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Planner Agents: A toolkit for support planning a low carbon urban form (A preliminary research)

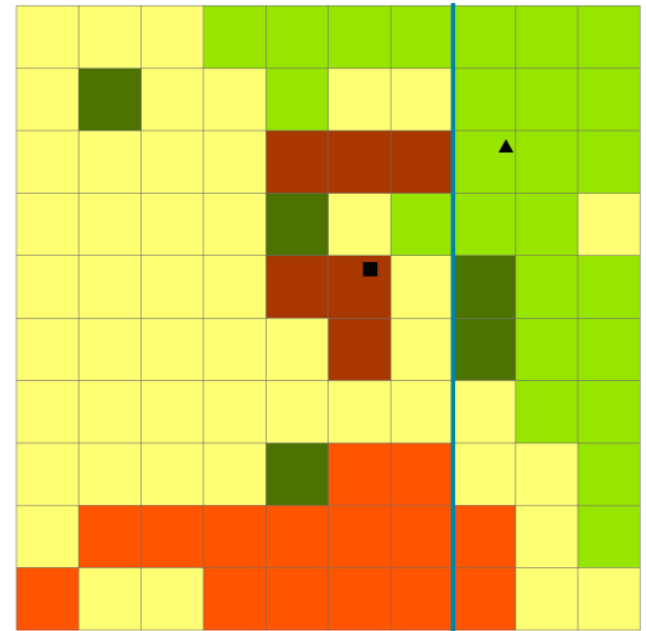
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University of Cambridge

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1 INTRODUCTION

Land use pattern (urban form),

- or land use layout, is a key part of physical plan (master or detailed)
 - Spatial distribution of land use and density
 - Hard to predict by a planning support system (PSS)
 - Proxy of carbon emission and energy consumption
- Land use pattern scenario analysis (**LUPSA**) – most are parcel-based
 - CUF (Landis 1994)
 - What if? (Klosterman 1999)
 - INDEX (Allen 2001)
 - iCity (Stevens et al. 2007)
 - Other papers regarding land use layout optimization



Planners in LUPSA tools

- Less attention was paid on the behavior of urban planners
- **Our research question:** How do planners compile land use pattern?
 - What are rules (*preferences*)?
 - How to identify these rules?
 - Are these rules varying among planners?
 - Could we develop a PSS for “simulating” land use patterns using the identified rules?
 - Is the pattern associate with low carbon emission?

