

城市模型及其规划设计响应

Applied Urban Models and Their Applications in Urban Planning & Design

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城市模型及其规划设计响应

1 城市模型与规划支持系统

1.1 规划支持系统在城市规划中的应用探索

1.2 多尺度的北京城市空间发展模型

1.3 规划师主体模型：一项低碳城市形态规划支持的工具

1.4 囊括方法、软件和模型的规划支持系统框架体系

1.5 面向空间规划的微观模拟

2 大模型与定量城市研究

2.1 大模型及中国应用案例

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3 规划设计响应

3.1 数据增强设计：新数据环境下的规划设计回应与改变

3.2 街道城市主义

3.3 城市规划实施评价：针对中国城市的分析框架

3.4 基于人类活动和移动数据的城市增长边界实施评价

3.5 中国收缩城市及其研究框架

3.6 历史上的北京规划



Applied Urban Models and Their Applications in Urban Planning & Design

1 Urban Models and Planning Support Systems

1.1 Planning support systems in urban planning

1.2 Beijing urban spatial development model families

1.3 Planner Agents: A toolkit for support planning a low carbon urban form

1.4 An applied planning support toolkit including quantitative methods, software and models in China

1.5 Urban micro-simulation for spatial planning

2 Big Models and Quantitative Urban Studies

2.1 Big models: Several fine-scale urban studies for the whole China

2.2 Automated identification and characterization of parcels (AICP) with OpenStreetMap and points of interest

2.3 Simulating urban expansion at the parcel level for all Chinese cities

2.4 Estimating population exposure to PM_{2.5} in China

2.5 Bus landscapes: Analyzing commuting pattern using bus/metro smartcard data in Beijing

2.6 Four changes on quantitative urban studies in the big data era

3 Applications in Urban Planning & Design

3.1 Data augmented design (DAD): Planning & design in new data environment

3.2 Street urbanism

3.3 Evaluation of urban planning implementation: An analytical framework for Chinese cities and case study of Beijing

3.4 Evaluating the effectiveness of urban growth boundaries with human mobility data

3.5 Shrinking cities in China and the research agenda

3.6 Historical city plans in Beijing



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BUDEM Families

✦ Beijing Urban Spatial Development Model

- Launched in 2007 and in development
- Supported by Beijing Institute of City Planning and Beijing Planning Commission

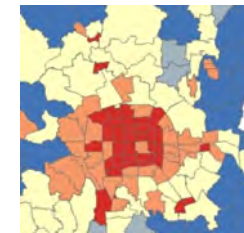
✦ Macro-level (city-scale)

- Urban expansion analysis and simulation
- Cellular automata, 500*500 m



✦ Meso-level (city-scale)

- Land development, residential / firm location choice
- Traffic Analysis Zones (TAZ)



✦ Micro-level (parcel-scale)

- Spatial policy / energy / environment evaluation
- Microsimulation, parcels / households / firms

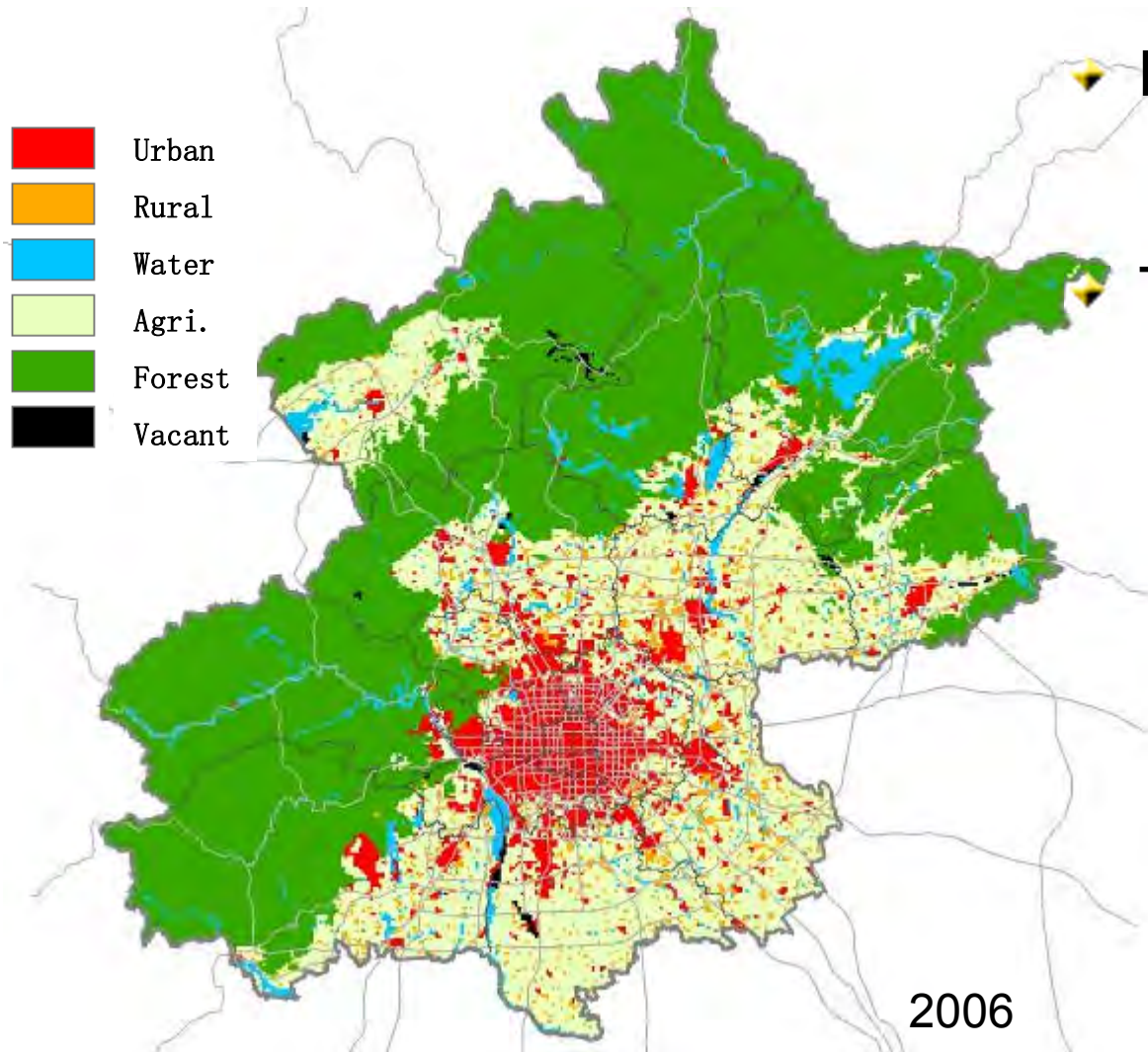


Study area of BUDEM



- The Beijing Metropolitan Area (BMA)
- Capital of P. R. China, northern china, adjacent to Tianjin and Hebei
- 16410 sqkm
 - mountainous:10071 km²
- 16 district
- Ring road 2nd, 3rd, 4th, 5th, 6th

Rapid urban expansion in Beijing

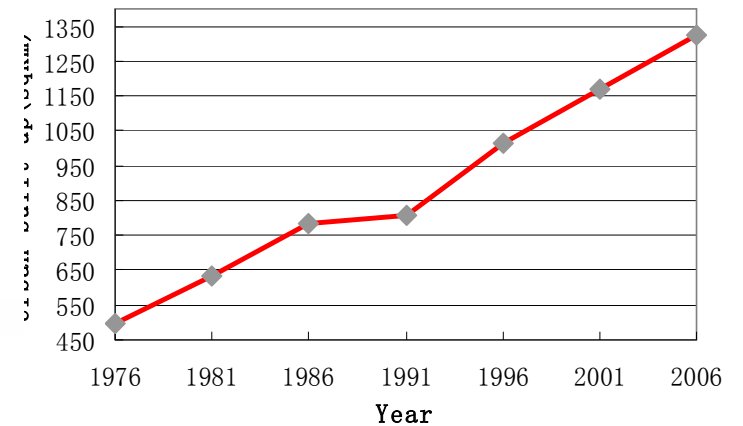


Land use of Beijing

- Interpreted from Landsat TM/ETM/MSS

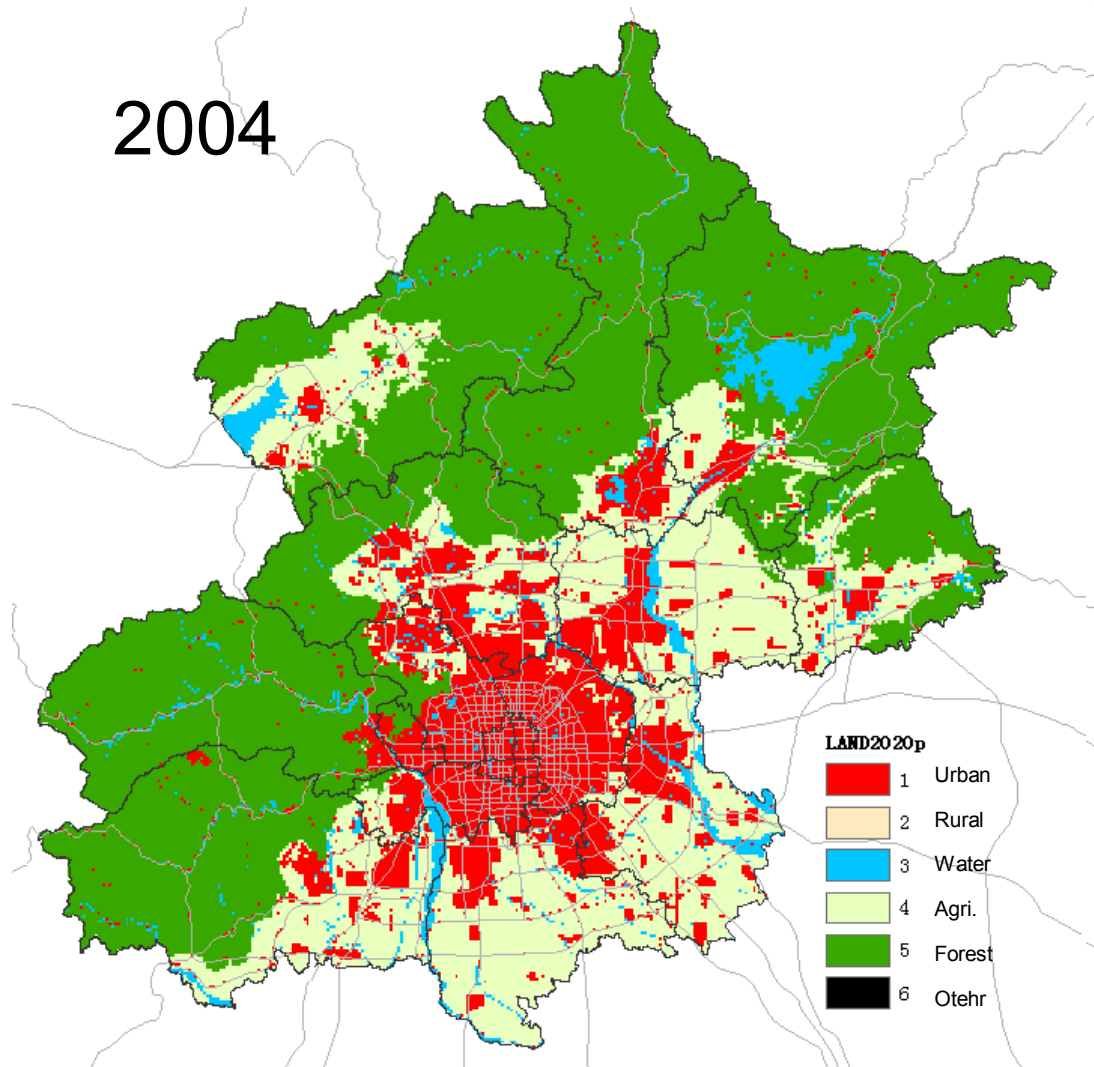
The near future

- Both expansion and redevelopment
- Increasing urban redevelopment
 - Opportunity for micro model



Master plans in the BMA

2004



Urban master planning of Beijing metropolitan area, as the capital city, since the foundation of P. R. China

- 2004
- 1992
- 1982
- 1973
- 1958

The new master plan might be compiled in 2013

All focusing on *spatial*

- Urban growth / expansion, redevelopment
- Urban form / urban structure
- Strong relationship between urban spatial organization and CO2 emission
 - Owens, 1987, Anderson et al., 1996; Banister et al., 1997

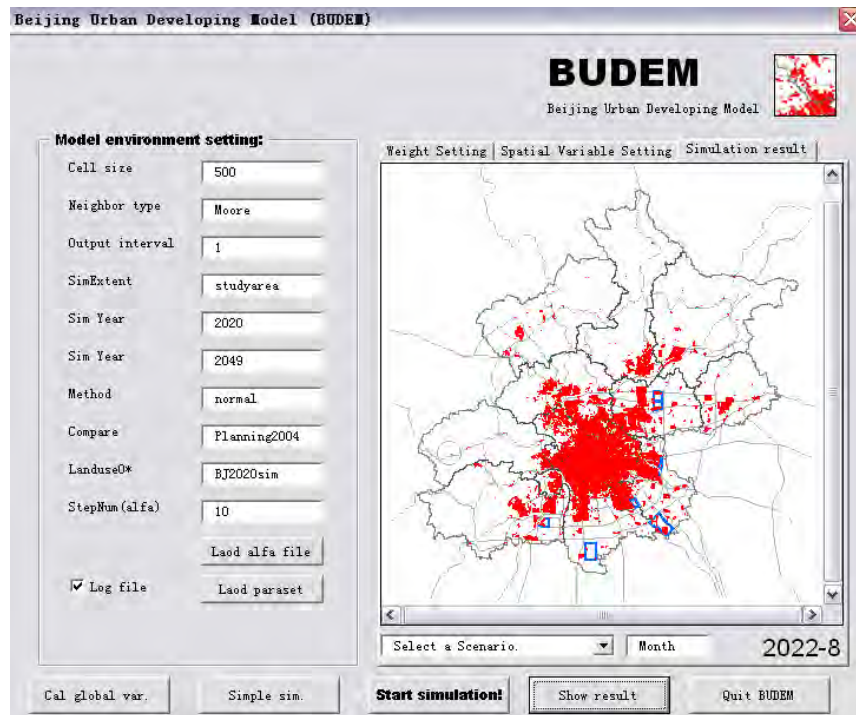
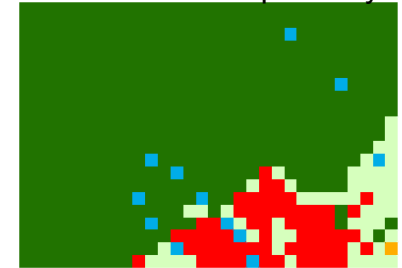
Macro BUDEM (2006-)

- ✦ Identifying driving force of urban expansion in various historical phases
- ✦ Evaluating the effectiveness of urban master plans in urban expansion
- ✦ Retrieving policies required to implement master plan for 2020
- ✦ Simulating urban growth scenarios with different policies set in 2049
- ✦ Planning support system for practical urban planning and management (various developing policies)

Long Y, Mao Q, Dang A, 2009, "Beijing urban development model: Urban growth analysis and simulation" *Tsinghua Science and Technology* 14(6) 787-794

An applied CA model

Urban growth from undeveloped to developed only



Approaches

1. Constrained cellular automata (CA)
2. Logistic regression
3. Regional sensitivity analysis

CA settings:

Cells

- 500m * 500m
- 65628 cells

Cell States

- V=1: urban built-up
- V=0: none urban built-up

Status Transition Rule

- Multi-criteria evaluation, MCE
- Retrieved by logistic regression

Neighborhoods

- Moore
- 3*3, rectangle, 8 adjacent cells

Discrete Time

- 1 iteration/step = 1 month

Driving forces of urban expansion

Select spatial factors using hedonic model

✦ Location

- Minimum distance to hierarchical urban center
 - Tian an men d_{tam} 、 important new city d_{vcity} 、 new city d_{city} 、 important town d_{vtown} 、 town d_{town}
- Minimum distance to wetland d_{river}
- Minimum distance to regional road d_{road}
- Minimum distance to ward (town level) boundary d_{bdtown}
- Regional attraction of greater Beijing area f_{rgn}

✦ Neighborhood

- Developing intensity in neighborhood $neighbor$

✦ Government

- Urban master planning $planning$
- Cultivating suitability $landresource$
- Constrain zoning
 - Constructing forbidden area con_f

$$V_{i,j}^{t+1} = f\{V_{i,j}^t, Global, Local\}$$

$$= \{V_{i,j}^t, LOCATION, GOVERNMENT, NEIGHBOR\}$$

$$= f \left\{ \begin{array}{l} V_{i,j}^t, \\ d_{tam_{i,j}}, d_{vcity_{i,j}}, d_{city_{i,j}}, d_{vtown_{i,j}}, d_{town_{i,j}}, \\ d_{river_{i,j}}, r_{road_{i,j}}, d_{bdtown_{i,j}}, f_{rgn_{i,j}}, \\ planning_{i,j}, con_f_{i,j}, landresource_{i,j}, \\ neighbor^t_{i,j} \end{array} \right\}$$

