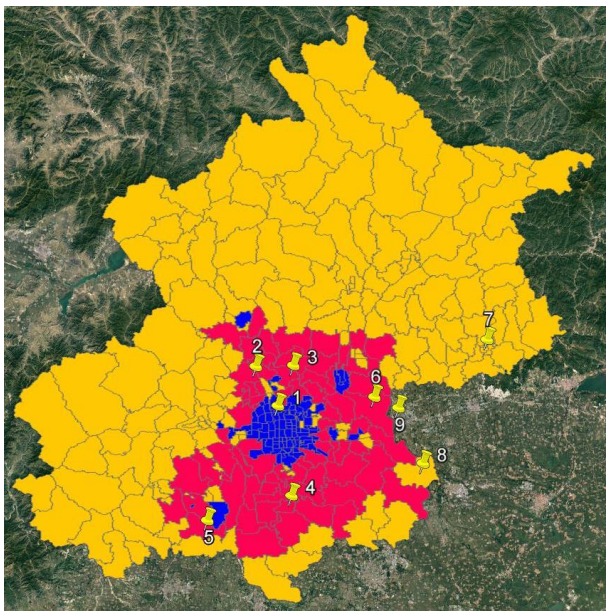
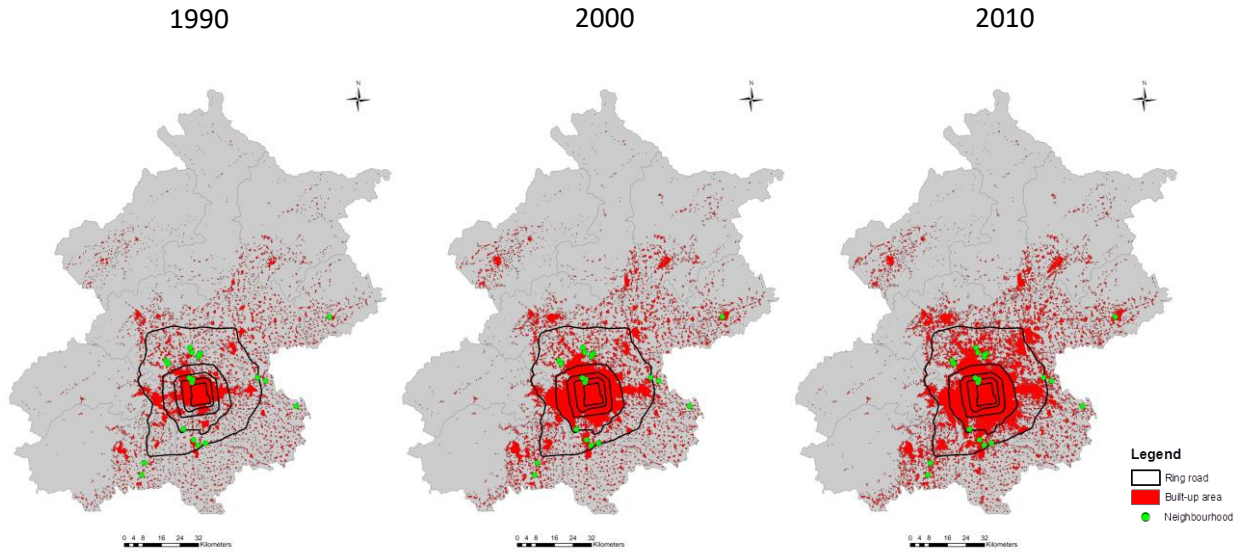


Figure 9 Nine selected case study townships[3] shown on spatial typology map



[3] Tag 9 shows the location of Yanjiao Town, Hebei

Figure 10 Urbanisation level (built up areas), ring roads and case study neighbourhoods

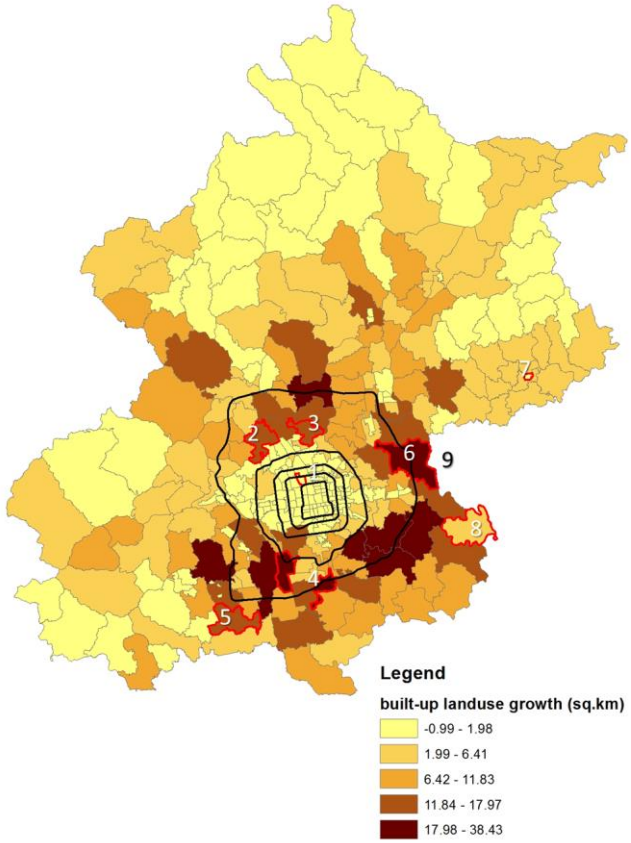


Figure 10 Township samples shown on Beijing land-use change map (2000-2015)