Building city in a vitro

Hatner and Benenson, 2007, EPB

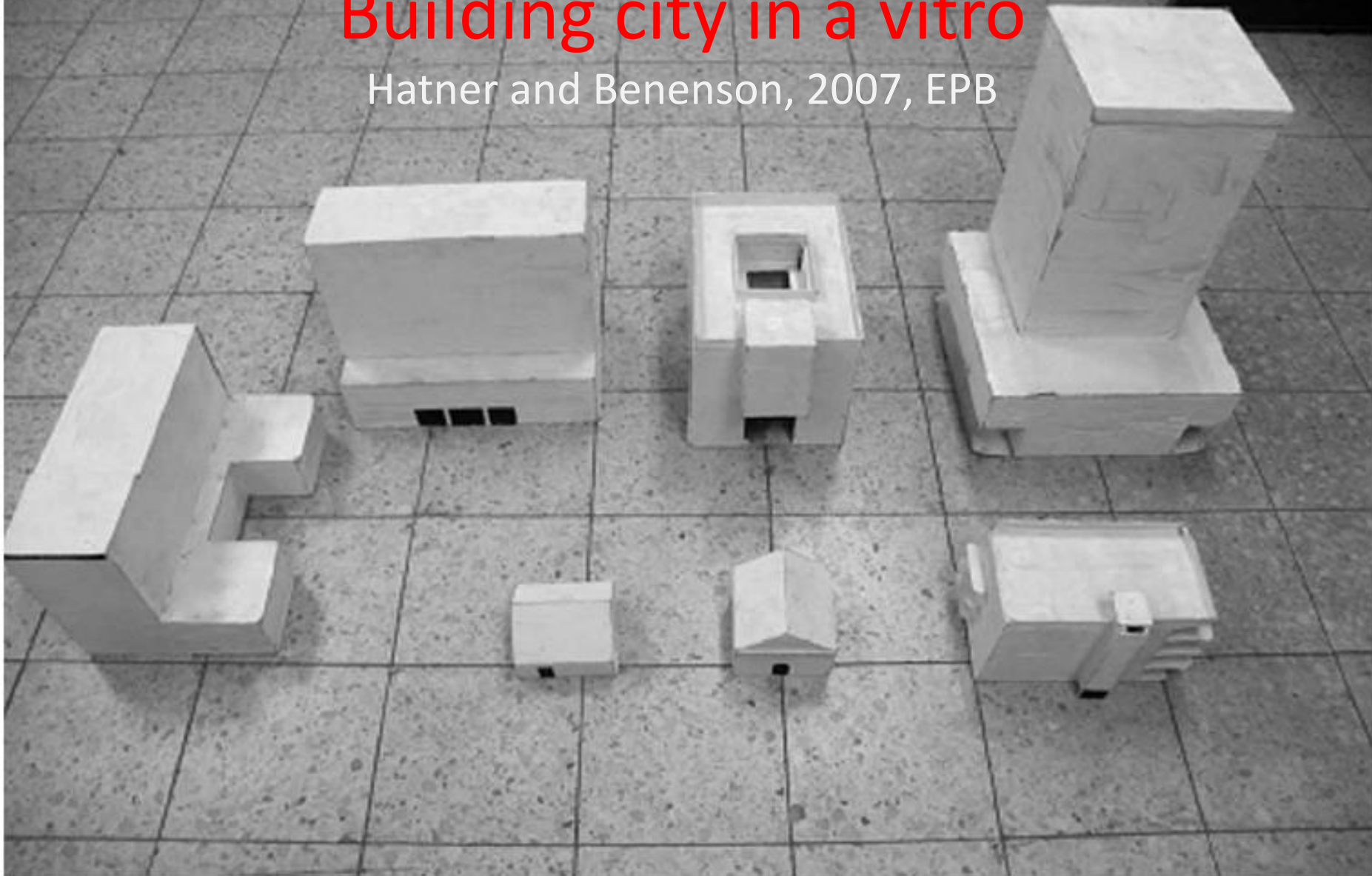


Figure 1. Seven of the fifty-two mock-ups used in the experiments (the floor tiles are of 20 cm × 20 cm size).

The entropy of LEGO

Crompton, 2012, EPB



(a)



(b)



(c)



(d)



(e)



(f)

Figure 4. LEGO® models: (a) Guggenheim Museum, (b) Hancock Tower, (c) Empire State, (d) Falling Water, (e) Sears Tower, (f) Seattle Needle.

In this research, we will identify planner rules by

- Questionnaire
 - What one planner will do
- Mining plan drawings
 - What one planner has done



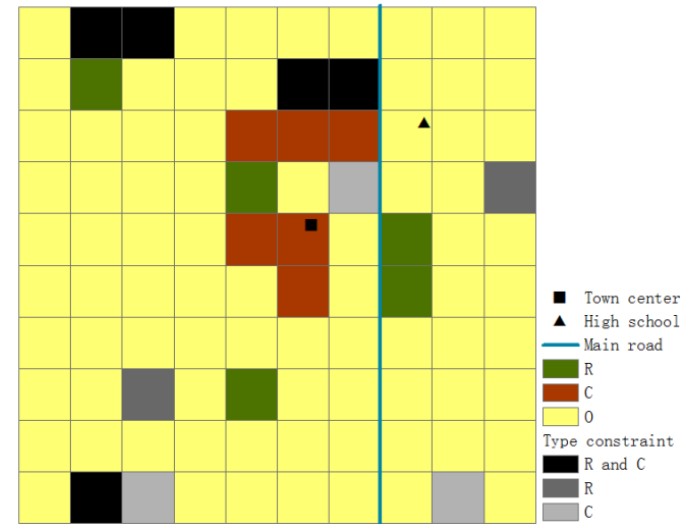
关于用地布局规划的问卷调查

您好,非常感谢您抽出宝贵的时间参与我们的问卷调查。本调查目的在于了解不同因素对不同土地使用类型布局(总规和控制尺度)的影响程度,进而了解规划师进行城市用地布局方案制定时的规划规则与偏好。请您根据自己的真实想法作答,所填写的资料仅供学术研究使用,不作个别披露或其他用途。非常感谢您对我们的支持!