Model calibration

Logistic regression result of various historical phases

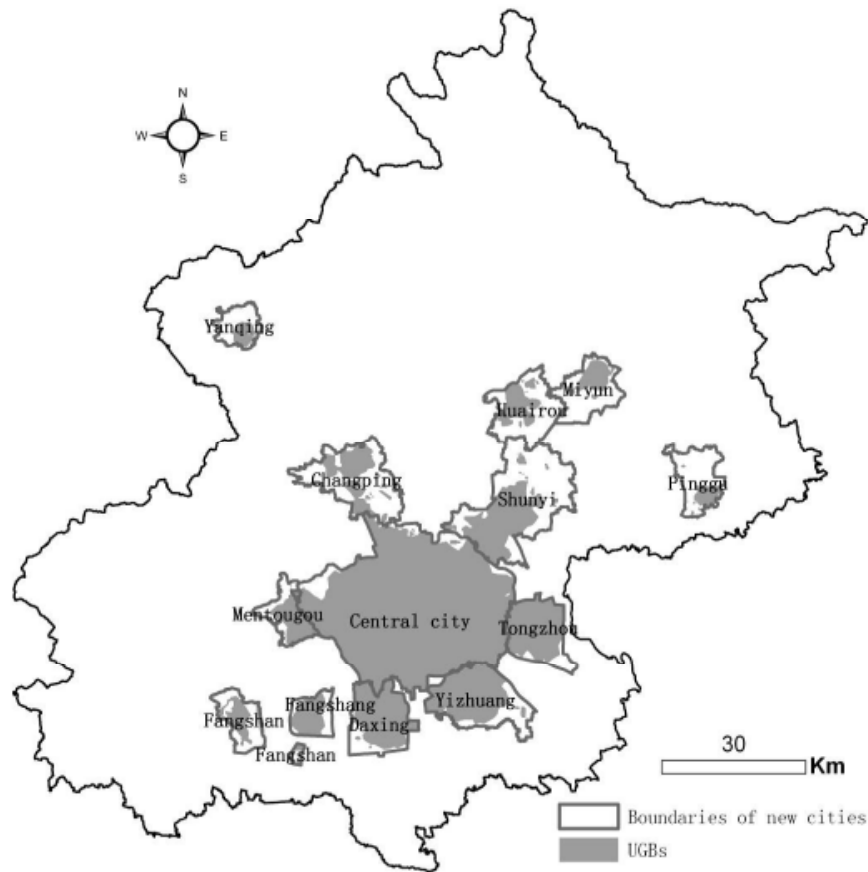
variable	B(2001–2006)	B(1996–2001)	B(1991–1996)	B(1986–1991)
<i>d_tam</i>	-0.000016*	-0.000035*	-0.000041*	
<i>d_vcity</i>	-0.000025*	-0.000031*		-0.000031*
<i>d_city</i>	-0.000019*	-0.000066*	-0.000033*	
<i>d_vtown</i>			0.000025*	0.000058*
<i>d_town</i>		0.000089*	0.000066*	
<i>d_river</i>	-0.000138*			
<i>d_road</i>	-0.000256*	-0.000804*	-0.000524*	-0.001092*
<i>d_bdtown</i>		-0.000377*		
<i>f_rgn</i>	4.302458*	-13.737258*		
<i>planning</i>	-0.410472*	0.254173	0.575671*	1.310654*
<i>con_f</i>	-0.521103*	-0.453115*	-0.497453*	-1.506241*
<i>landresource</i>			-0.075543	-0.233262
<i>Constant</i>	-0.174524	0.588961	-0.998267*	-3.610055*

*Significant at 0.001 level

Model validation: The simulation in 1986–2006 well replicates historical urban expansion, in terms of Kappa and spatial pattern.

- ✦ Variable in different phases differ greatly (market and government balancing, macro-policy)
- ✦ Common character: road directing developing, constructing forbidden area protected
 - **2001-2006:** river>new city>region
 - **1996-2001:** new city developing, slow town developing, negative regional influence
 - **1991-1996:** center city>city, planned area developing, agricultural land with high suitability encroached
 - **1986-1991:** new city promoted, agricultural land protected, planning promoted

2 Establishing urban growth boundaries (UGBs)



- ✦ UGBs for the central city and 11 new towns, 142 towns not included
- ✦ Significant differing from planned UGBs in the master plan, with
 - Less expansion in the north
 - Different new towns layout
- ✦ High probability to be broken for planned UGBs in coming years

3 Urban planning implementation effectiveness

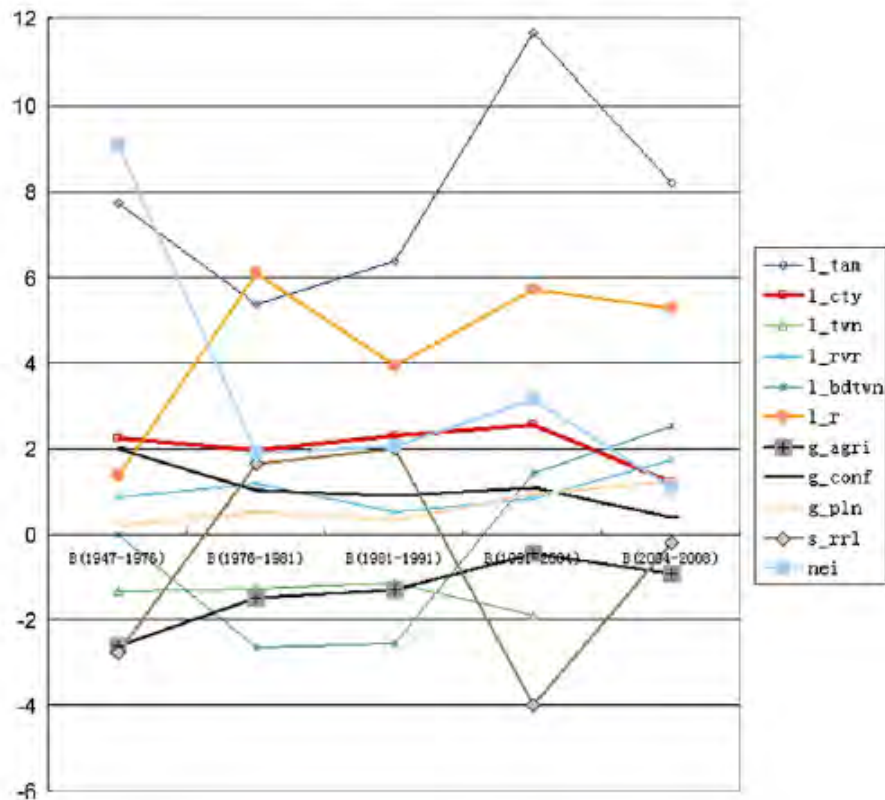


Fig. 3. Coefficients of all factors in various periods.

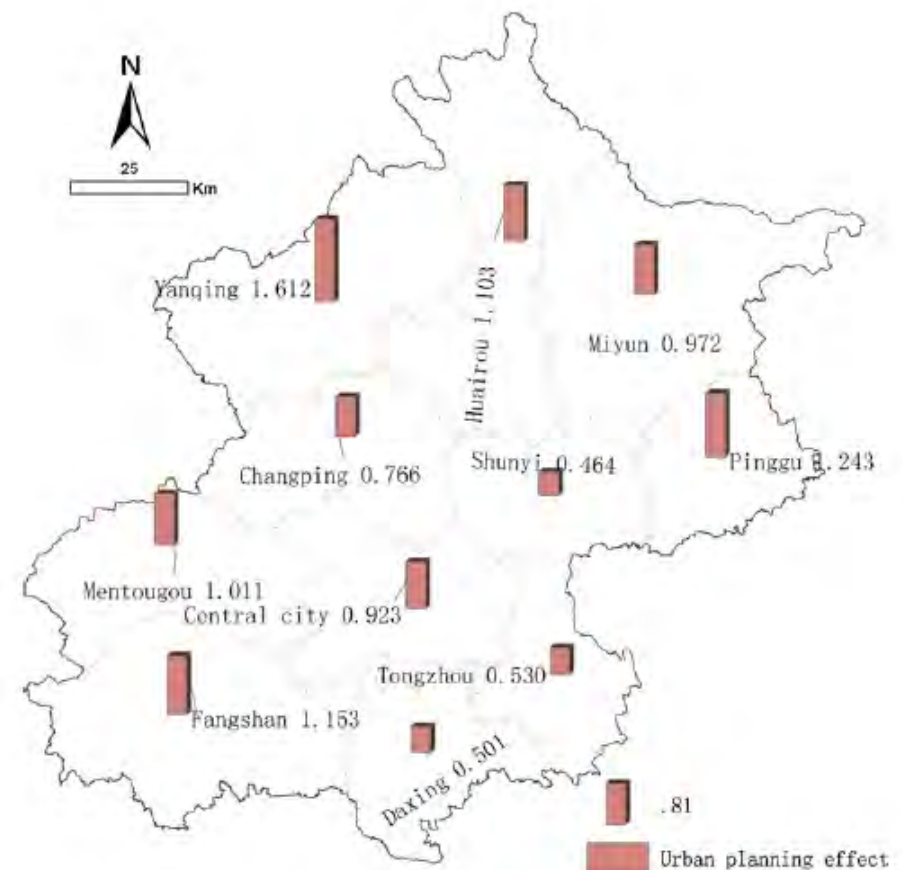


Fig. 4. Comparison of urban planning coefficients in various districts.

Long Y, Gu Y, Han H, 2012, "Spatiotemporal heterogeneity of urban planning implementation effectiveness: Evidence from five master plans of Beijing" *Landscape and Urban Planning* 108: 103-111.

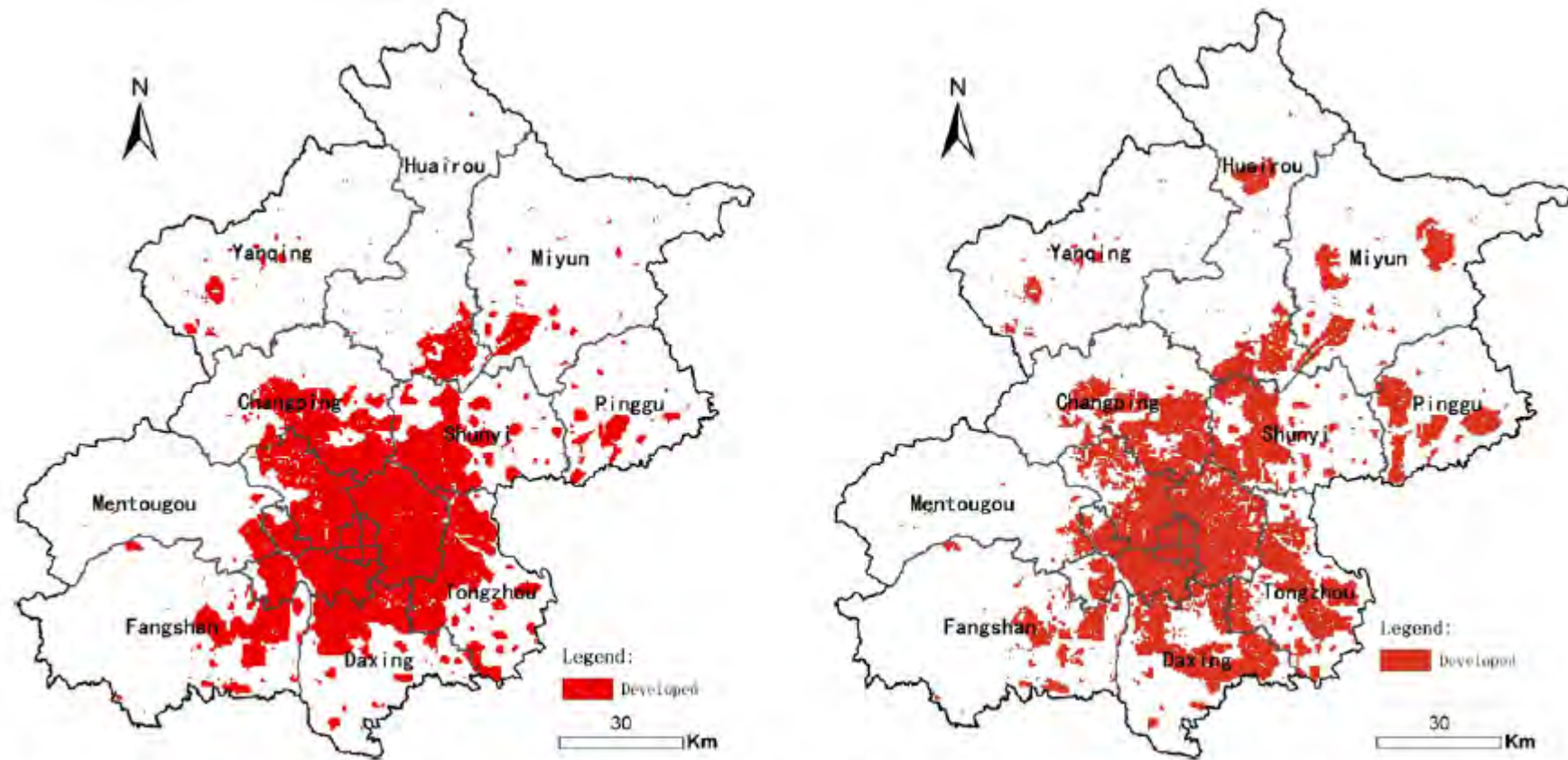
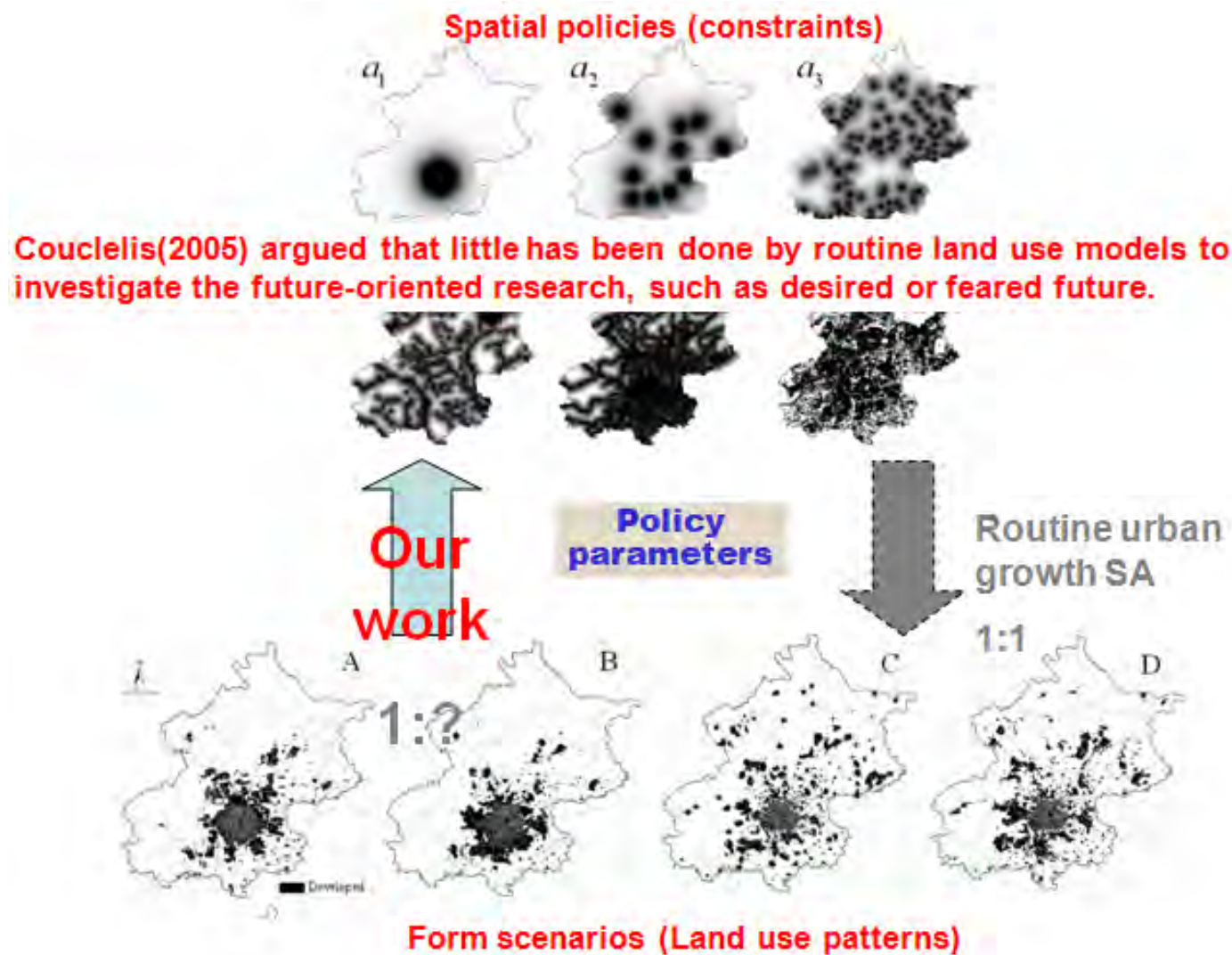


Fig. 5. Simulated urban forms by adjusting urban planning coefficient in BUDEM: the baseline scenario (left) and planning-strengthened scenario (right).

4 Identifying policy parameters for spatial plans



Long Y, Shen Z, Mao Q, 2012, "Retrieving spatial policy parameters from alternative plans using constrained cellular automata and regionalized sensitivity analysis" *Environment and Planning B: Planning and Design* 39(3) 586-604.