The selected sample townships in Beijing were cross-checked against the spatial distribution of Beijing's urban expansion patterns (see Figure 10). Figure 11 shows the land use expansion for built-up areas between 2000 and 2015 at the township level. Darker colour indicates a larger expansion of urban land and thus the townships have encountered a higher level of urbanisation pressure. Figure 11 shows that the five of our sample townships situate in the high urbanisation pressure bands and three in the lower pressure bands. This confirms that the chosen townships provide a good representation of areas undergoing different urbanisation pressure, and more importantly, this research focuses on examining the dynamics of areas under most pressure of urbanisation.

Table 1 Statistical profile of eight townships in Beijing[4]

No. tag	1	2	3	4	5	6	7	8
	Beitaipingzhuang Street, Haidian 北太平庄街道，海淀	Xibeiwang Town, Haidian 西北旺镇，海淀	Dongxiaokou District, Changping 东小口地区,昌平	Huangcun District, Daxing 黄村地区，大兴	Doudian Town, Fangshan 窦店镇，房山	Songzhuang Town, Tongzhou 宋庄镇，通州	Binhe Street, Pinggu 滨河街道，平谷	Xiji Town, Tongzhou 西集镇，通州
Total pop.	201,614	142,664	359,415	168,444	65,574	104,143	44,897	43,244
0.2% sample size	*403.228*	*285.328*	*718.83*	*336.888*	*131.148*	*208.186*	*89.794*	*86.488*
Area (sq.km)	4.636072	45.202492	29.33891	58.300153	58.114199	99.452977	2.991353	79.98898
Population density	43488.110944	3156.109156	12250.454962	2889.254867	1128.364521	1047.158199	15008.929907	540.624411
Open low rise (%)	.023077	.469234	.546158	.676928	.446157	.400003	.007692	.261540
Bush and shrub (%)	.007692	2.953866	1.646165	3.838488	2.007706	1.246162	.115385	.330771
Under 15 (%)	.053880	.087408	.086538	.106255	.091927	.083789	.134085	.074207
Compact high rise (%)	.246156	.292310	.492311	.476926	.176924	.161540	.015385	.007692
Age 15-64 (%)	.863631	.880636	.856077	.859835	.827096	.840316	.786868	.799186
Malepop (%)	.506180	.561487	.514188	.559302	.512962	.536051	.490411	.512048
Under-ground access per 1000 pop	.00496	0	.016694	0	0	0	0	0

[4] No accurate census data for Yanjiao Town due to its specific administrative status. Its total population is 750,000.

Beitaipingzhuang Street, Haidian

Beitaipingzhuang Street lies in the inner part of Beijing, close to the historical areas and Hutong areas but stands out as a major residential cluster. This area hosts the first round of urbanisation and housing in the 1980s and 1990s. As these early developments get older, it is bound to regenerate given the new pressure of urban development in Beijing.

Figure 10 Beitaipingzhuang Street, Haidian

Xibeiwang Town, Haidian

Xibeiwang Town hosts the renowned regeneration project of Tangjialing. From the satellite image, we can see this area is well-planned and set for new urban functions as it is close to the metropolitan core of Beijing.

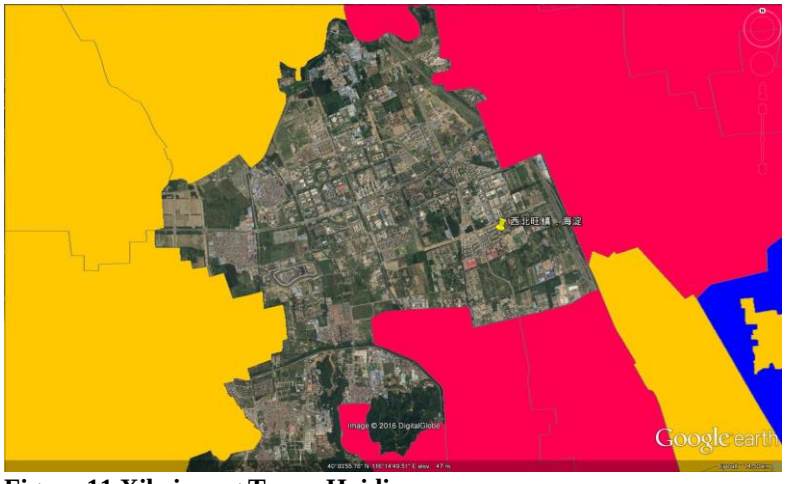


Figure 11 Xibeiwang Town, Haidian

Dongxiaokou district, Changping

Dongxiaokou district locates at the outer rim of north 5th Ring road. Dongxiaokou district hosts one of China's largest affordable housing projects – Tiantongyuan. According to local sources, the population of permanent (over six months) residents in Tiantongyuan is around 300,000 and there is roughly equal size of floating population. The construction of Tiantongyuan started in 1999; over the years, it has grown from an isolated suburban housing site to a mature neighbourhood with abundant amenities, improved transport connection, and a vibrant resident neighbourhood. However, Tiantongyuan also faces serious challenges. The construction site of Tiantongyuan used to be the biggest waste land-fill site. The concern of contaminated soil and water has always haunted the residents. The sheer size of Tiantongyuan has overloaded the administrative capacity of a township level government. Thus, the delivery of public services has always been a problem.