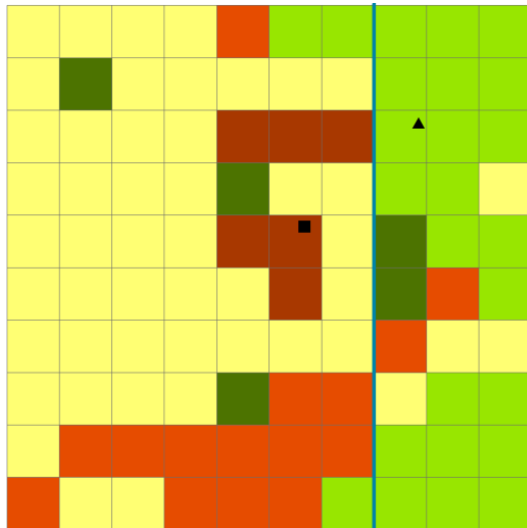
问卷中将土地使用类型分为四类:居住用地、商业用地、工业用地和其他用地。通过分值大小(0-9)反映各因素对规划师制定方案的影响程度,如对于工业用地布局,如果需要特别考虑邻近城市主干道,则打分为9,如果不需要考虑城市主干道,则用0表示。

影响用地布局的因素		评分(0-9分:没有影响-影响很大)		
因素类别	因素名称	居住(R)	商业(C)	工业(M)
1. 基础地形	高程	4	4	4
	坡度	6	6	4
2. 可达性	飞机场	2	2	2
2.1 交通设施	火车站	4	7	6
	高速公路	1	1	7
	城市主干道	6	4	7
	地铁站	9	9	3
	公交车站	9	9	7
2.2 公共服务设施	政府机关	6	3	6
	体育娱乐设施	9	9	1
	生活便利设施(商场、超市等)	9	9	1
	医疗卫生机构	9	3	3
	教育设施(学校、科研机构等)	9	5	6
	银行、保险机构	7	9	5
	公园、景点	9	7	1
2.3 区位	CBD	5	8	3
	城镇中心	8	8	3
	开发区(如优惠产业政策区)	4	4	9
	河流、湿地	9	3	9
3. 地块属性	现状土地使用类型	6	6	6
	地块面积	3	3	7
	土地价格	6	6	6
4. 社会经济特征	人口密度	5	9	3
	就业率	4	7	3
5. 环境因素	空气质量	9	8	3
	交通噪音	9	8	3
	植被覆盖率	9	8	3
	邻避设施(高压站、垃圾场等)	9	9	3

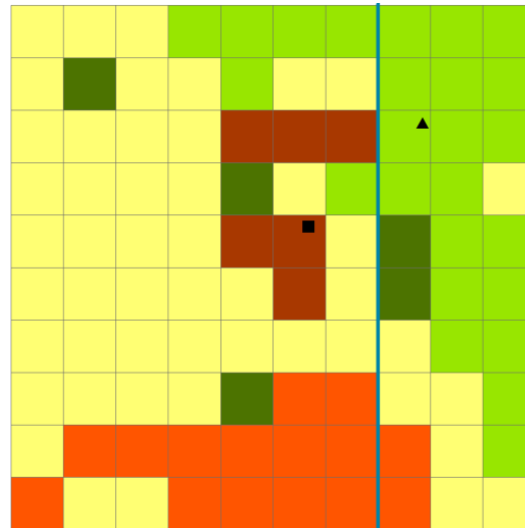
Then we will develop a PSS (**Planner Agents**), and simulate land use pattern using identified rules.