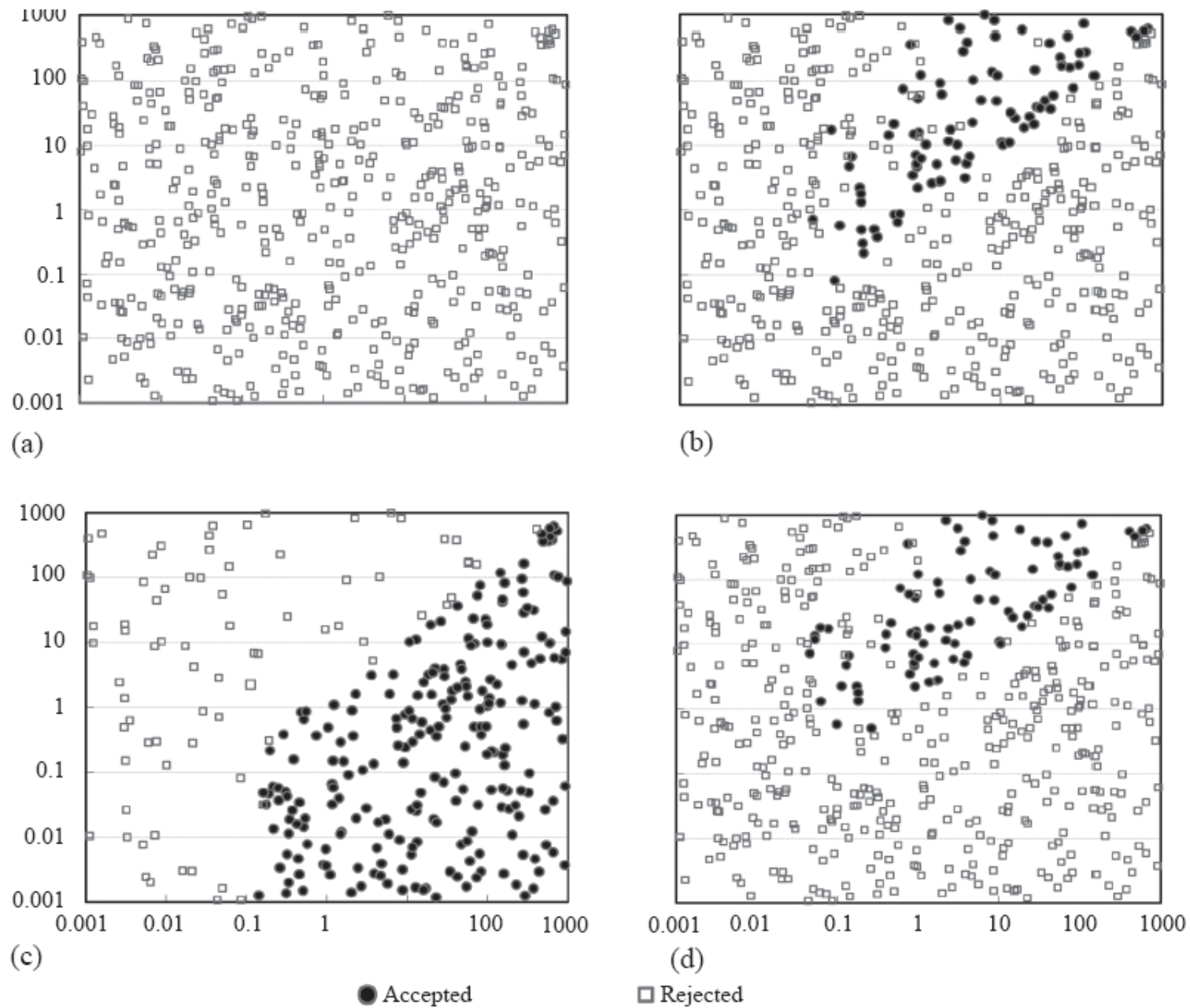


Figure 6. Scatter plots of policy parameters identified for two combined constraints in the virtual space, when the x axis is x_1 , y axis is x_2 and ‘accepted indicates’ $\kappa \geq 80\%$. (a) Form 1, possibility of the urban form $P = 0\%$; (b) form 2, $P = 17.8\%$; (c) form 3, $P = 46.4\%$; (d) form 4, $P = 17.8\%$.

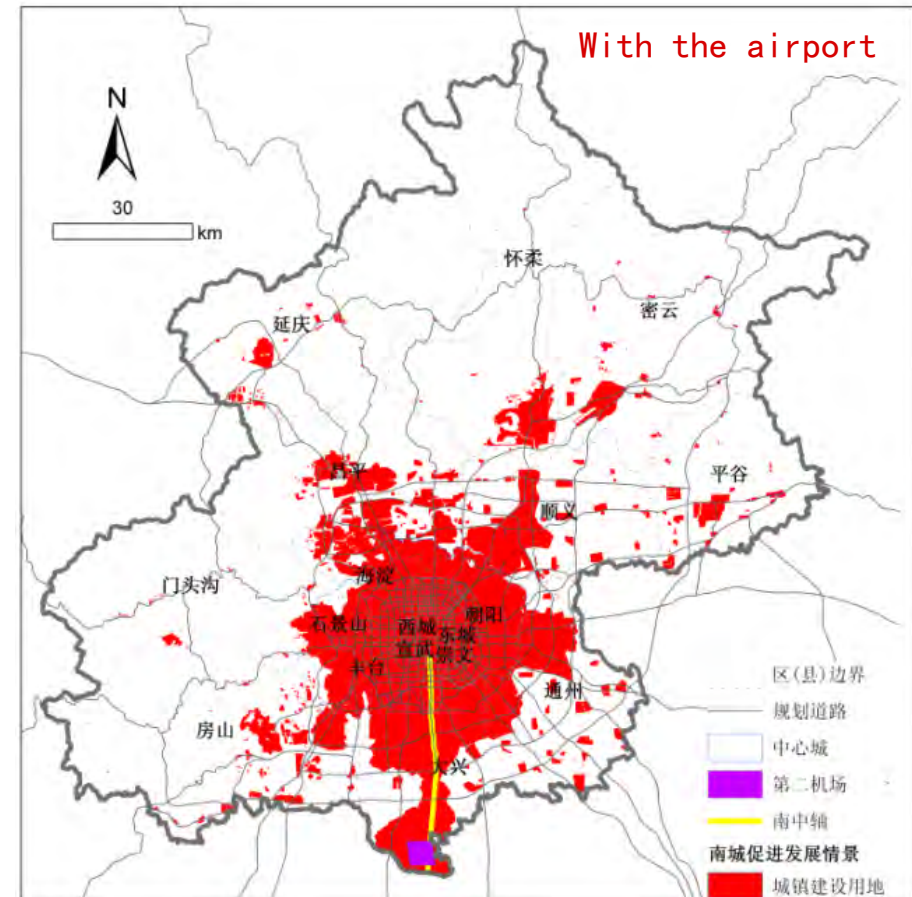
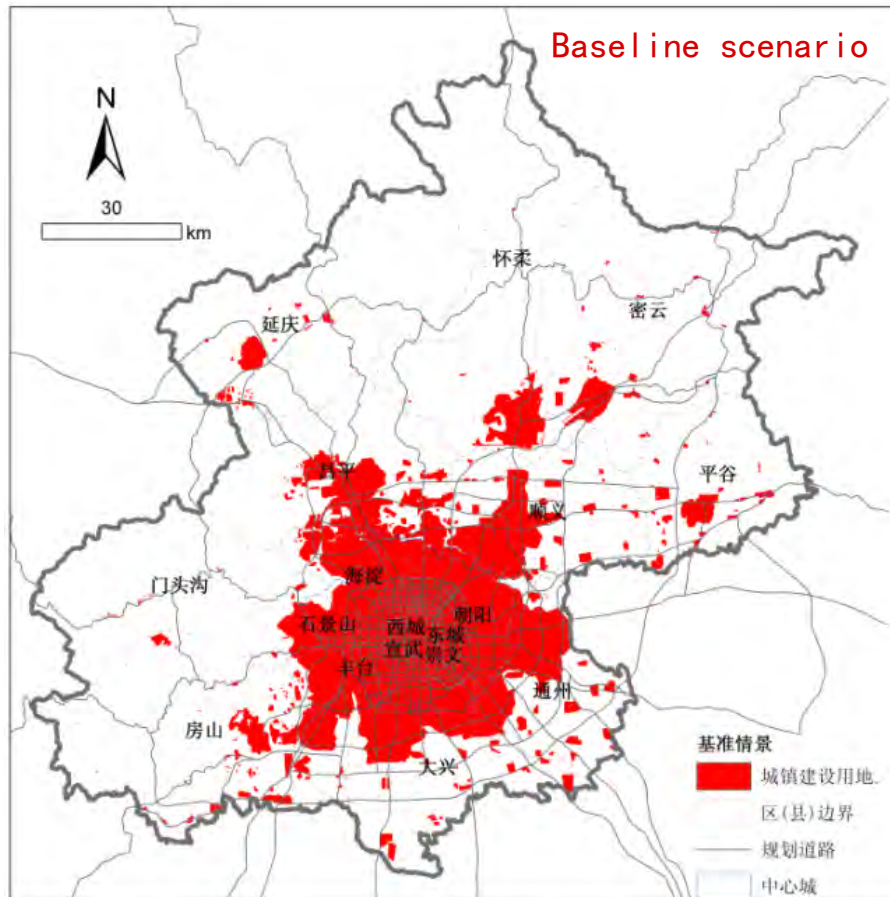
✦ Our findings:

- Under current spatial policy settings, the spatial layout of master plan for 2020 could not be implemented.
- This module of Macro BUDEM could facilitate planners compiling a spatial plan with higher possibility to be implemented.

✦ Backgrounds:

- Planned layout is occasionally broken through in China due to lack of consideration of economy factors
- Empirical studies in Beijing, Guangzhou, and Shanghai (Han et al, 2009; Xu et al, 2009; Tian et al, 2008)

5 The second international airport location choice



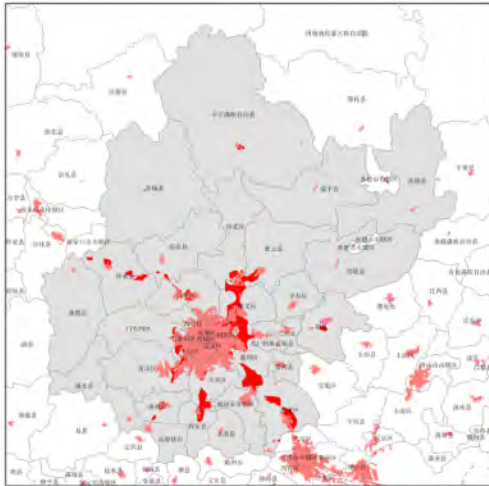
MACRO

MESO

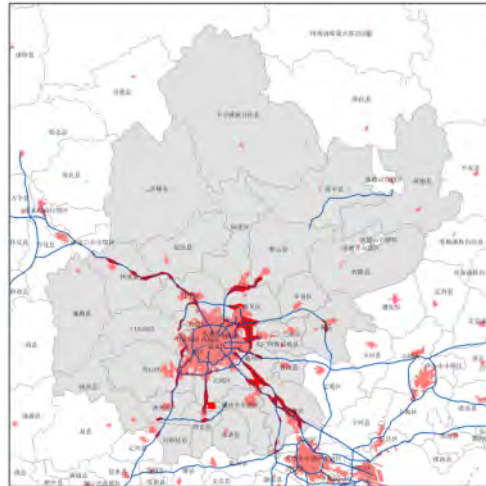
MICRO

6 Extended to the Greater Beijing Area

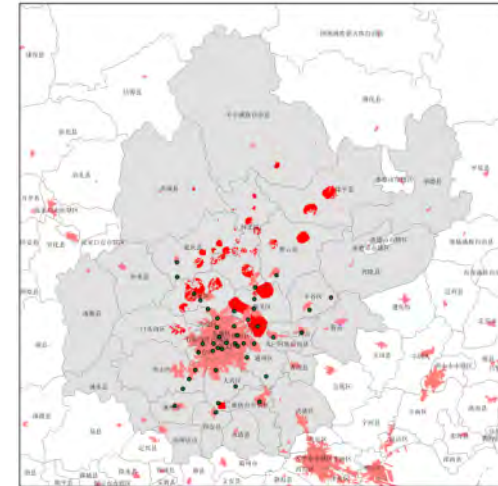
A1



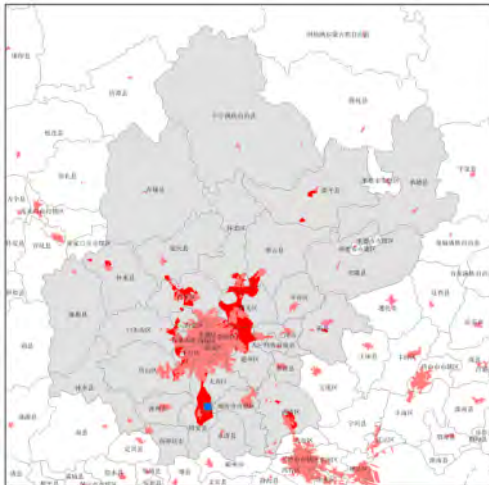
A2



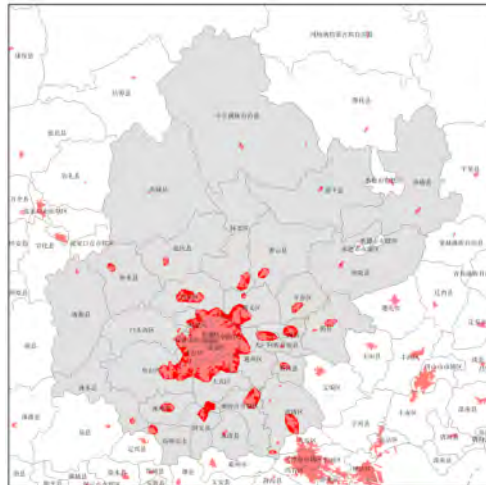
A3



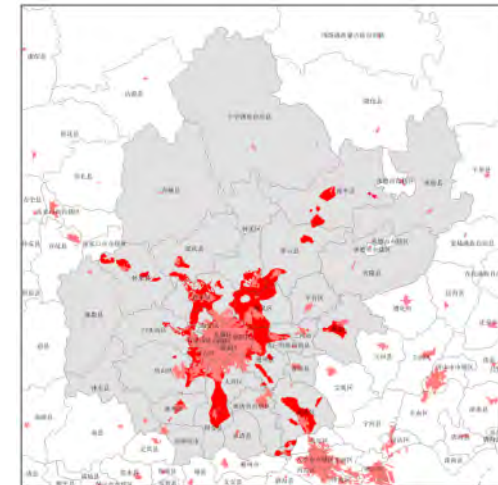
A4



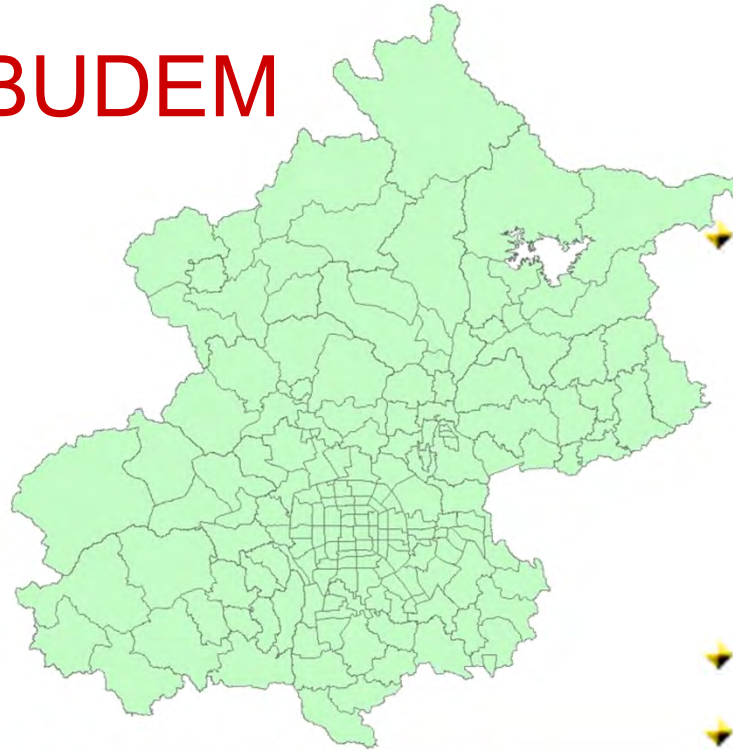
A5



A6



Meso BUDEM



Beijing Land-use and Transportation Integrated Model

- BLUTI v1.0
- Developed in 2009
- Long term forecast (2020)
- Based on Cube

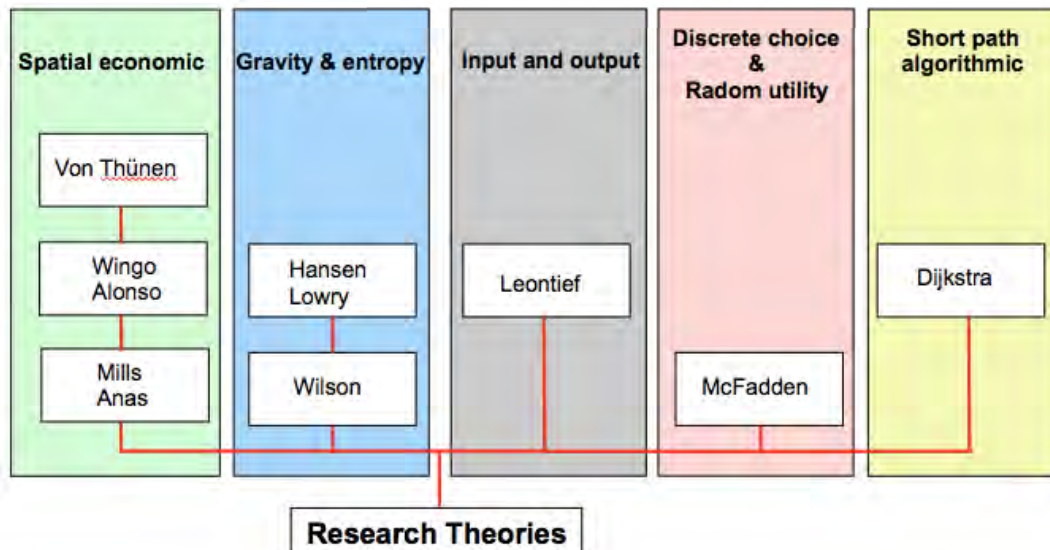
178 TAZs

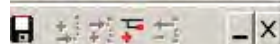
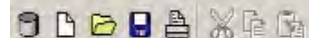
Applications in urban planning practices