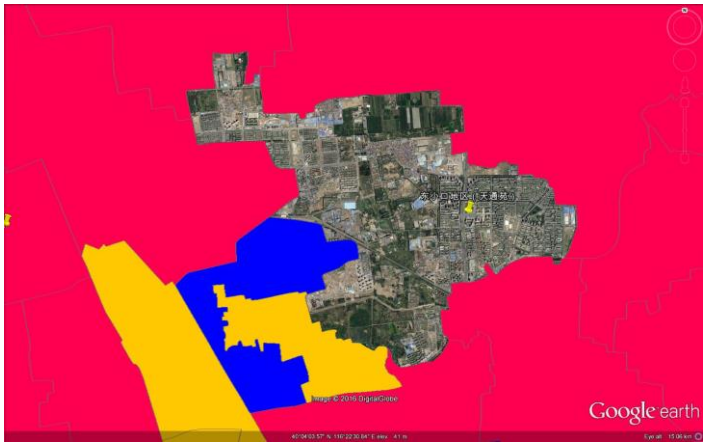


Figure 12 Dongxiaokou district, Changping

Huangcun district, Daxing

Huangcun district locates in the southern suburban county Daxing and between the south 5th Ring Road and south 6th Ring Road. Huangcun district is at the heart of the government's initiative to develop South Beijing. This area is close to the Beijing Economic and Technological Development Zone. Huangcun district has become the latest hot spot of real estate projects. Several major real estate companies have purchased development right at a price much higher than the current price level.

Figure 13 Huangcun district, Daxing

Doudian Town, Fangshan

Doudian Town locates at the south-west to the metropolitan centre of Beijing. The Beijing Advanced Manufacturing Industrial Park has been planned here to take advantage of its cheap land and highway connections.

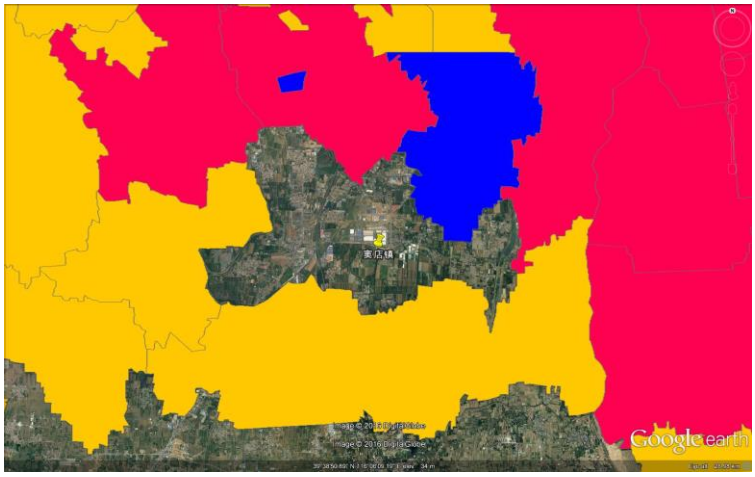


Figure 14 Doudian Town, Fangshan

Songzhuang Town, Tongzhou and Yanjiao Town, Hebei

Songzhuang Town lies at the border of Beijing and Hebei. It has one of the largest expansions of built-up areas at the township level. It is also famous for the clustering of artists who initially take advantage of cheap rents in such a peripheral location of Beijing. It is also border to Yanjiao Town of Hebei, where a lot of residents commute long hours to work in Beijing.