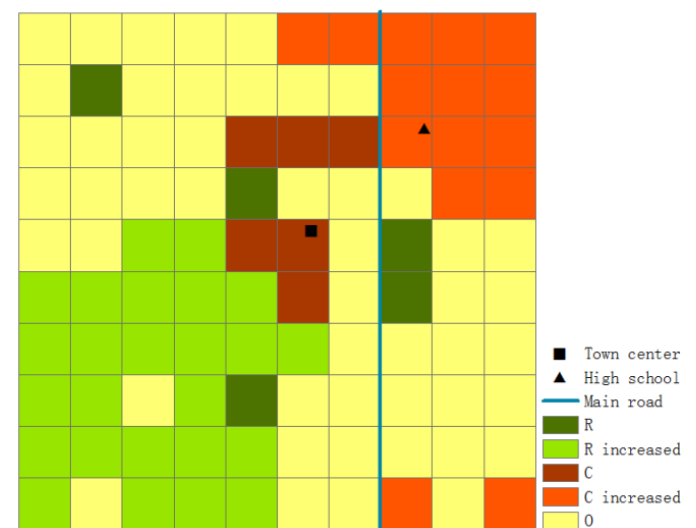
Planner A



Planner B



Planner C



Ideally and hopefully to

- save planner's time and promote plan compilation efficiency
- Support planning a low carbon urban form
- E.g.
 - A plan area
 - Identified rules of 20 planners
 - Generate 20 patterns in one minute by using Planner Agent
 - The principal investigator chooses a perfect one
 - All 20 planners focus on it and propose the final drawing
 - Planner C's work associates with low carbon

2 PLANNER AGENTS

Planner types

- Non-spatial planners
 - Infrastructure, transportation
 - Not directly with land use pattern
- **Spatial planners**
 - Responsible for preparing land use pattern
- Chief planner
 - Confirm the final plan scheme

Spatial planner: the general process

1. Totals in area

- For each type of land use (e.g. residential, commercial and industrial)
- From decision makers or forecasted by macro models

2. Constraints

- Geographical context: *slope, eco space*
- Institutional constraints: *development restrictions*

3. Negotiating with non-spatial planners (**factors**)

- Assume planned facilities, roads, city centers, CBD, etc., are ready prior to plan a land use pattern
- **Weight factors**

4. Negotiating with citizens (public participation process)

- Not accounted in our current research

Spatial planner: simplified rules

- The taste (*weight*) of each land use on factors is different.
- The weight could be calibrated using questionnaire or data mining on existing plan archives (land use with the highest probability would be selected for a parcel).

– E.g., industrial parcels tend to be located along main transportation network, commercial parcels around amenities.