- 3A Hospital site planning assessment
- Influence of subway Line 5 on housing location choice

Contributors

- ZHENG Meng, ZHANG Xiaodong, ZHANG Yu, ZHANG Xin in Department of Transportation Planning, BICP





BMI_Model.cat

Scenarios

- Base

Applications

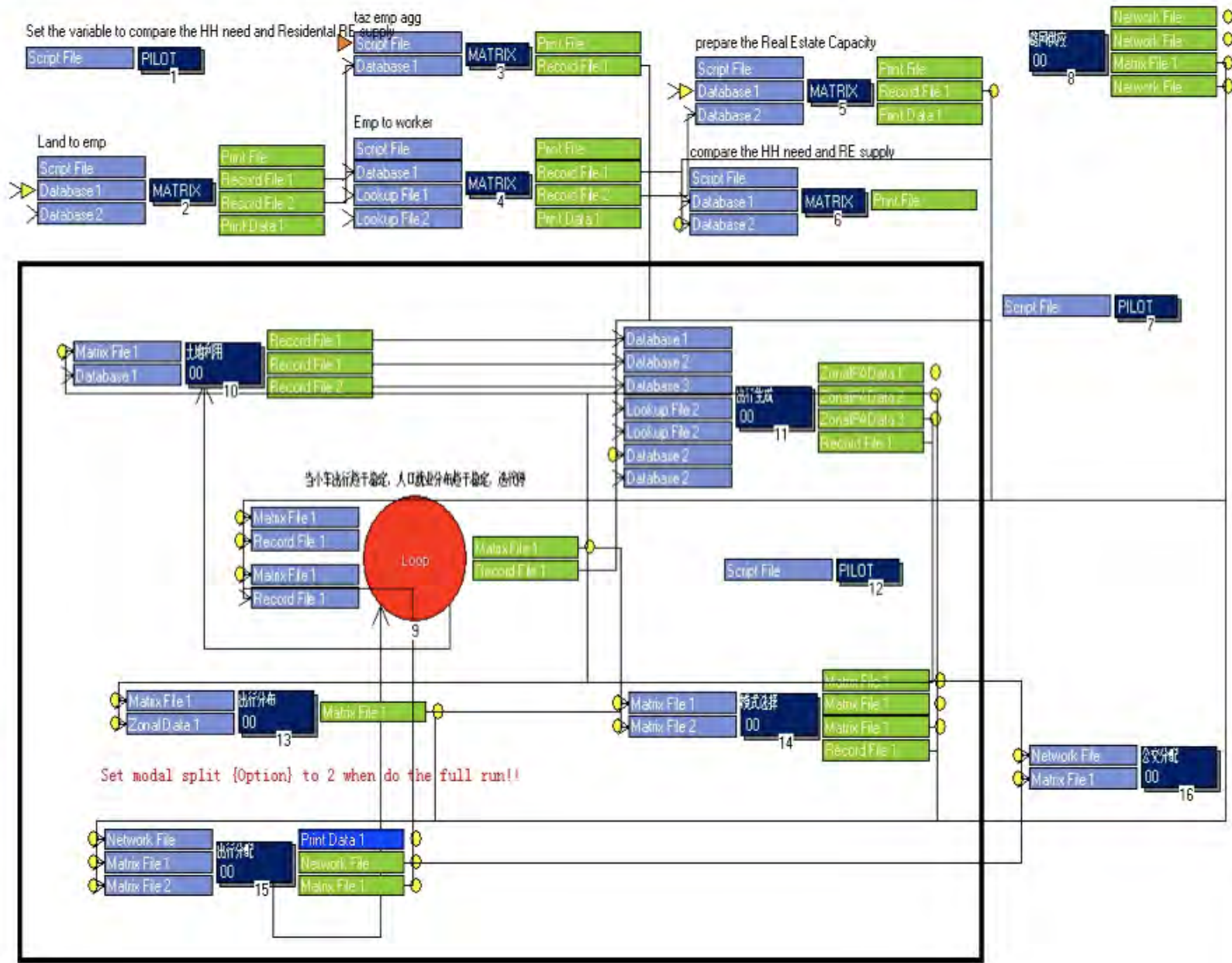
- 北京模型

Data

- Inputs
- Outputs
- Reports

Keys

Key	Value
Scen. Name	Base
Plan_Year	2004
Land_Use	???.dbf
Zones	374
Internal_Zones	178
RateColumn	2



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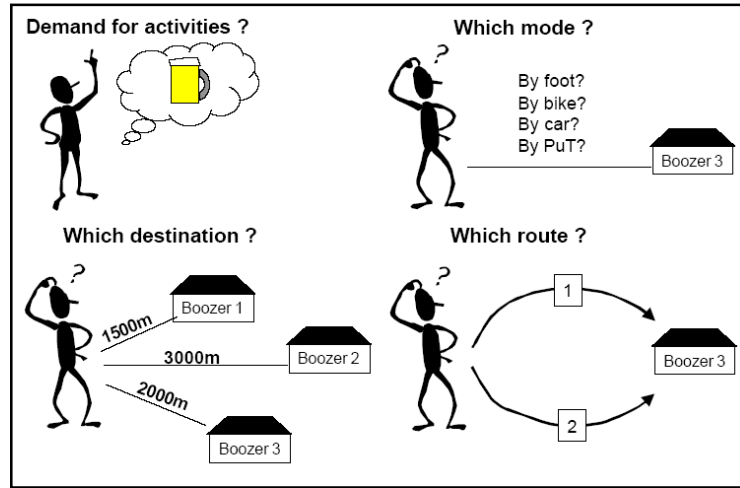
System structure of meso BUDEM

Transportation sub-models



Trip Gen

Trip Dist



Mode Choice

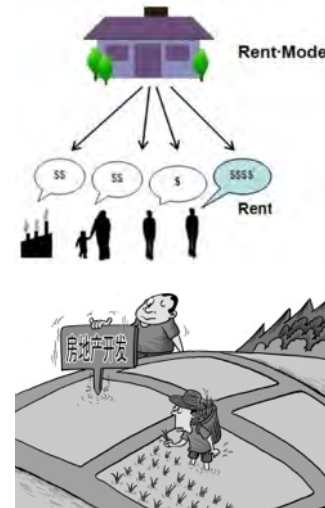
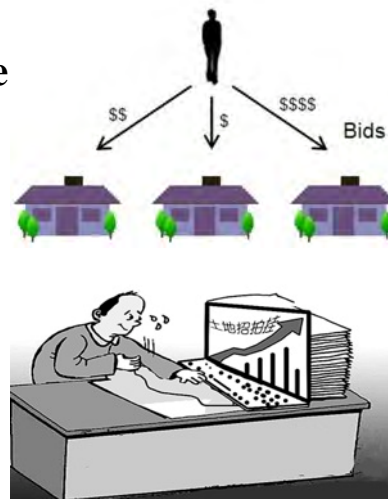
Traffic Ass

Land use sub-models



Location Choice

Land Auction



Rent Model

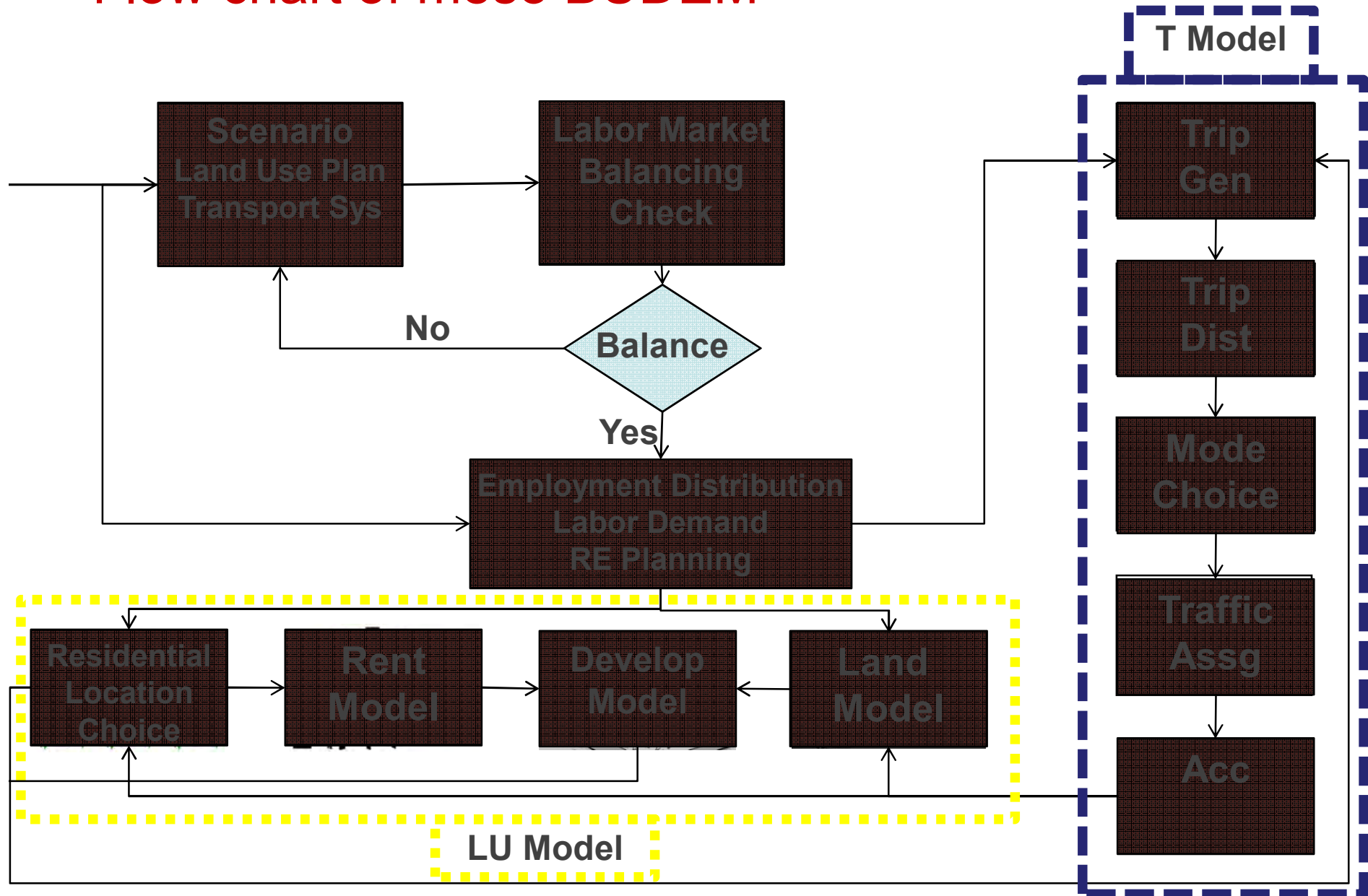
Develop Model

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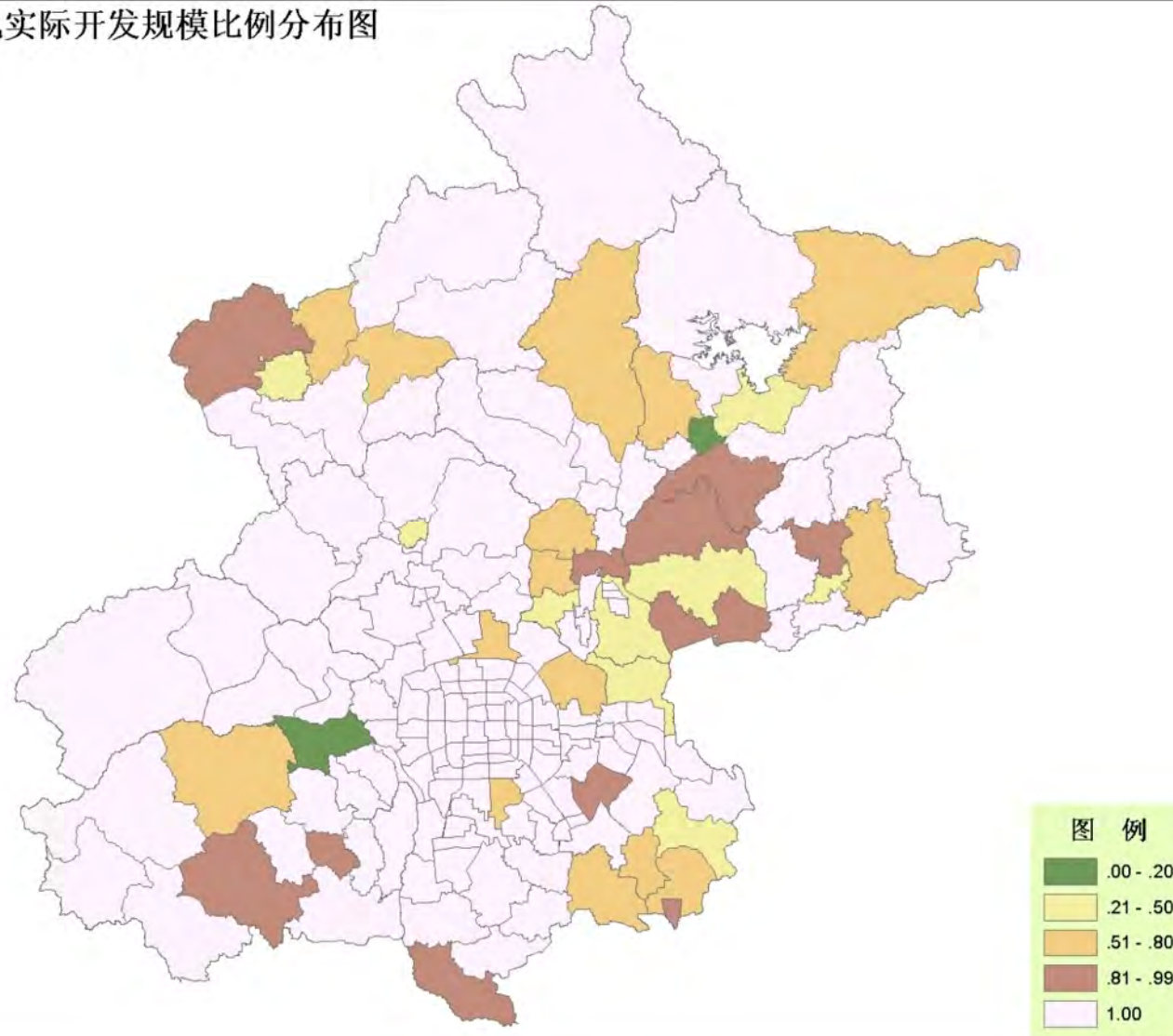
Flow chart of meso BUDEM



Applications:

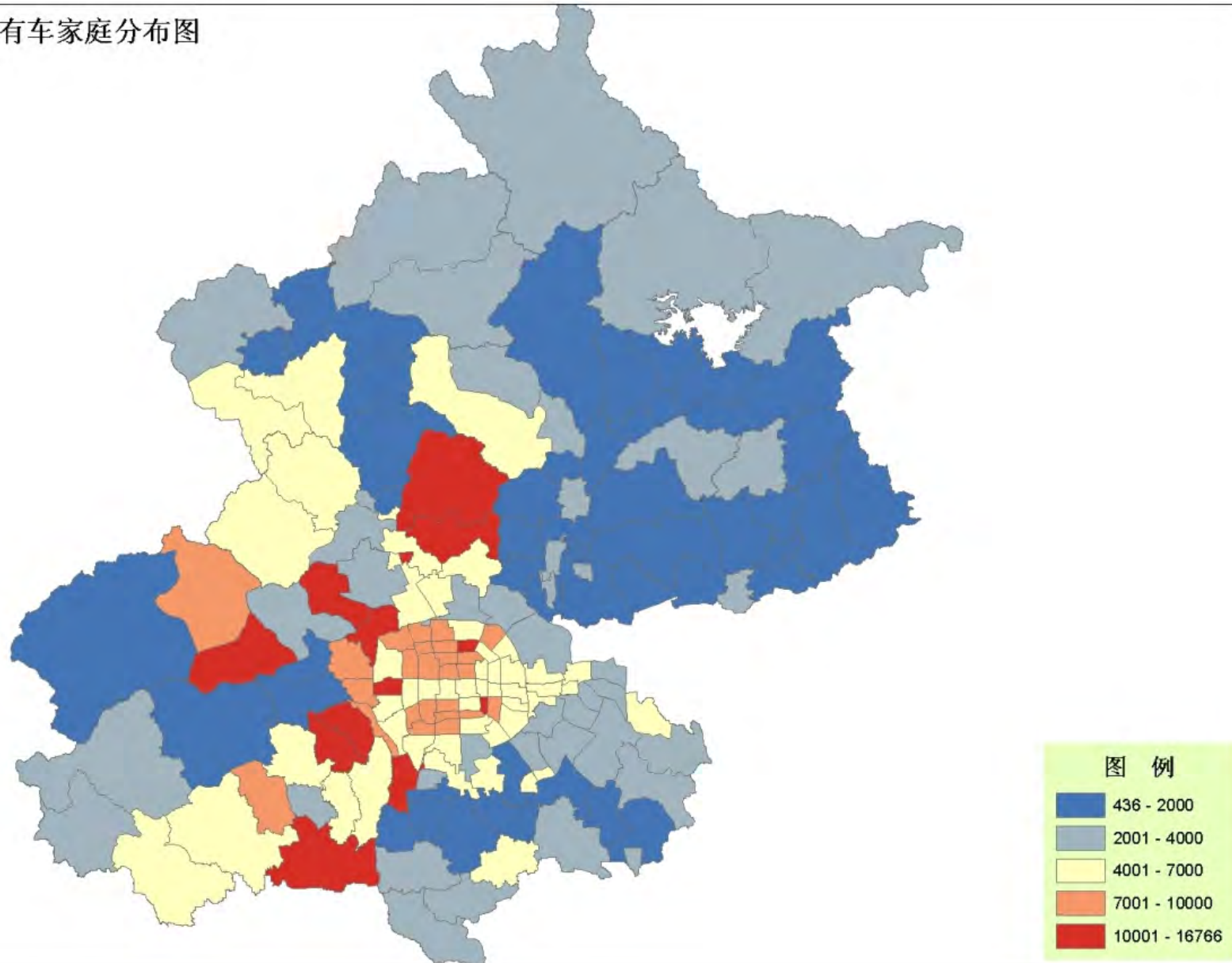
1 Residential land scale and distribution appraisal