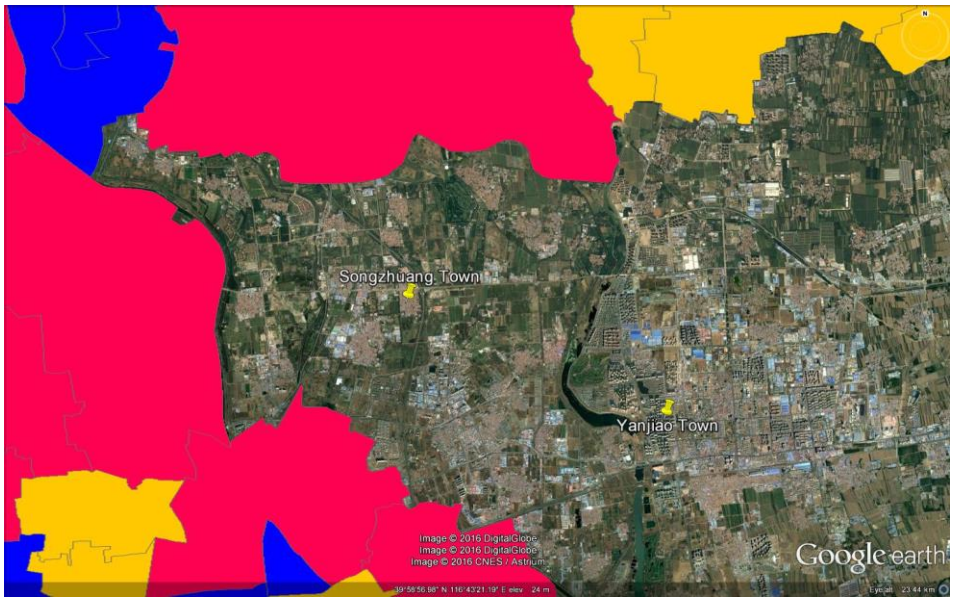


Figure 15 Songzhuang Town

Xiji Town, Tongzhou

Xiji Town lies at the border separating Beijing and Hebei and on the corridor connecting the metropolitan areas of Beijing and Tianjin. From the satellite image, this area features compact and neatly aligned rural dwellings surrounded by farmland. We can also observe industrial land-use. This area may experience huge urbanisation pressure as Beijing and Tianjin both push their urbanised frontline and develop links between them at the same time.

Figure 16 Xiji Town, Tongzhou

Binhe Street, Pinggu

Binhe Street is the urban centre of Pinggu district. We conceptualise Binhe Street as the regional urban centre of Beijing's peripheral, more rural areas. We expect that Binhe Street will evolve in accordance with the dynamics of regional economic development.

Figure 17 Binhe Street, Pinggu

Neighbourhood sample and survey participants

The total population size of all 8 case township units is just over one million (1,129,995). After considering the robustness and validity of the sample size as well as time and financial resources, a 0.2% sample size (2,260 participants) was decided. By building in a 10% attrition rate, a total survey sample of 2,310 was finally determined. Due to a lack of a comprehensive sampling frame of individuals/households in the chosen townships, it is not possible to fix the sample fraction to choose the neighbourhood and then the survey participants. A pragmatic solution was thus devised: first, by categorising township level units into four population size bands; second, by setting the survey participant numbers in each neighbourhood at 100 (with an extra 10% attrition rate); and finally, the number of neighbourhoods to be chosen were allocated on a pro-rata basis according to the population size bands of the townships (see Table 3).This means that a total of 21 neighbourhoods had to be selected.

An extra township from Hebei was also included as it is located at the border of Beijing (adjacent to one of the case study neighbourhood) to allow for extra comparative case study analysis.

Table 2 number of sample neighbourhoods from each case area

Population Size band	Number of neighbourhoods selected per township	Name of township level units	Total sample size
<=50k	1	Binhe Street, Pinggu; Xiji Town, Tongzhou	200
50k – 150k	2	Doudian Town, Fangshan; Xibeiwang Town, Haidian; Songzhuang Town,Tongzhou;	600
150k – 300k	4	Beitaipingzhuang Street, Haidian; Huangcun district, Daxing	800
>=300k	5	Dongxiaokou district, Changping	500
Extra case in Hebei	1	Yanjiao Town, Hebei	100

In order to obtain a probability sample to carry out household survey, a complete list of residential neighbourhoods in a township and their demographical and socio-economic profile are required to develop a reliable sampling frame. Such information is very expensive and only available to internal use or government commissioned research who works closely with governmental bodies such as the Beijing Bureau of Civil Affair, Beijing Statistical Bureau and related resident committees. Therefore, the comprehensive data at the neighbourhood level are not available to this research study.

However, *a list of sampled neighbourhoods for the 1% sample of the 2014 national census* and the official document that explained the sampling process were obtained as both are available online for public access. According to the documents, the sampling of residential neighbourhoods involved two stages: stratified sampling and Probability Proportional to Size (PPS) sampling. Firstly, Beijing Statistics Bureau stratified all village level administrative units (neighbourhoods and villages) based on census data. The indicators selected include social and economic development level, geographical and geological features, urban or rural status, non-agricultural population ratio, birth and death rate, floating population and collective *hukou* population. The sample of neighbourhoods or villages was

then produced through the Probability Proportional to Size (PPS) sampling method according to the result of stratification.

Since this study is not able to source a reliable sample frame, the best alternative is to use the 2014 national census' list of sampled neighbourhoods as it was the result of proper statistical sampling procedures. The official list covers all the eight chosen township level cases and the number of neighbourhoods in each case is larger than our targeted numbers as stated in Table 2. As a result, 21 neighbourhoods in Beijing were randomly selected from this official list as shown in Table 3.