$$T = \{t_k | k = 1, 2, 3, \dots, K\} \quad (1)$$

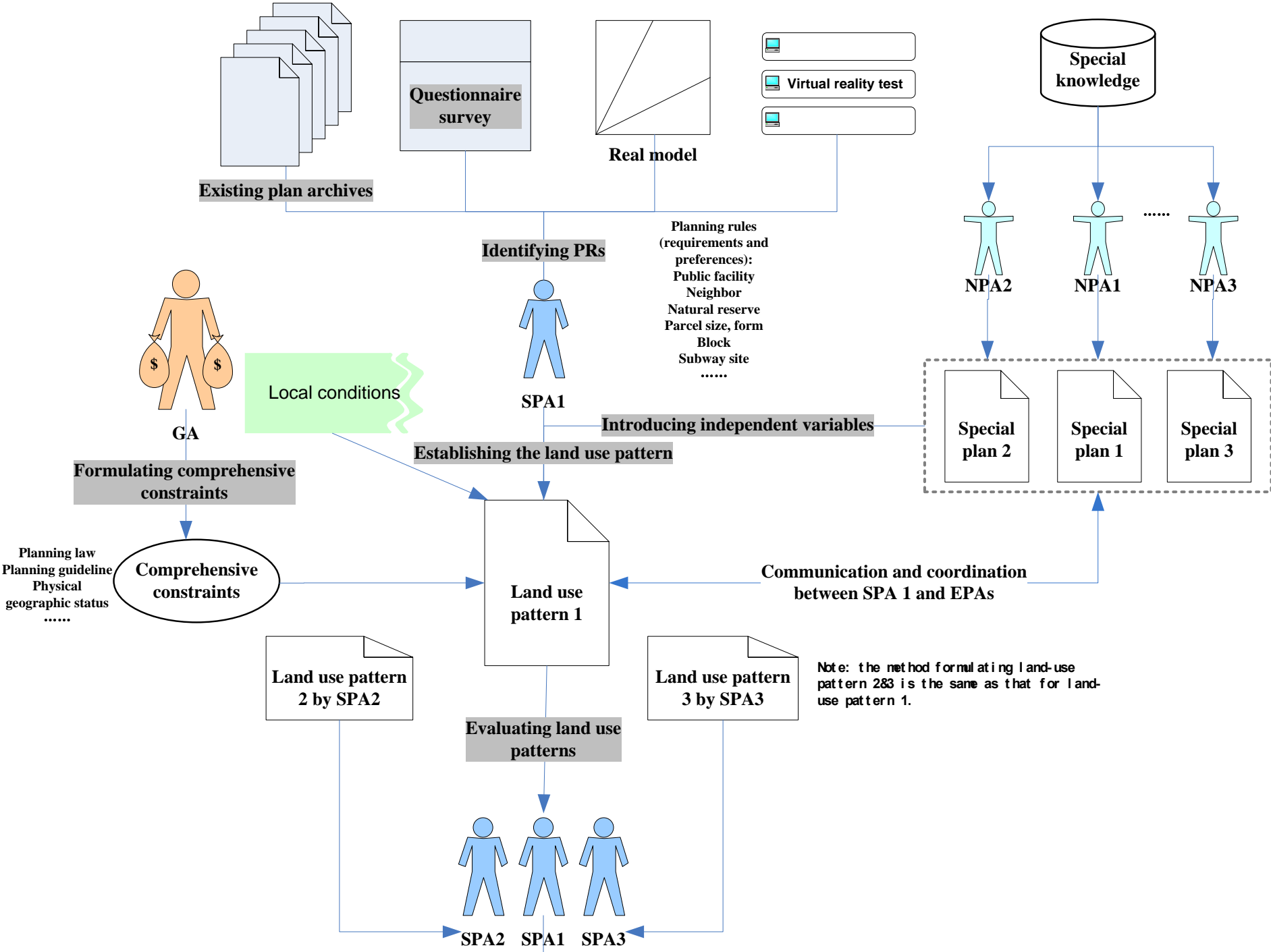
$$F = \{f_i | i = 1, 2, 3, \dots, I\} \quad (2)$$