规划住宅用地实际开发规模比例分布图



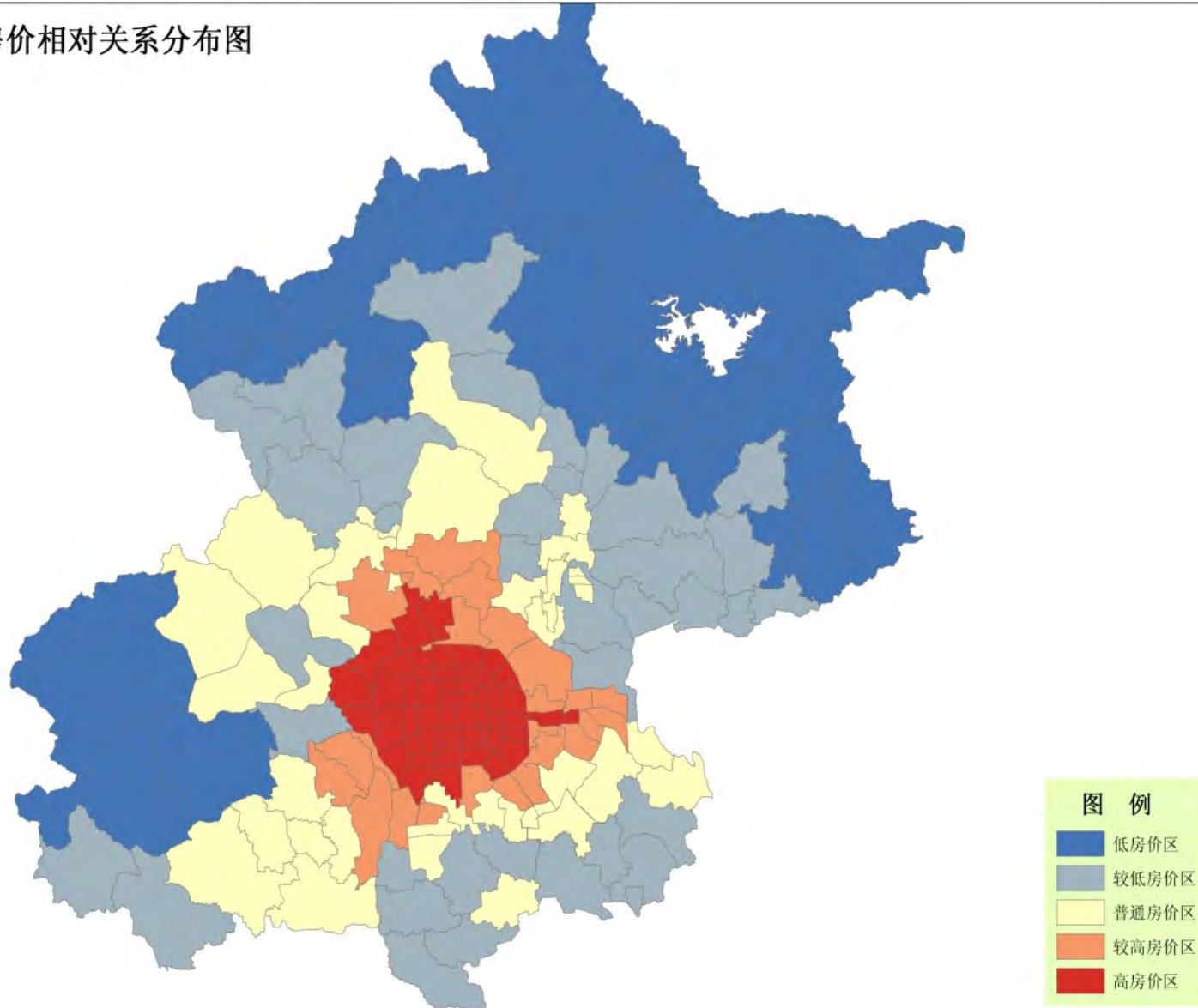
2 Forecasting the distribution of different household type