Table 3 Sample neighbourhoods of the selected townships

Beitaipingzhuang Street 北太平庄街道	Xueyuannanlu 32 neighbourhood (学院南路32社区) Beitaipingzhuang neighbourhood (北太平庄社区) Luozhuangdongli neighbourhood (罗庄东里社区) Jinqiuzhichun neighbourhood (锦秋知春社区)
Xibeiwang Town 西北旺镇	Liangjiadian village (亮甲店村) Hanjiachuan village (韩家川村)
Dongxiaokou District[5] 东小口地区	Longjinyuandong No.1 neighbourhood (龙锦苑东一区社区) Tiantongyuan No.1 neighbourhood (天通苑第一社区社区) Dongchenxiaoqu neighbourhood (东辰小区社区) Aobeizhongxin neighbourhood (奥北中心社区) Langezhuang village (兰各庄村)
Huangcun district 黄村地区	Huangcunxili neighbourhood (黄村西里社区) Haizijiao village (海子角村) Xinfeng neighbourhood (新凤社区) Langfa No.2 village (狼垡二村)
Doudian Town 窦店镇	Qinyuanchunjing neighbourhood (沁园春景社区)[6] Baicaowa village (白草洼村)
Songzhuang Town 宋庄镇	Dinggezhuang village (丁各庄村) Tuanli village (疃里村)
Binhe Street 滨河街道	Jingudongyuan neighbourhood (金谷东园社区)
Xiji Town 西集镇	Huzhuang village (胡庄村)

[5] There was a boundary reorganisation of Dongxiaokou district by splitting it into Dongxiaokou district, Huoying Street, Tianbei Street, Tiantongyuannan Street (东小口地区, 霍营街道, 天北街道, 天通苑南街道)in December 2012.

[6] Qinyuanchuanjing neighbourhood is a substitute for Yaxintezhongjiancaigongsi neighbourhood as the latter is not easily accessible

Yanjiao Town[7] (Hebei) 燕郊镇	Xinggong Village (行宫村)

For the final stage of sampling, 110 participants will be chosen in each neighbourhood based on a quota sample (based on the criteria of age and gender, plus a question to ask about whether they have any physical and mental health conditions that may affect their participation of the survey). The detailed quota distribution will be fixed by further analysing on the local contextual information of the neighbourhoods.

Sample quota

From the 2010 population census data, some information on the population structure (e.g. gender and age group structure) at the township level can be identified (see Table 4). Generally, the population structure doesn't show much difference except Xiji Town, which has a larger proportion of elder people. The Male-to-Female ratios are all around 50:50, which suggests we can aim for equal number of male and female in the sample quota. Though the age group ratio are also quite similar to each other at the township level (except Xiji Town), we will expect variations of age group structure at the neighbourhood level. However, the official statistics at the neighbourhood are often not available to public access. For the 22 sample neighbourhoods for this research, we can only find information for three neighbourhoods, i.e. Xueyuannanlu No.32 neighbourhood, Beitaipingzhuang neighbourhood, and Jinqiuzhichun neighbourhood (see Table 5).

Table 4 Demographic distribution by gender and age group at township level

	Male pop	Female pop	M/F ratio	15-64 pop	Over 64 pop	age group ratio
Beitaipingzhuang	102053	99561	51:49	174120	16631	91:9
Xibeiwang	80104	62560	56:44	125635	4559	96:4
Dongxiaokou	184807	174608	51:49	307687	20625	94:6
Huangcun	94211	74233	56:44	144834	5712	96:4
Doudian	33637	31937	51:49	54236	5310	91:9
Songzhuang	55826	48317	53:47	87513	7904	92:8
Binhe	22018	22879	49:51	35328	3549	91:9
Xiji	22143	21101	51:49	34560	5475	86:14
Yanjiao[8](Hebei)	--	--	--	--	--	--

[7] In Hebei

[8] lack of information on Yanjiao.

Table 5 Sample quota of surveyed neighbourhood, based on age and gender distribution at township level

		M/F ratio	age group ratio	Male 15-65	Male over 65	Female 15-65	Female over 65
Beitaipingzhuang (*neighbourhood level data are available, and age groups are 15-60 and over 60)	Xueyuannanlu No.32*	44:56	76:24	37	12	47	15
	Beitaipingzhuang *	48:52	62:38	33	20	35	22
	Luozhuangdongli	51:49	91:9	51	5	49	5
	Jinqiuzhichun*	37:63	94:6	38	2	65	4
Xibeiwang	Liangjiadian village	56:44	96:4	59	2	46	2
	Hanjiachuan village	56:44	96:4	59	2	46	2
Dongxiaokou	Longjinyuandong No.1 neighbourhood	51:49	94:6	53	3	51	3
	Tiantongyuan No.1 neighbourhood	51:49	94:6	53	3	51	3
	Dongchenxiaoqu neighbourhood	51:49	94:6	53	3	51	3
	Aobeizhongxin neighbourhood	51:49	94:6	53	3	51	3
	Langezhuang village	51:49	94:6	53	3	51	3
Huangcun	Huangcunxili neighbourhood	56:44	96:4	59	2	46	2
	Haizijiao village	56:44	96:4	59	2	46	2
	Xinfeng neighbourhood	56:44	96:4	59	2	46	2
	Langfa No.2 village	56:44	96:4	59	2	46	2
Doudian	Qinyuanchunjing neighbourhood	51:49	91:9	51	5	49	5
	Baicaowa village	51:49	91:9	51	5	49	5
Songzhuang	Dinggezhuang village	53:47	92:8	54	5	48	4
	Tuanli village	53:47	92:8	54	5	48	4
Binhe	Jingudongyuan neighbourhood	49:51	91:9	49	5	51	5
Xiji	Huzhuang village	51:49	86:14	48	8	46	8

Yanjiao [9] (Hebei)	Xinggong village			54	5	48	4

[9] Due to a lack of information on Yanjiao, the quota ratios just follow those of its neighbour, Songzhuang.