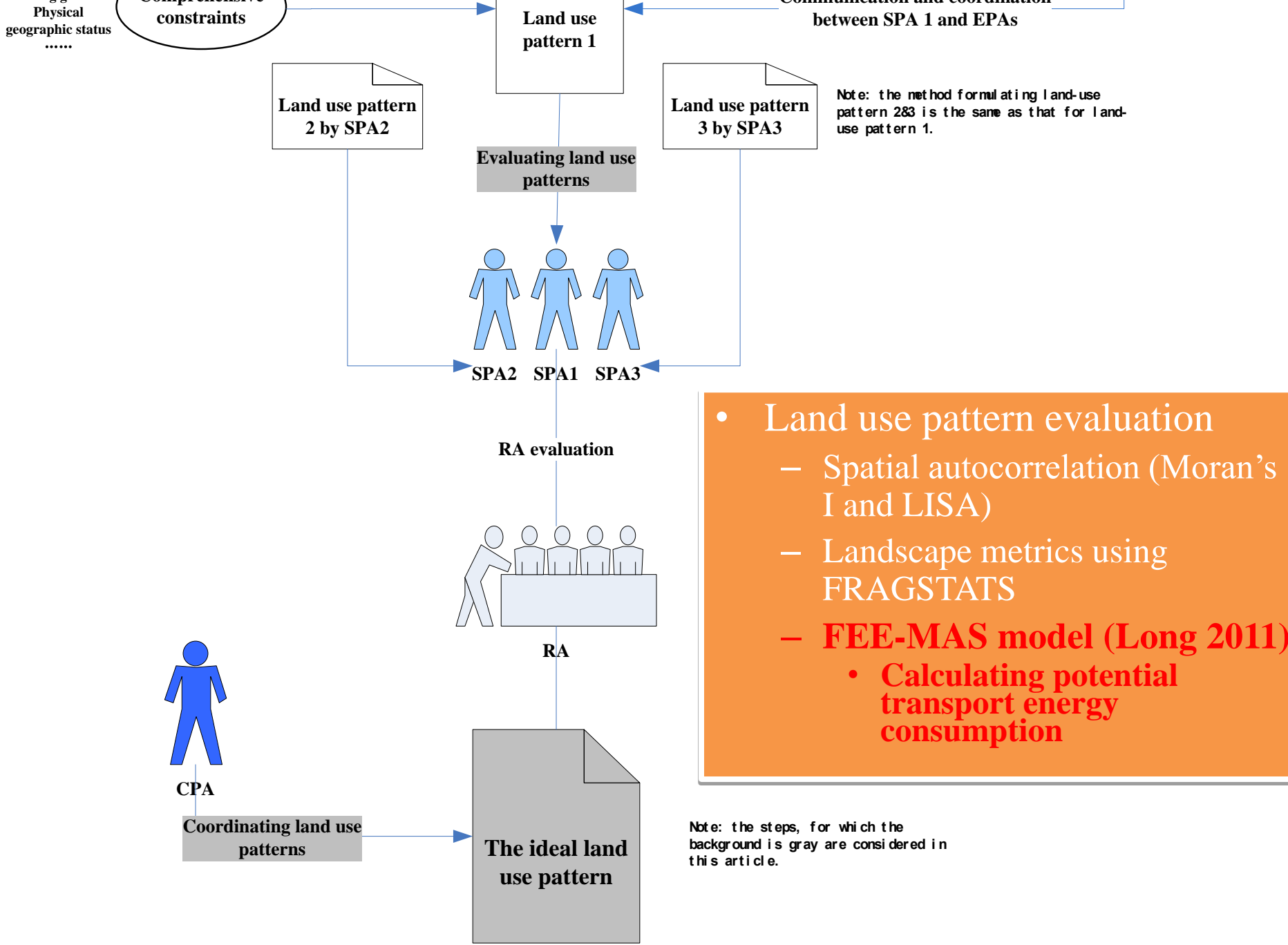
$$P = \{p_n | n = 1, 2, 3, \dots, N\} \quad (3)$$

$$W = \{w_{ik} | i \in [1, I], k \in [1, K]\} \quad (4)$$

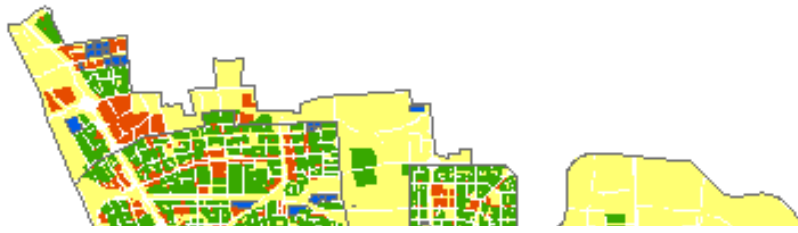
$$P_{nk} = \frac{e^{r_k + \sum_{i=1}^I w_{ik} \times f_i}}{1 + \sum_{k=1}^{K-1} e^{r_k + \sum_{i=1}^I w_{ik} \times f_i}} \quad (5)$$

re t_k is the planned land use type, K is its number, f_i is the PIF, I is its number, parcel, N is its total amount, w_{ik} is the weight of f_i for t_k , P_{nk} is the probability of t_k , and r_k is the corresponding constant term.