高收入有车家庭分布图

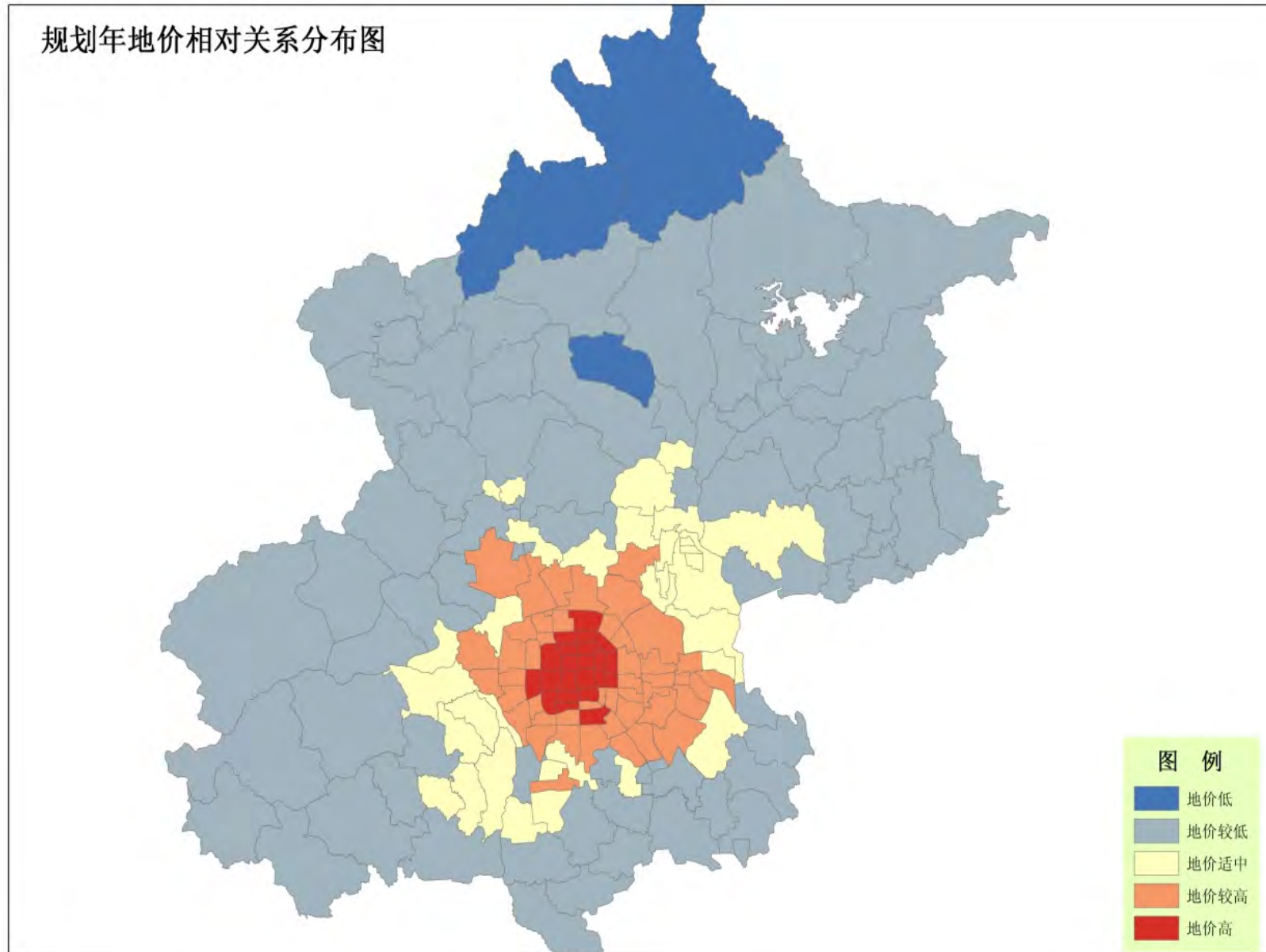


3 Forecasting the distribution of rent price

规划年房价相对关系分布图

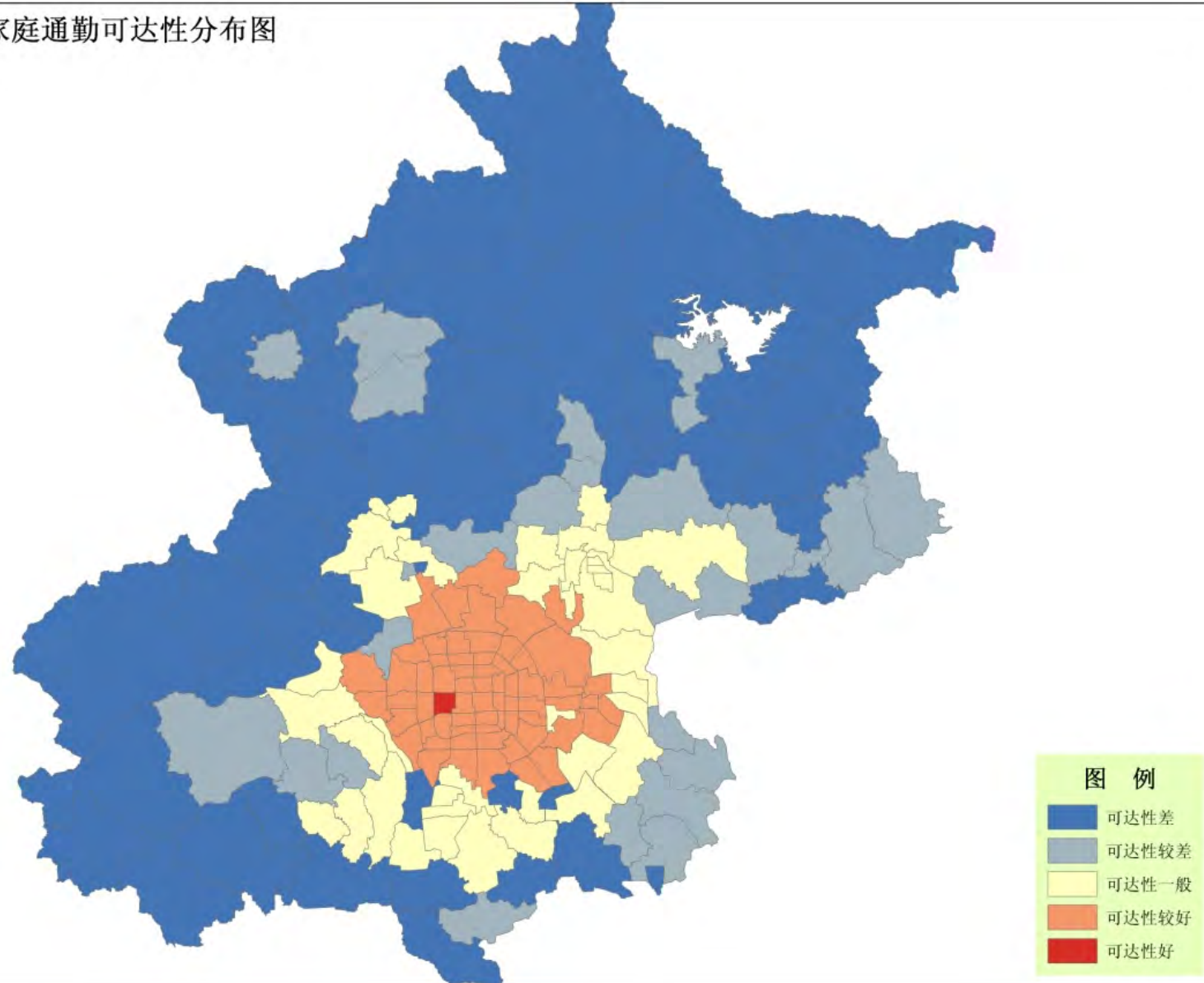


4 Forecasting the distribution of land price

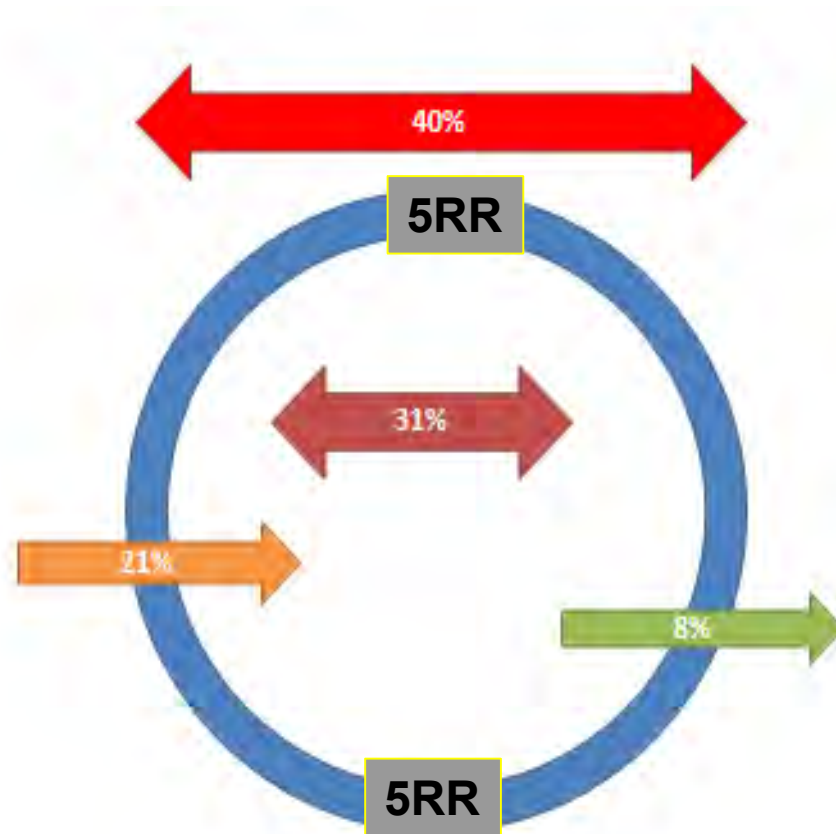


5 Forecasting the accessibility

高收入无车家庭通勤可达性分布图

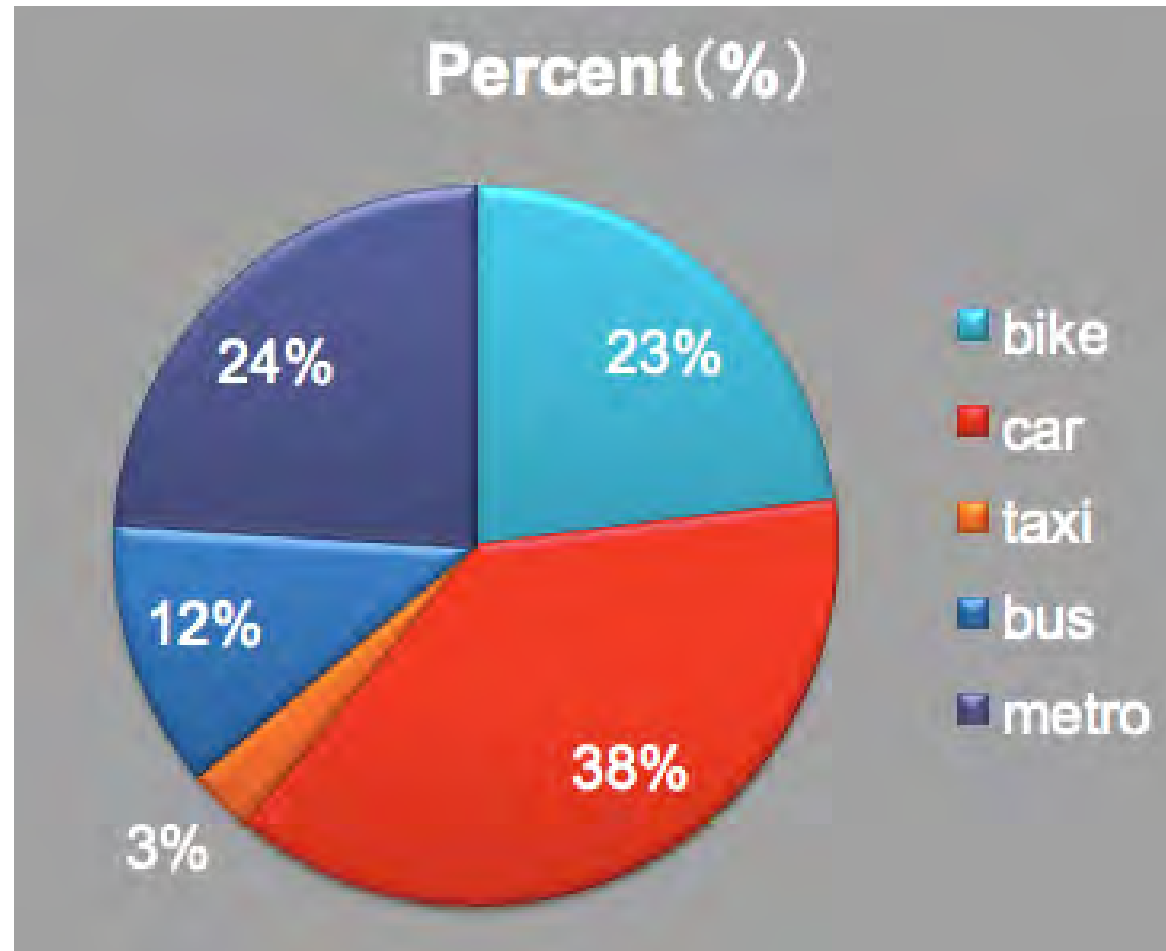


6 Forecasting the distribution of trips



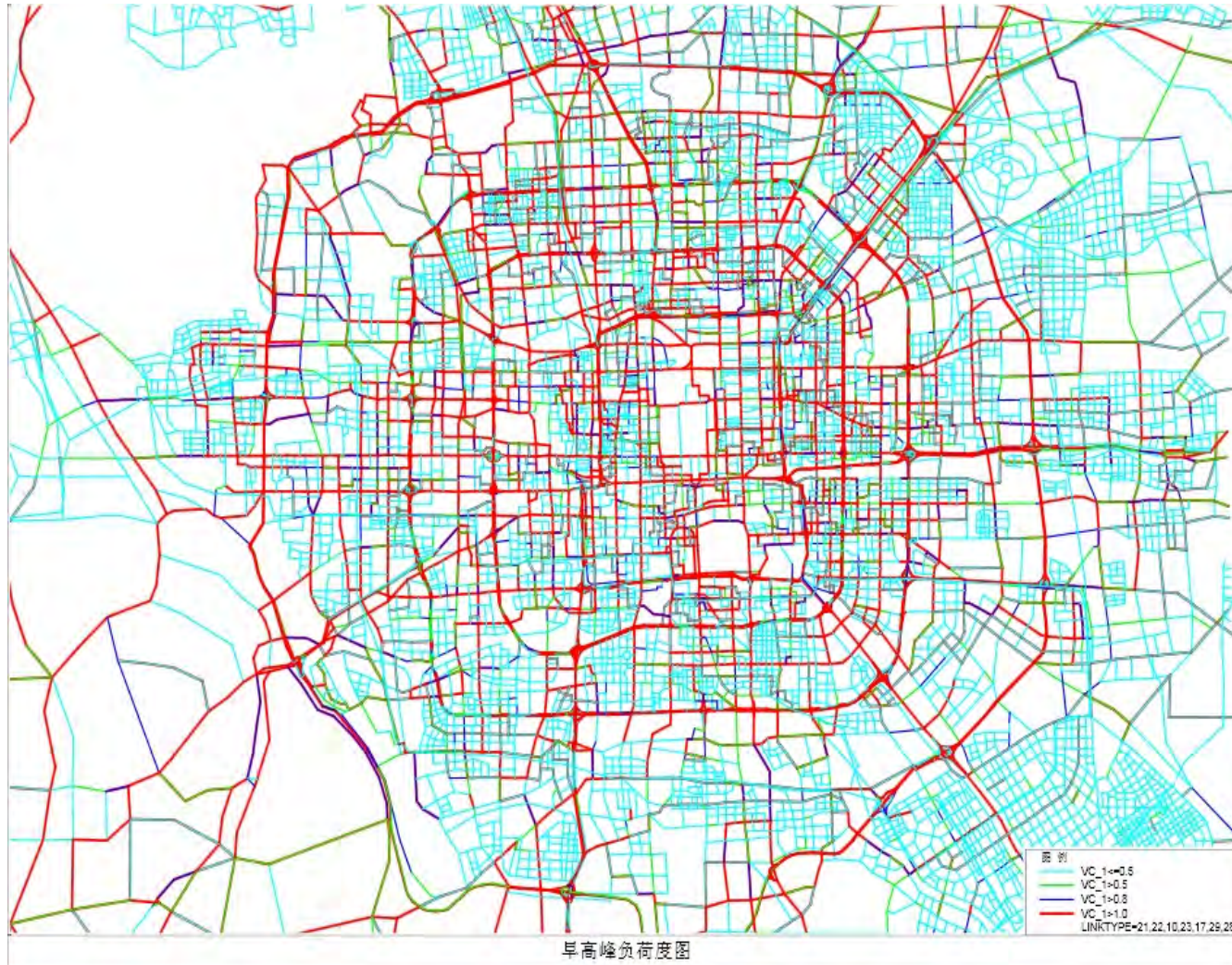
AM Peak-Hour PCU DISTRIBUTION

7 Forecasting the traffic modal split



AM PH Modal split result

8 Forecasting the traffic volume through assignment



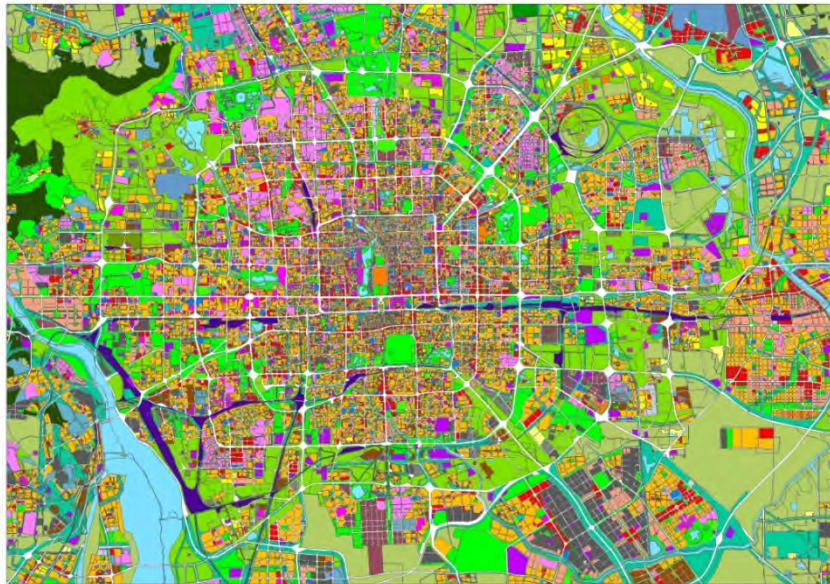
AM PH VC ratio of Planning Year

MACRO

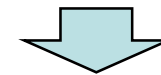
MESO

MICRO

9 Balance between the labor demand and supply appraisal



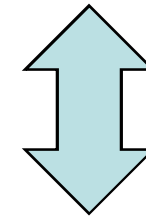
Labor demand: 10 million



Pop demand: 18.6 million

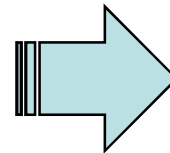
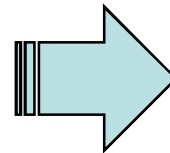


HH demand: 7.2 million



Balance

HH supply: 7.6 million



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In upgrading to 1911 TAZs using Cube.

Micro BUDEM

- ✦ An ongoing project
 - 2012-2014
 - Expected to continue during the academic visit to University of Cambridge from March 2013 to March 2014
- ✦ A fine-scale model for the whole Beijing Metropolitan Area
 - Rather than limited to typical neighborhoods based on questionnaire
 - Static parcels
- ✦ Supported by macro and meso BUDEMs
 - Providing exogenous variables for micro BUDEM
- ✦ Proposal a fine-scale model for
 - Establishing micro-level data infrastructure (**BEIJING100%**)
 - Present
 - Environment, energy consumption, CO2, spatial policy
 - Short-term
 - Demographic evolution, residential location choice, job location choice, land use layout scenario analysis

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BEIJING100%

Parcels

- Existing, planned and permits

Population

- Households / residents

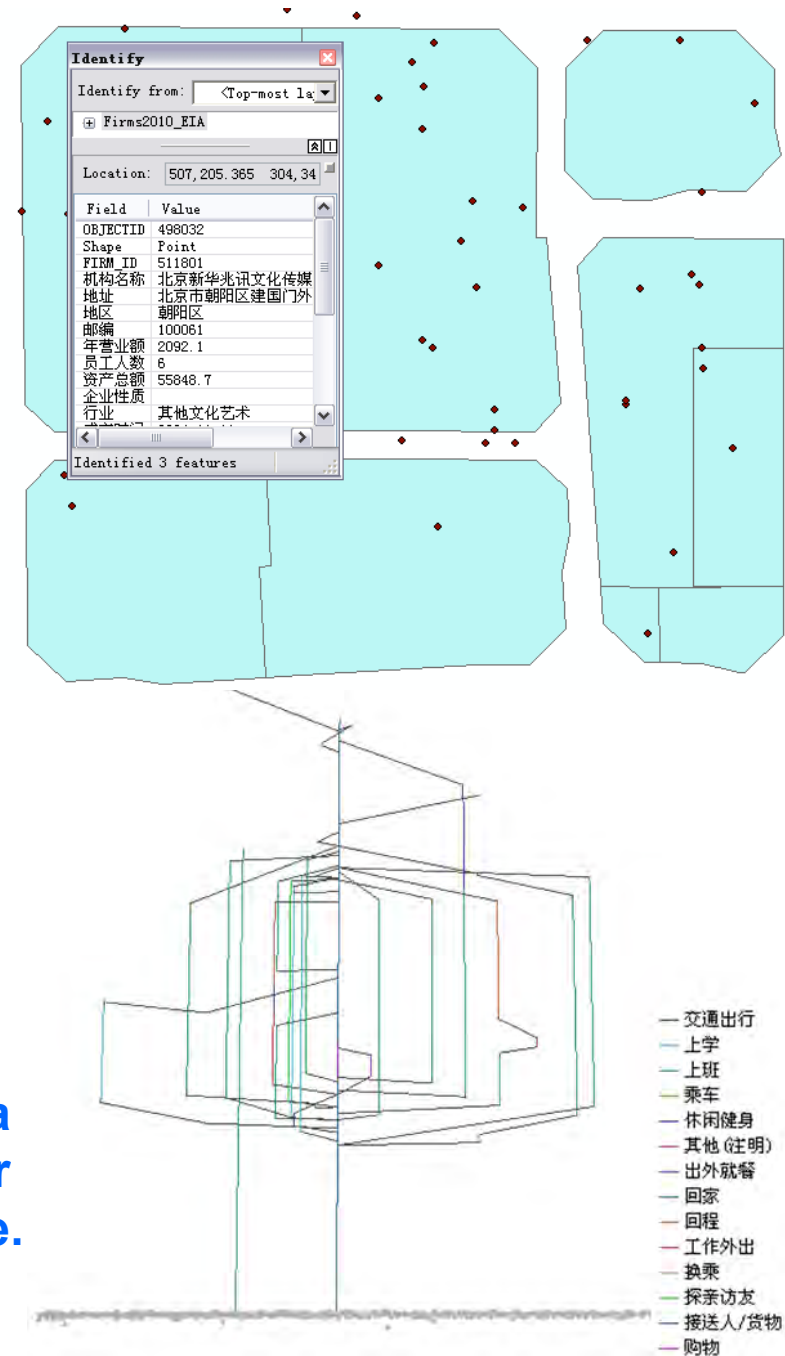
Human mobility

- Daily activities and all-modal trips

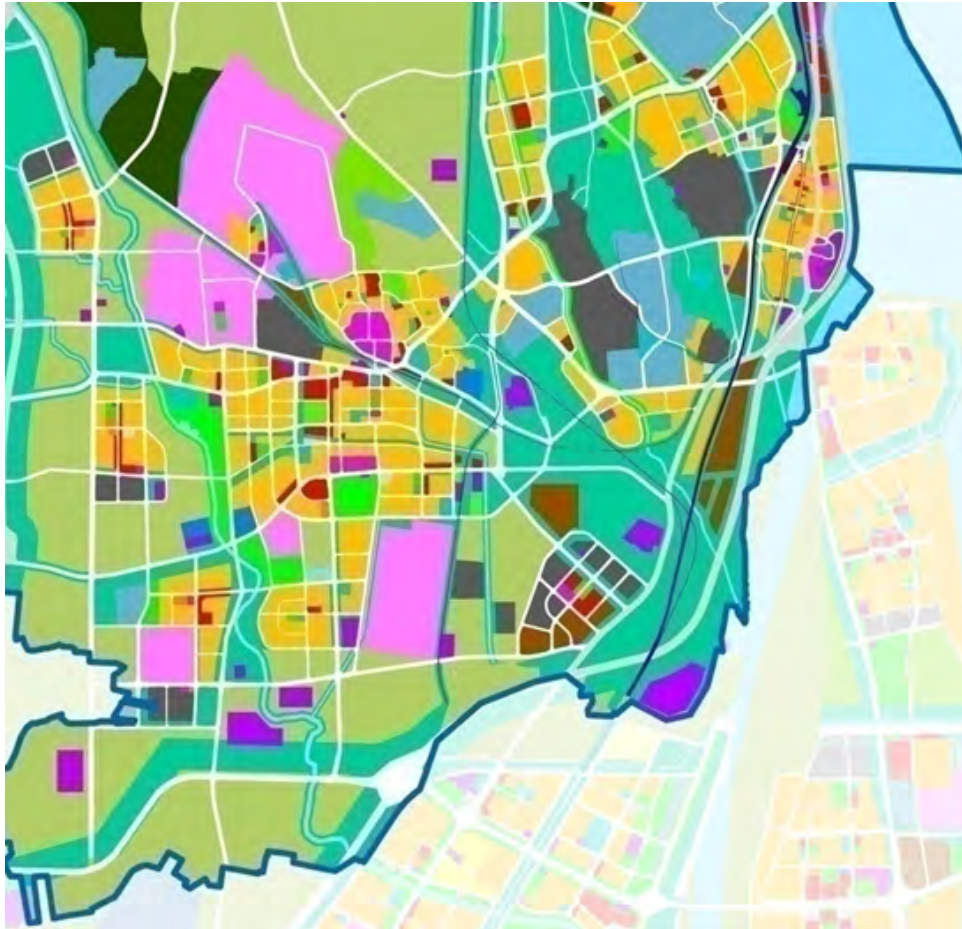
Firms

- All sectors

BEIJING100% is 2010 based, and an extra evolution submodel will be proposed for short-term data synthesis in the near future.