Final sample

The fieldwork was commenced in May and June 2017 and the total number of questionnaire achieve was 2,507 in Beijing and 2,646 in total when including Yanjiao in Hebei. Table 6 compares the final sample distribution with the targeted sample quota. The final sample size exceeds the original target and the quota was strictly adhered.

Table 6 Final sample and sample quota at neighbourhood level

	Beitaipingzhuang Street, Haidian 北太平庄街道，海淀	Xibeiwang Town, Haidian 西北旺镇，海淀	Dongxiaokou District, Changping 东小口地区,昌平	Huangcun District, Daxing 黄村地区，大兴	Doudian Town, Fangshan 窦店镇，房山	Songzhuang Town, Tongzhou 宋庄镇，通州	Binhe Street, Pinggu 滨河街道，平谷	Xiji Town, Tongzhou 西集镇，通州
Actual sample size	440	248	587	382	350	245	120	135
Age 15-64 (%)	86.4	88.1	85.6	86.0	82.7	84.0	78.7	79.9
Sample Age 15-64 (%)	86.1	90.7	88.9	86.1	86.3	89.4	80.8	83.0
Male Pop (%)	50.6	56.2	51.4	55.9	51.3	53.6	49.0	51.2
Sample Male Pop (%)	49.0	52.4	50.8	52.1	51.7	52.7	48.3	46.7

(nb. Yanjiao Town, Hebei: actual sample size is 139 and age 15-64 is 91.4)

Questionnaire Design

Urban resource consumption and its environmental impacts have been widely debated in recent years. Many relevant surveys have been carried out in Beijing. Building on the experience and knowledge of these general surveys at more crude spatial scale e.g. city level, this study aims to focus on the spatial variations of different urban contexts to compare and contrast how neighbourhoods live and operate at the local level in different parts of the Beijing metropolitan area.

Other Relevant Surveys

The list below shows some existing relevant surveys. This list is not exhausted but including those that is particularly relevant to this study in terms of the content of the survey or the methodology used. The findings from these surveys will be used to benchmark and compare with the findings of this study for validation and evaluation at the later stage.

Sustainable consumption survey[10]

- [Report] 'China sustainable consumption report 2012'[11] by China's Academy of Social Science (CASS) and L'Oreal Company (China). This survey collected 3,004 answers to online questionnaire, covering consumers for six major cities (Beijing, Shanghai, Guangzhou, Shenyang, Xi'an, and Chengdu).
- [Report] 'Beijing neighbourhood sustainable consumption report 2015'[12] by ACEF[13] and UNEP[14]. Little information is available online.
- [Academic paper] 'Sustainable consumption behaviour and preference – a case of Changsha'[15] by Yang Zhi and Dong Xuebing, 2011. The questionnaire contains six themes, namely, purchasing resource-saving products, resource-saving behaviour, purchasing environment-friendly products, repeat use, recycling, and biodiversity conserving. This survey collected 376 samples in four districts of Changsha.
- [On-going project] A survey of consumption behaviour of urban residents in Beijing, Tianjin, and Guangzhou. Each city has 1,000 samples. Dr. Zhu Difrom China Academy of Social Science leads this survey. This survey contains consumption of 'sustainable goods', like electric car.

Household energy consumption survey

- [Report] 'China household energy consumption report 2015' [16] by National Academy of Development and Strategy, Renmin University[17].The subjects of this survey are rural households and the sample contains 3,404 rural households from 12 provinces and 69 villages and towns. The survey themes include cooking fuel, electric home appliance usage (especially that of heating and cooling appliances), transport mode, as well as subjective opinions on energy consumption. This report also presents a series of special research findings, such as the 'Urban-rural comparison of electricity consumption', 'relationships between urbanisation and household energy demand', 'information feedback and household energy demand', 'rural renewable energy', 'factors of energy usage of cooking in rural areas', and 'energy poverty of rural household'[18].

[10]中国居民可持续消费调查
[11]中国可持续消费研究报告 2012
[12]北京市社区可持续消费现状调查报告
[13] All-China Environment Federation (ACEF) 中华环保联合会
[14] United Nations Environment Programme (UNEP) 联合国环境规划署
[15] See link
[16]中国家庭能源消费研究报告（2015）
[17]中国人民大学国家发展与战略研究院
[18]See link

General social survey

- 'China General Social Survey (CGSS)' hosted by National Survey Research Centre, Renmin University.[19]
- 'China Family Panel Studies (CFPS)' hosted by Institute of Social Science Survey, Peking University.[20]
- 'Chinese Social Survey (CSS)'hosted by China Academy of Social Science[21]. The data can be available to the public conditioned on successful application for permission. According to Professor Chen, CASS' Director of Sociology Institute, they spent several millions RMB to work with Ministry of Civil Affair (中国民政部) to develop a comprehensive 'sampling frame'(抽样框), which consists catalogue of cities, counties, towns/townships, and resident committees. They then did random sampling (probability sampling).

Challenges of conducting survey research in China

There are some practical concerns in designing the questionnaire and carrying out the survey. First, there is the urban-rural difference. In rural area, it is very flexible about how you consume energy. But in urban area, it is rather predetermined by the evolution of energy infrastructure (from coal burning to gas, etc.). It is difficult for resident to report an exact amount of water or electricity they have used. It is better to ask them their water and electric bill, which again will be more or less guess work. Paying for electricity is like Pay-as-you-go.

Second, the Chinese authority tends to be highly sensitive for large-scale survey in China, especially carried out by foreign organisations. Therefore, it is important to be well communicated with relevant governmental bodies before carrying out the survey. Otherwise, it is very likely to be interrupted.

Questionnaire design and content

The content of the questionnaires was based on literature review on the key factors that affecting the sustainable lifestyle of residents at the neighbourhood level. In addition, the topics covered in the questionnaire are cross-checked with the indicators identified in Table 1 of the New Urbanisation Plan. Pre-test of the questionnaire items was carried out with Chinese researchers of the research team in the first instance before testing with other Chinese students at UoM. Before the proper survey started, 30 pilot studies were carried out in Beijing with a full analytical report. The pilot findings were used to refine the wordings of the questions asked, the ordering of questions and the number of answer categories provided, as well as the field operation of the survey.

The final questionnaire consists of 5 key sections and 57 questions:

- Demographics
- Housing and Local Environment
- Transport Modes and Trips
- Waste Disposal and Recycle
- Lifestyle and Attitude

[19]中国综合社会调查 See link
[20]中国家庭追踪调查 See link
[21]中国社会状况综合调查 See link

Questionnaire survey in field

The conduction of questionnaire survey fieldwork was subcontracted to Dr. Qian Yun and his team at the Beijing Forestry University. The fieldwork was carried out in two phases: a small-scale pilot survey and the actual large-scale survey.

Pilot survey (April 15th, 2017)

The Pilot survey is conducted for the following purposes:

- To gather feedbacks on questionnaire design, such as
  - Whether questionnaire questions can be completed in due time (within 20 mins)?
  - Whether the terms used in questionnaire are comprehensible to lay people?
  - Whether the options in questionnaire questions cover all important facts?
- To inform a feasible working plan for the large scale survey, such as
  - How many surveyors need to be recruited? What is the realistic workload?
  - How to best approach potential participants?
  - What are the potential health and safety issues to be addressed in the field?

The pilot survey was carried out in one neighbourhood in Qinghe Street of Haidian District by a small group of Dr. Qian's students. A feedback report was returned from the students. The questionnaire design was fine-tuned according to the feedbacks. All raised issues are also fed into the making of plan for the rolling-out of large-scale survey for the 22 sample neighbourhoods. For details of the feedback report, please see **Error! Reference source not found.**.

Large-scale survey of 22 neighbourhoods (May to June, 2017)

The organisation of personnel who took part in the survey were summarised in the following diagram:

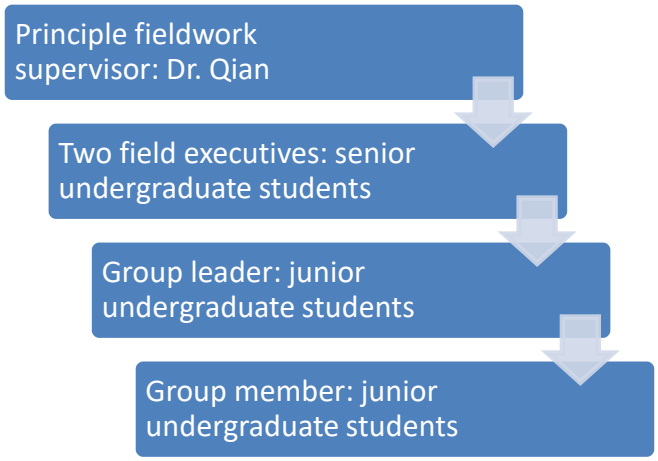


Figure 18 Personnel framework of survey in field

The major work of survey is carried out in three rounds during May and June of 2017. In each round, 3 to 4 groups of surveyors are recruited from first year and second year of undergraduate students in Beijing Forestry University. Each group has a size of 10 surveyors and was responsible for collecting a minimum of 120 questionnaires from one neighbourhood per day. Usually, one surveyor was tasked

with collecting 15 questionnaires per day. Each round last two days, usually the weekends when the students have no class. Each round of survey includes three parts of work as followed:

- Preparation

First, all surveyors were summoned to attend a one-hour training session, delivered by principle fieldwork supervisor, on questionnaire contents, communication skills, and health and safety issues. Printed questionnaire hard copies and due amount of small gifts were distributed to surveyors. Second, one neighbourhood was assigned to each group to collect questionnaires from. For assigned neighbourhood, group leader will collect basic information about that neighbourhood and pass them to group members, including location, boundaries, travel options and other helpful information. Third, surveyors are reminded to bring their mobile phone and contact numbers are circulated among principle supervisors, two executives, group leader and group members.