BEIJING100%: **Parcels**



✦ Buildings

- Footprint & #floor
- Within 6th ring road
- 2004/2006/2008/2010
- 254 million buildings in 2010

✦ 136638 existing parcels

- Floor area, land use type, resident count, job count

✦ 100912 planned parcels

- Land use type, FAR, maximum building height,

✦ 139886 cadastres

- Within 6th ring road

✦ 38894 land use permits

- 1950-2011
- Land use type, developer, issue date

BEIJING100%: Population

✦ 19.1 m residents and 8.0 m households in the BMA

✦ Input datasets:

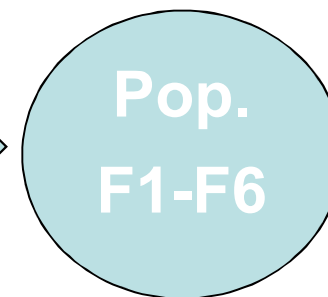
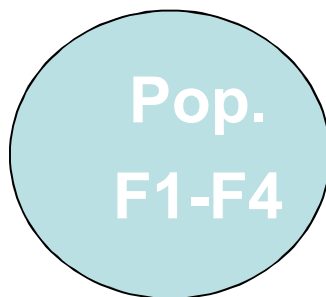
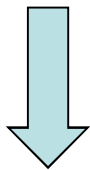
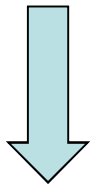
- Samples (116,142 residents / 46,900 households)
- The 6th population census of Beijing
- Existing researches regarding statistical characteristics of population attributes and relationships among attributes

✦ Population synthesis

- PopGen: based on samples and marginal
 - Developed by Arizona State University
 - <http://urbanmodel.asu.edu/popgen.html>
- Agenter: does not need samples
 - Developed by Ying LONG
 - Long Y, Shen Z, 2012, “Disaggregating heterogeneous agent attributes and location from aggregated data, small-scale surveys and empirical researches” Computers, Environment and Urban Systems (Revision under review)

BEIJING100%: Population

- **Samples**
- **Aggregated data**

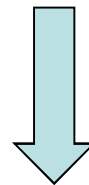


Samples: F1, F2, F3, F4

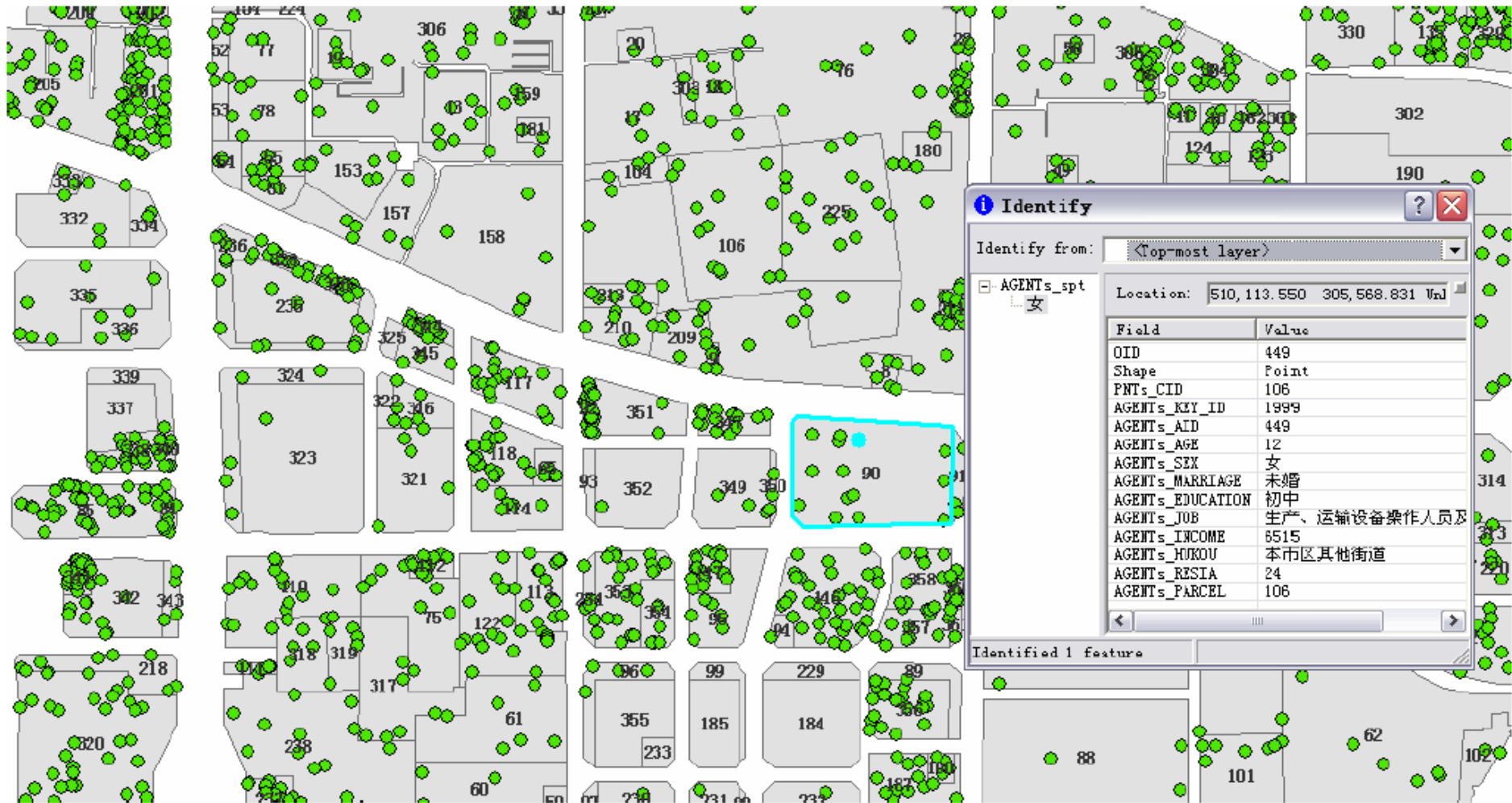
Aggregated data: F1, F2, F3, F4, F5, F6

Pop. = Households + Residents

- **Aggregated data**
- **Existing researches**



Synthesized population



Resident attributes: age, gender, education, martial status, job, nation

Household attributes: size, income, location

A demographic sub-model to be developed to synthesizing short-term population.

BEIJING100%: Human mobility

Travel purposes

Work

School

Returning home

Shopping

Entertainment

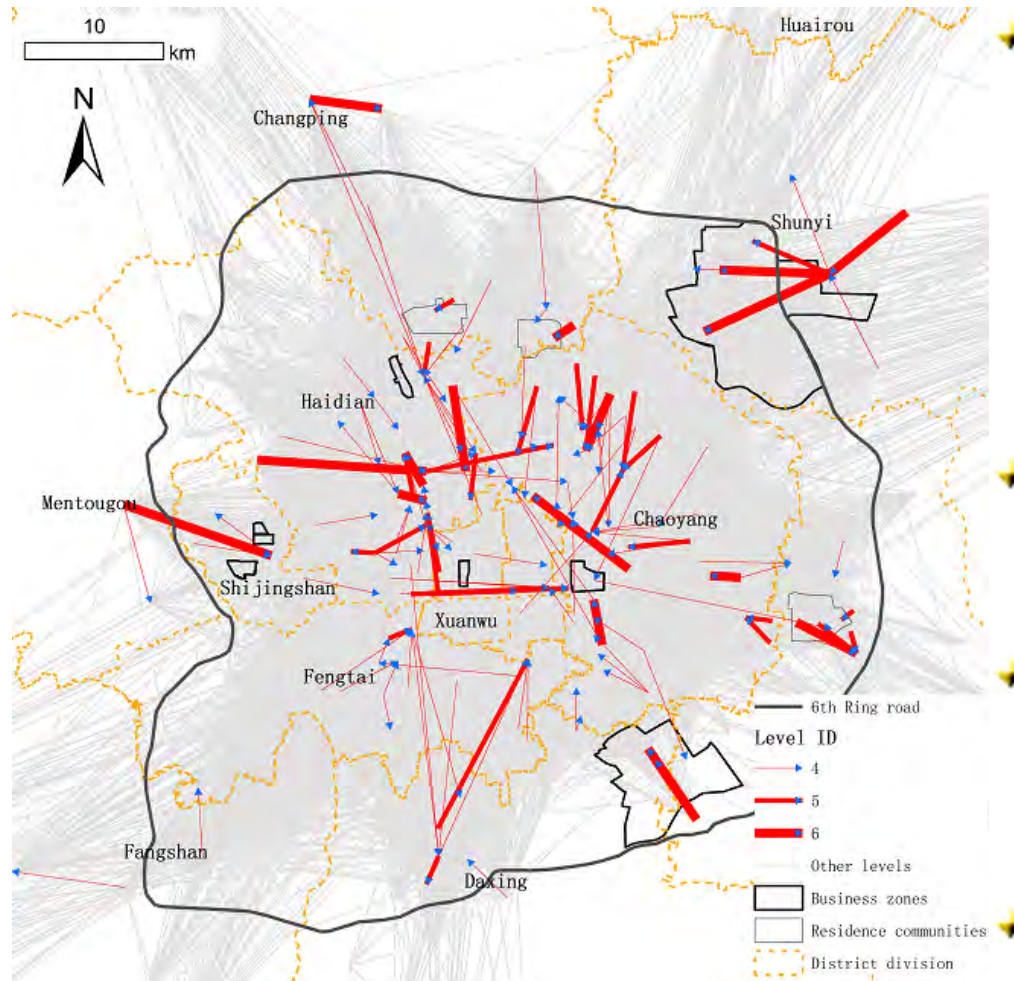
Daily life

Business

Other

- ✦ The Beijing Household Travel Survey in 2010
 - 46,900 households / 116,142 persons surveyed
 - 253,584 trips (52,640 commuting from housing to job)
 - Information including
 - Socio-economic attributes of households and persons
 - One-day travel diary of each person (mode, purpose, OD, departure and arrival time, etc.)
- ✦ Converting trips to activities
 - 75032 persons' 287027 activities
- ✦ The 2005 version
 - 81,760 households / 208,290 persons surveyed
 - 831,076 trips

Inferring urban activities from big data



Smart card data of Beijing in 2010

- Bus and metro ridings
- 10.9 million cards
- Over 100 million swaps
- Finishing identifying commuting trips

Crawled from Weibo

- China “Twitter”
- Check In

Taxi trajectories

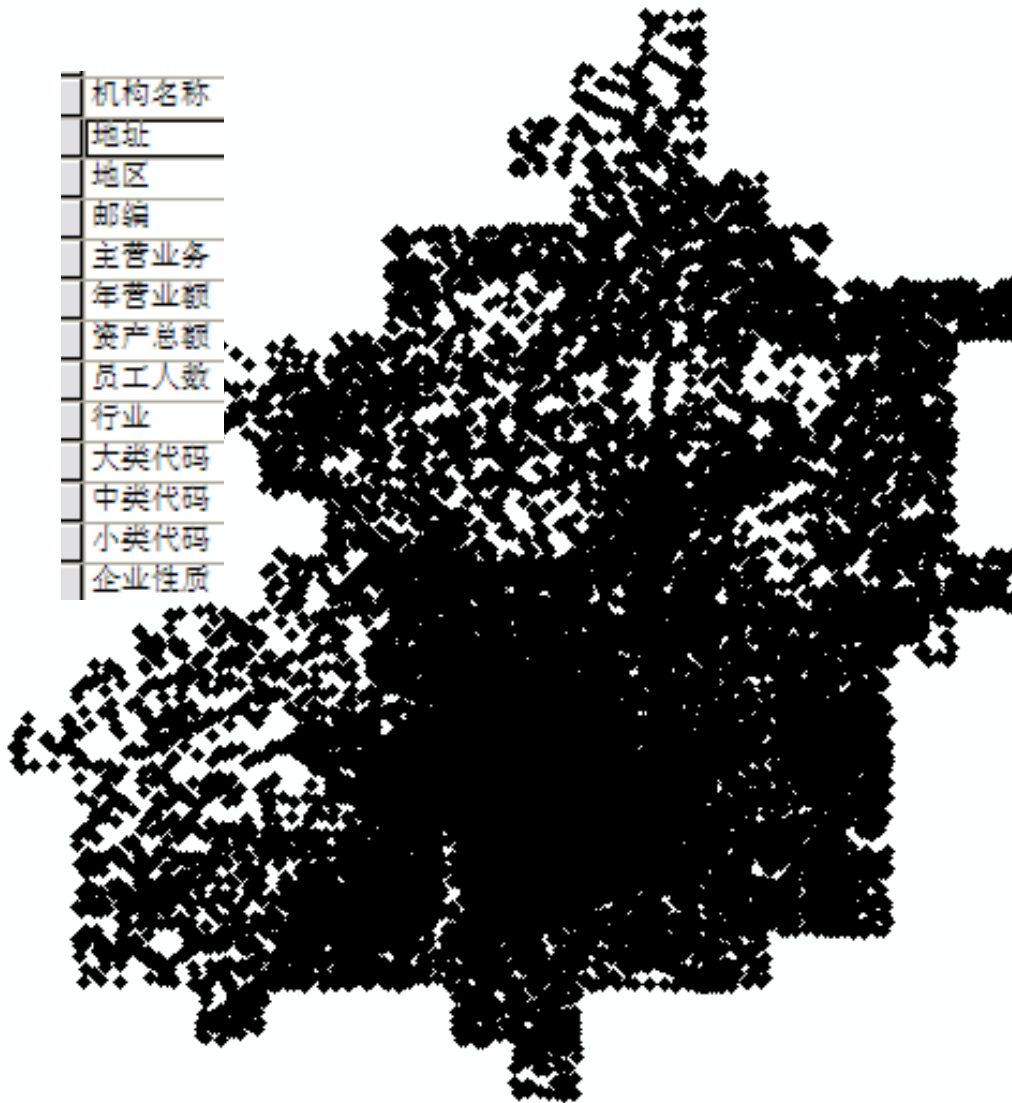
- Microsoft Research Asia (MSRA)
- 30,000 taxis

Combined with POIs

- Over 100,000 categorized POIs

BEIJING100%: **Firms**

机构名称
地址
地区
邮编
主营业务
年营业额
资产总额
员工人数
行业
大类代码
中类代码
小类代码
企业性质



✦ 630 thousand firms

- In 2010
- With 14.5 m job positions

✦ Attributes

- Location
- Sector (all sectors 1-98 of China)
- Revenue
- Employee count

MACRO	MESO	MICRO
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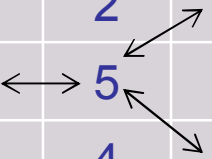
Microsimulation / microanalysis for macro policy evaluation

4	1	2	2	7	6	1	1	5	8
8	8	3	3	4	2	8	2	4	9
7	2	3	4	2	0	3	5	3	9
5	1	6	6	1	1	1	4	9	2
2	2	8	5	7	9	4	3	8	3
3	5	4	3	5	2	8	2	7	8
4	7	2	7	4	3	0	6	2	3
2	4	1	2	1	4	2	9	5	4
8	6	9	3	2	1	1	2	5	4
7	2	3	9	1	6	4	3	8	4

36

11%

18

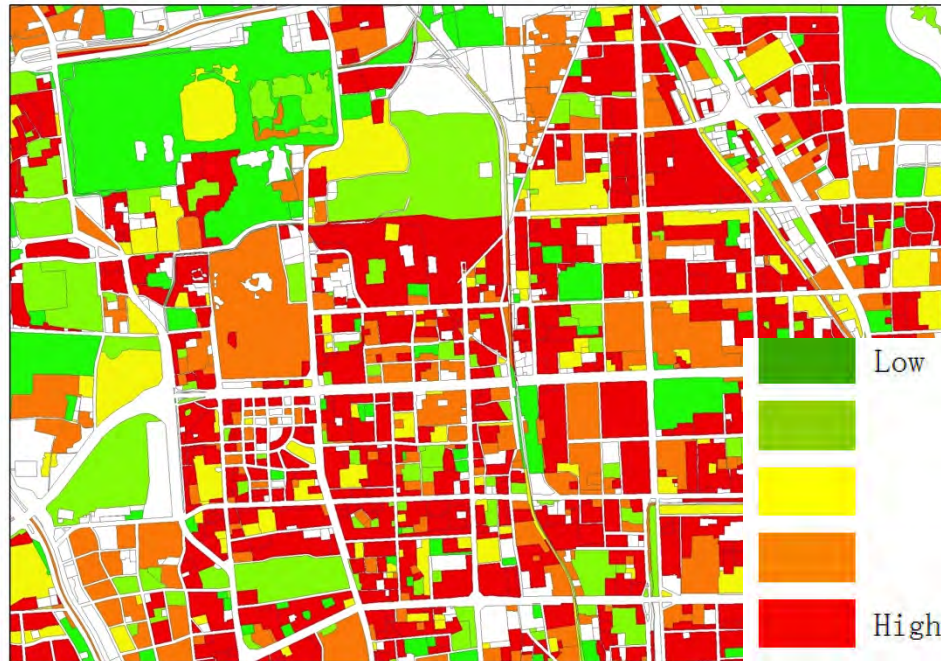


Policy (spatial or not)

- Feedback and decision by individuals
- Macro behavior and spatial heterogeneities

What could the plan response?

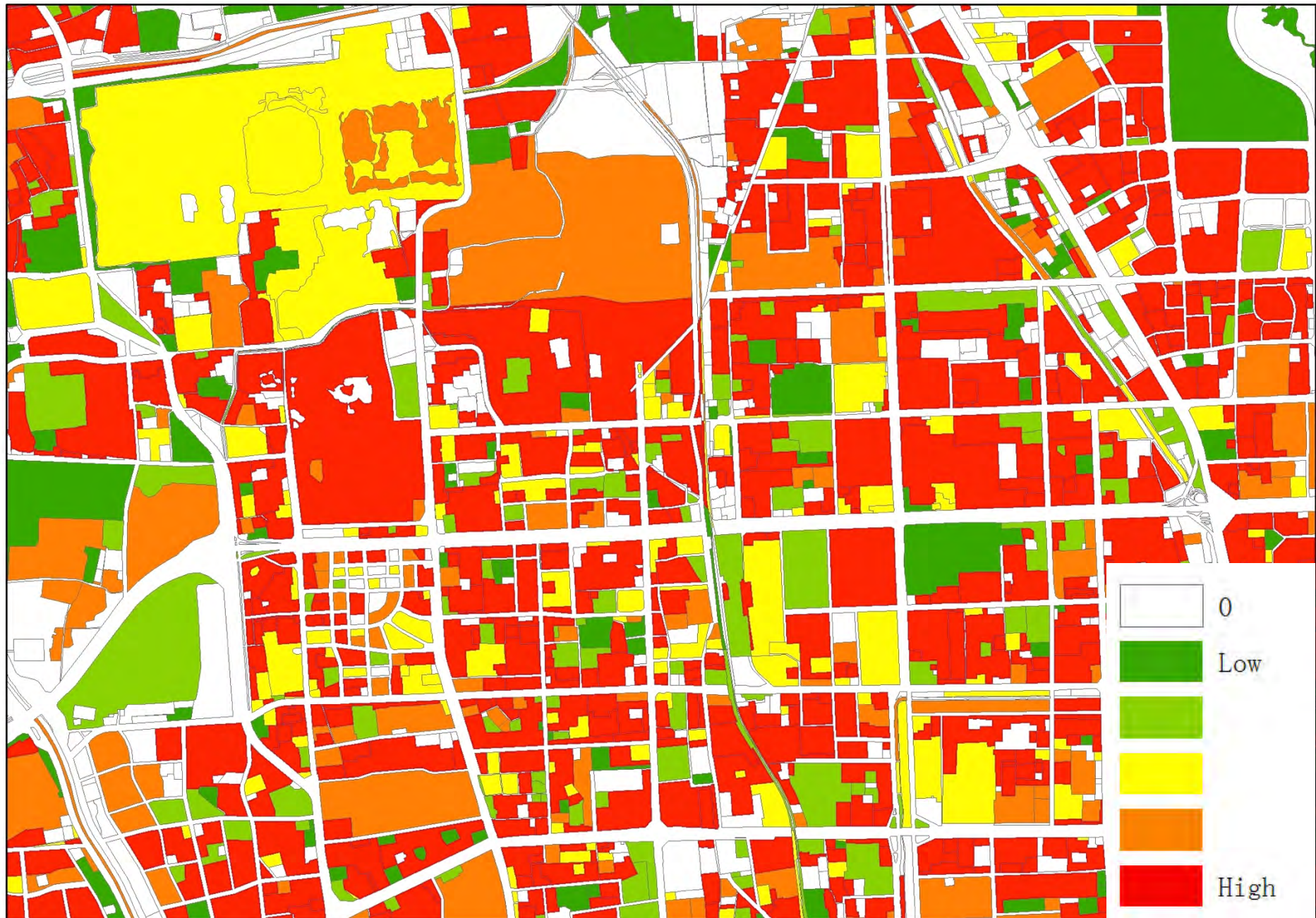
Case 1: Environmental evaluation



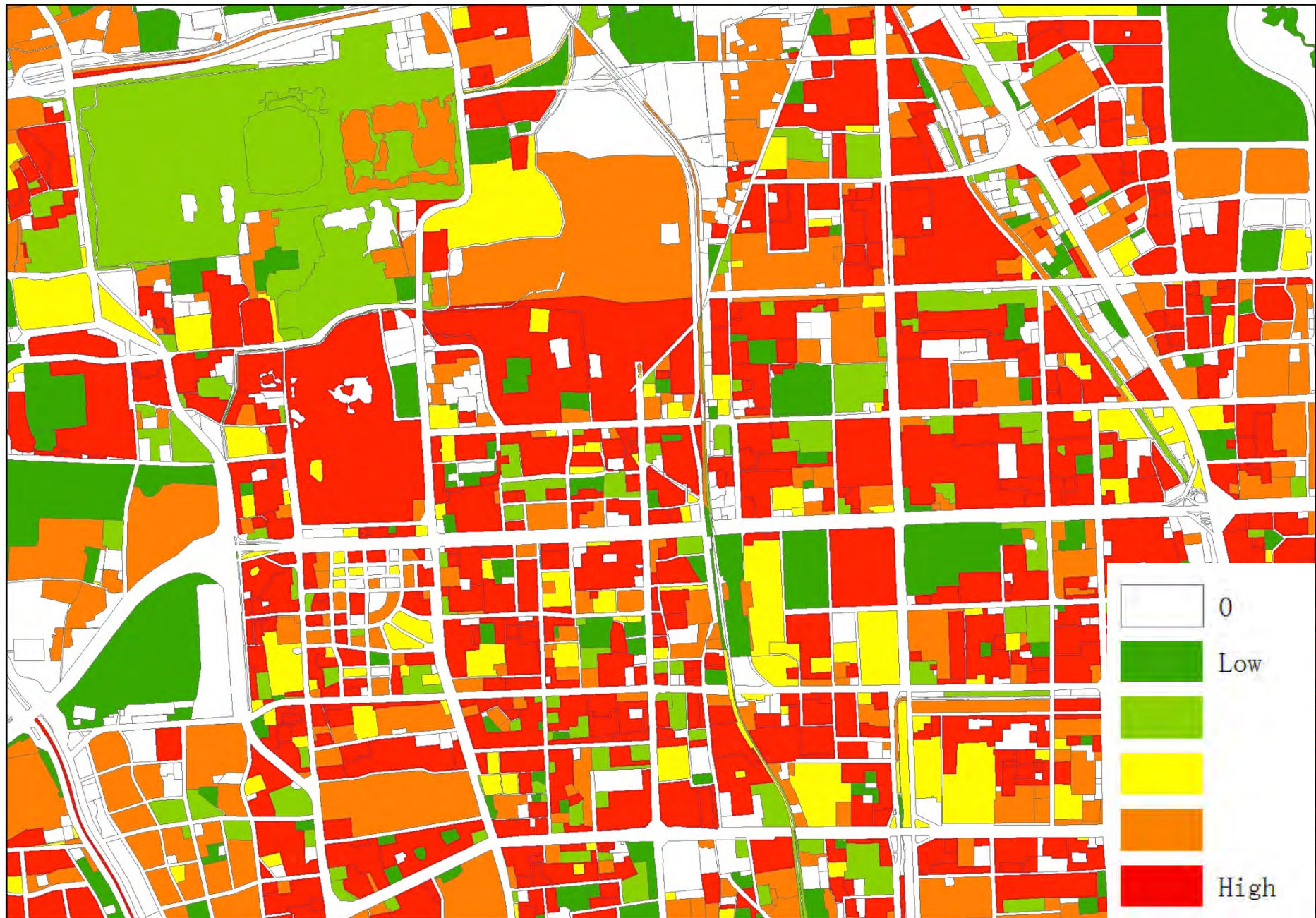
Energy consumption per sqkm

- ✦ Totals for all inventories from census report
- ✦ Allocating totals into parcels
 - Firms
 - Population
 - Human mobility
- ✦ Available for evaluating CO₂ emission in the parcel level

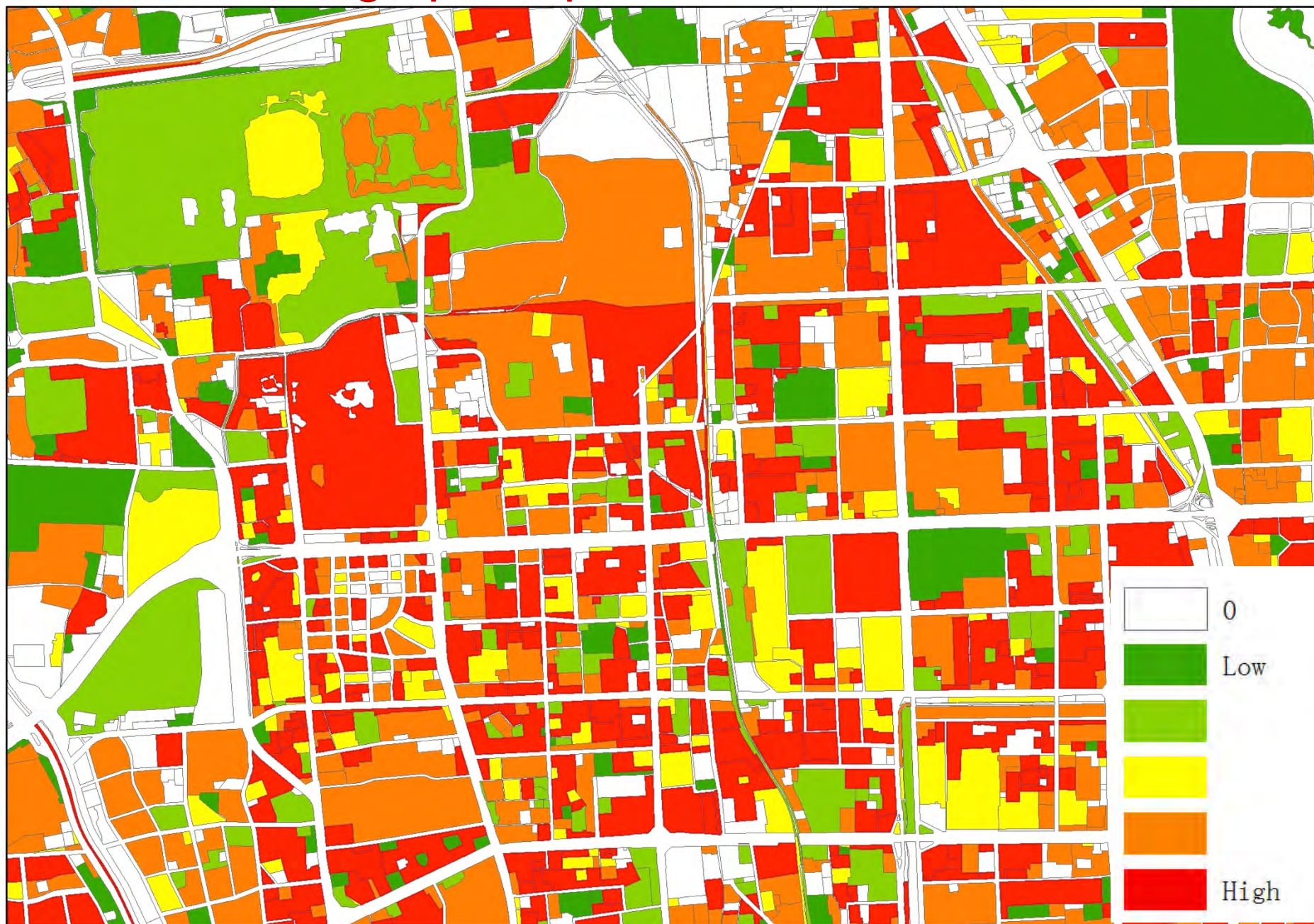
Wastewater discharge per sqkm



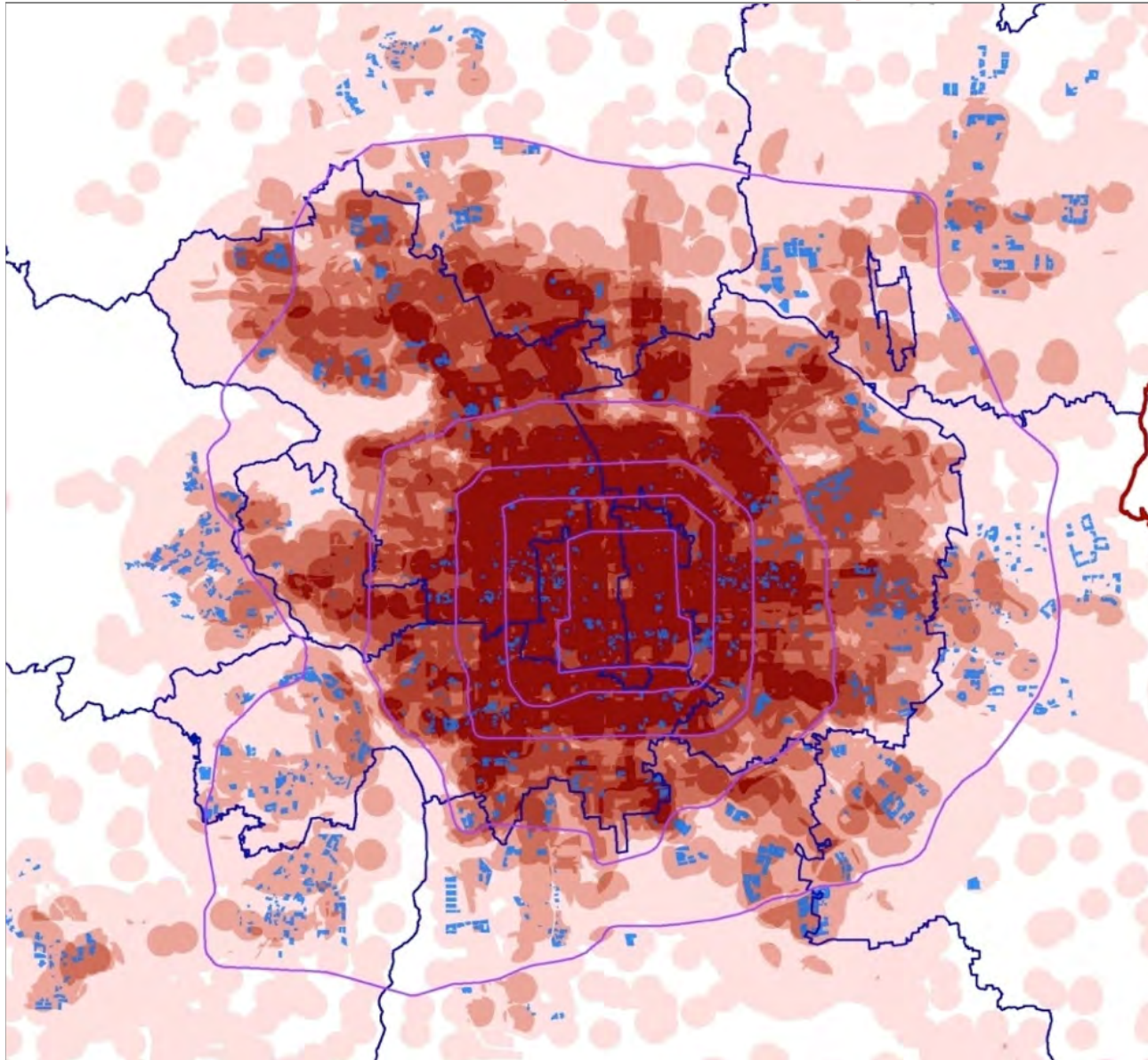
Solid waste discharge per sqkm



SO2 discharge per sqkm



Case 2: Policy housing location choice



Supply side

- Multi-criteria decision making using AHP
 - Market oriented factors
 - Institutional factors
- 110 sqkm available
- In the parcel scale

Demand side

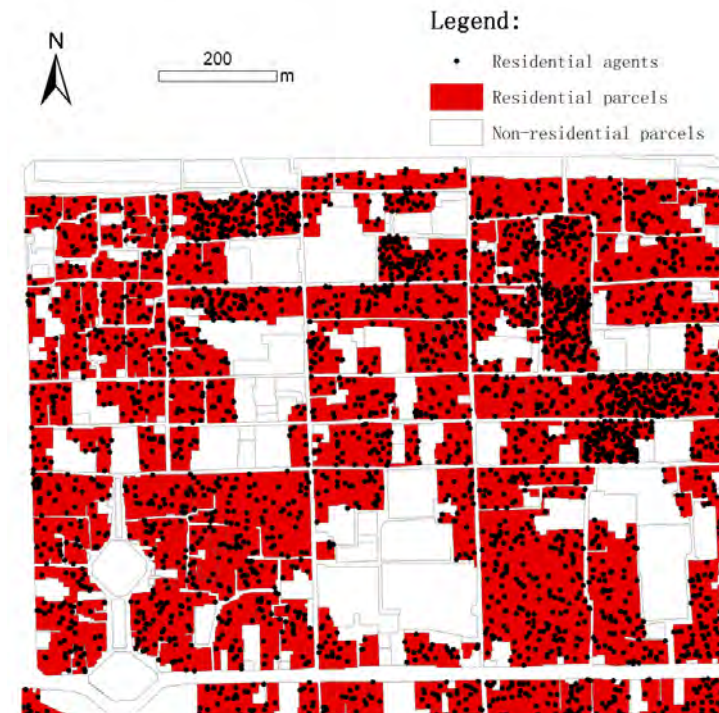
- Synthetic population
- Quantified policy housing policies
- Contingency survey

Combining supply and demand sides

- Suggested locations, scales and construction order
- Policy evaluation

Other potential applications using BEIJING100%

- Small-scale urban redevelopment in the downtown area
- Metro line location choice
- Congestion zone setting
- Underground ring road
- Hazard influence evaluation
- Market-oriented applications
 - Shopping facility



Short-term forecast / scenario analysis

On going...

- Extend human behavior in BEIJING100%
- Based on the macro/meso BUDEMs
- Parcel-scale UrbanSim
 - Land develop, residential location choice, firm location choice
- Activity-based travel model
 - Representative travel chains extracted from the 2010 survey

BUDEM1
继续完善

- 数据
- 方法
- 应用（地域和专业）

精细化数字基础设施（现状和近期）

- 居民、企业、地块 (HELN+WUYC)
 - 大数据SoLoMo（公交卡、微博）
- 居民全样本合成
- 基于人口统计学的人口预测
- 企业预测

BEIJING100%

基于现状的影响评价和政策评估
（友好界面）

- 空间视角的评价（地块、房价和地价）
- 影响评价（交通ZHANGY、环境、能源XUYF、碳排放）
 - 居民家庭→居民活动→居民出行→影响评价
 - 企业全样本→影响评价
- 政策评价（空间和非空间）
 - 设施选址
 - 经济政策

近期评价
（UrbanSim）

- 土地开发ZSQ
- 居住区位选择ZHENG SQ+LIAOZX+YANGM
- 就业区位选择ZHENG SQ+YANGM
- 其他：规划师主体PA→规划方案评价

Conclusions

Three urban spatial development models in Beijing

✦ A family of BUDEM s

- Ranging from macro, meso to micro

✦ Macro and meso BUDEM s

- Applications in strategic and master plans

✦ Micro BUDEM

- **BEIJING100%**
- Applications in the detailed plan scale, e.g. plan scheme evaluation, policy evaluation and EIA
- More frequent application in plan practices

✦ Demanding continuing efforts

Conclusions

Urban models in the era of “big data”

✦ “Big data”

- GSM, GPS trajectories, smart card swaps, credit card, SNS, etc.
- Individual based
- Increasing availability

✦ Opportunities or challenges

- Population synthesis **v.s.**
- inferring urban activities from bus/metro smart card data

✦ The second requiem for large-scale urban models?

- Too much data, rather than limited computation capacity, in contrast to the first requiem in 1970s (Lee, 1973)

✦ Urban modelling using “big data”?

- Enriching data related with urban physical space, transportation, and human mobility/ activities



BCL网站



BCL微信公众号

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微信公众号：beijingcitylab

未来更新将在BCL网站公布，敬请关注。

这套课件为龙瀛及其合作者近年来在城市模型领域研究的部分合集，包括传统的城市模型、基于大数据的城市模型、大模型这一城市与区域研究新范式，以及最近的面向规划设计应用的初步探索。

这些PPT在不同的学术会议和论坛上做过发表，时间和精力有限，并没有专门针对此课件进行调整。课件内容难免有不完善之处，欢迎将意见和建议致信到longying1980@gmail.com