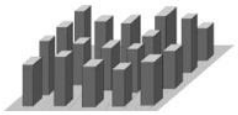
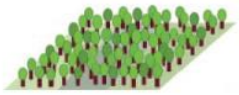
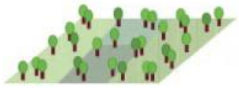
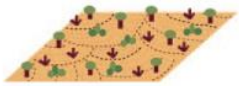
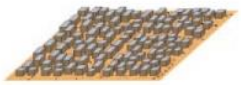
- In field

The surveyor group will arrive at targeted neighbourhood in the morning and start the work thereafter. Surveyors work in pairs. The group will gather during lunch break when surveyors report to group leader about the progress. The group leader will check the progress against sample quota framework and make due instructions to afternoon's work. For example, if the morning's work was biased towards man participants and elder people participants, the surveyors are advised to target on more woman participants and young participants in the afternoon. For safety concerns, a day's work will conclude at 6pm even if the minimum of 120 samples has not been achieved. Extra round of survey were carried out in neighbourhoods where the minimum target was not reached on the day.

- After a day's work

Surveyors carried the hard copies of completed questionnaires back to their university. Then, they will take picture of each page of questionnaires and compile the electronic files in order. They also will input the answers into Excel files according to the codebook. These questionnaire hard copies, picture files and Excel files were gathered and checked by group leaders who then sent these files to fieldwork executives. We received all files and documents from fieldwork executives.

Appendix A The Local Climate Zone (LCZ) typology

Built types	Definition	Land cover types	Definition
1. Compact high-rise 	Dense mix of tall buildings to tens of stories. Few or no trees. Land cover mostly paved. Concrete, steel, stone, and glass construction materials.	A. Dense trees 	Heavily wooded landscape of deciduous and/or evergreen trees. Land cover mostly pervious (low plants). Zone function is natural forest, tree cultivation, or urban park.
2. Compact midrise 	Dense mix of midrise buildings (3–9 stories). Few or no trees. Land cover mostly paved. Stone, brick, tile, and concrete construction materials.	B. Scattered trees 	Lightly wooded landscape of deciduous and/or evergreen trees. Land cover mostly pervious (low plants). Zone function is natural forest, tree cultivation, or urban park.
3. Compact low-rise 	Dense mix of low-rise buildings (1–3 stories). Few or no trees. Land cover mostly paved. Stone, brick, tile, and concrete construction materials.	C. Bush, scrub 	Open arrangement of bushes, shrubs, and short, woody trees. Land cover mostly pervious (bare soil or sand). Zone function is natural scrubland or agriculture.
4. Open high-rise 	Open arrangement of tall buildings to tens of stories. Abundance of pervious land cover (low plants, scattered trees). Concrete, steel, stone, and glass construction materials.	D. Low plants 	Featureless landscape of grass or herbaceous plants/crops. Few or no trees. Zone function is natural grassland, agriculture, or urban park.
5. Open midrise 	Open arrangement of midrise buildings (3–9 stories). Abundance of pervious land cover (low plants, scattered trees). Concrete, steel, stone, and glass construction materials.	E. Bare rock or paved 	Featureless landscape of rock or paved cover. Few or no trees or plants. Zone function is natural desert (rock) or urban transportation.
6. Open low-rise 	Open arrangement of low-rise buildings (1–3 stories). Abundance of pervious land cover (low plants, scattered trees). Wood, brick, stone, tile, and concrete construction materials.	F. Bare soil or sand 	Featureless landscape of soil or sand cover. Few or no trees or plants. Zone function is natural desert or agriculture.
7. Lightweight low-rise 	Dense mix of single-story buildings. Few or no trees. Land cover mostly hard-packed. Lightweight construction materials (e.g., wood, thatch, corrugated metal).	G. Water 	Large, open water bodies such as seas and lakes, or small bodies such as rivers, reservoirs, and lagoons.
8. Large low-rise 	Open arrangement of large low-rise buildings (1–3 stories). Few or no trees. Land cover mostly paved. Steel, concrete, metal, and stone construction materials.	**VARIABLE LAND COVER PROPERTIES**	
		Variable or ephemeral land cover properties that change significantly with synoptic weather patterns, agricultural practices, and/or seasonal cycles.	
9. Sparsely built 	Sparse arrangement of small or medium-sized buildings in a natural setting. Abundance of pervious land cover (low plants, scattered trees).	*b. bare trees*	Leafless deciduous trees (e.g., winter). Increased sky view factor. Reduced albedo.
		s. snow cover	Snow cover >10 cm in depth. Low admittance. High albedo.
10. Heavy industry 	Low-rise and midrise industrial structures (towers, tanks, stacks). Few or no trees. Land cover mostly paved or hard-packed. Metal, steel, and concrete construction materials.	*d. dry ground*	Parched soil. Low admittance. Large Bowen ratio. Increased albedo.
		w. wet ground	Waterlogged soil. High admittance. Small Bowen ratio. Reduced albedo.

Source: Stewart and Oke (2012)