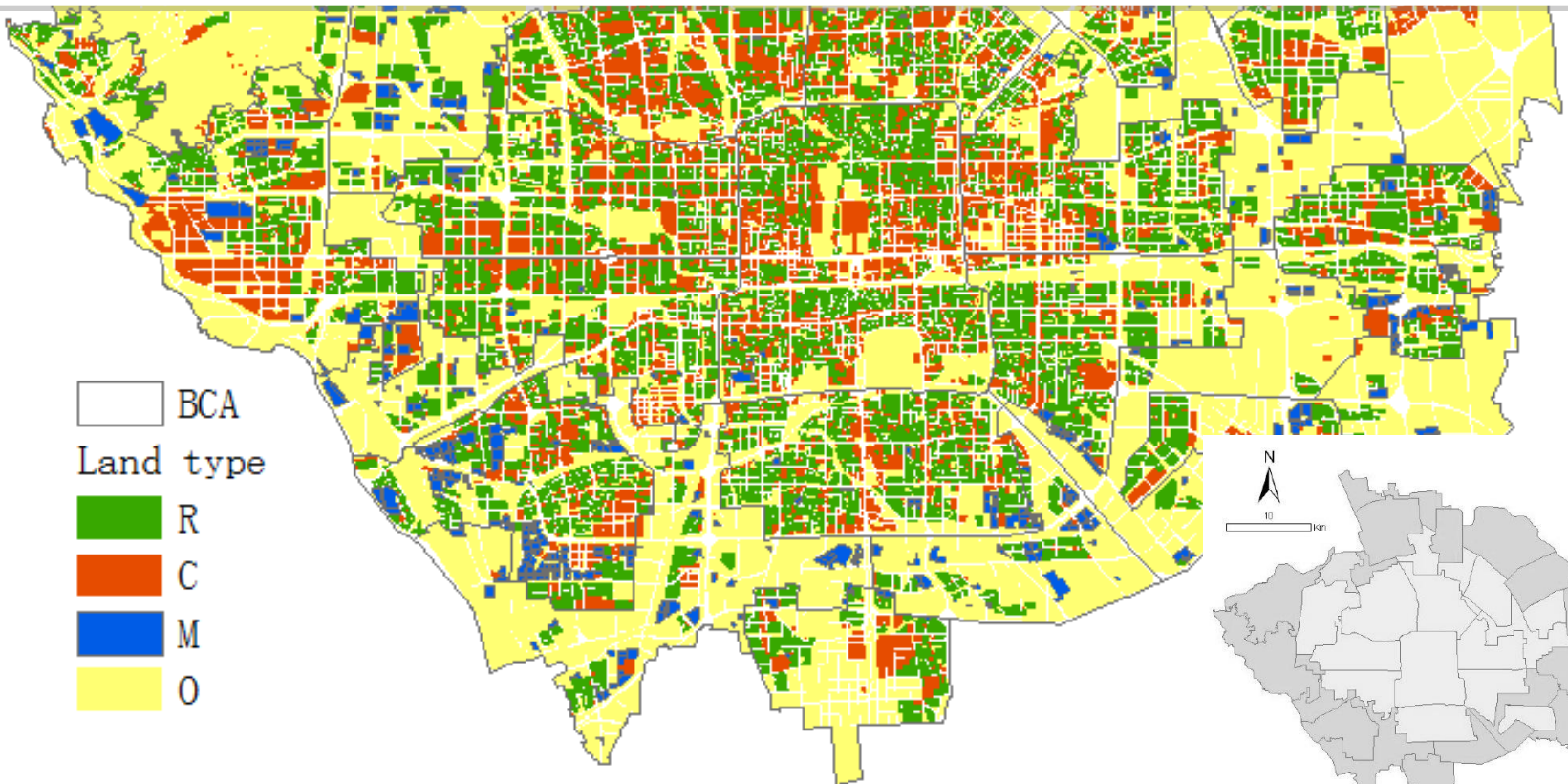




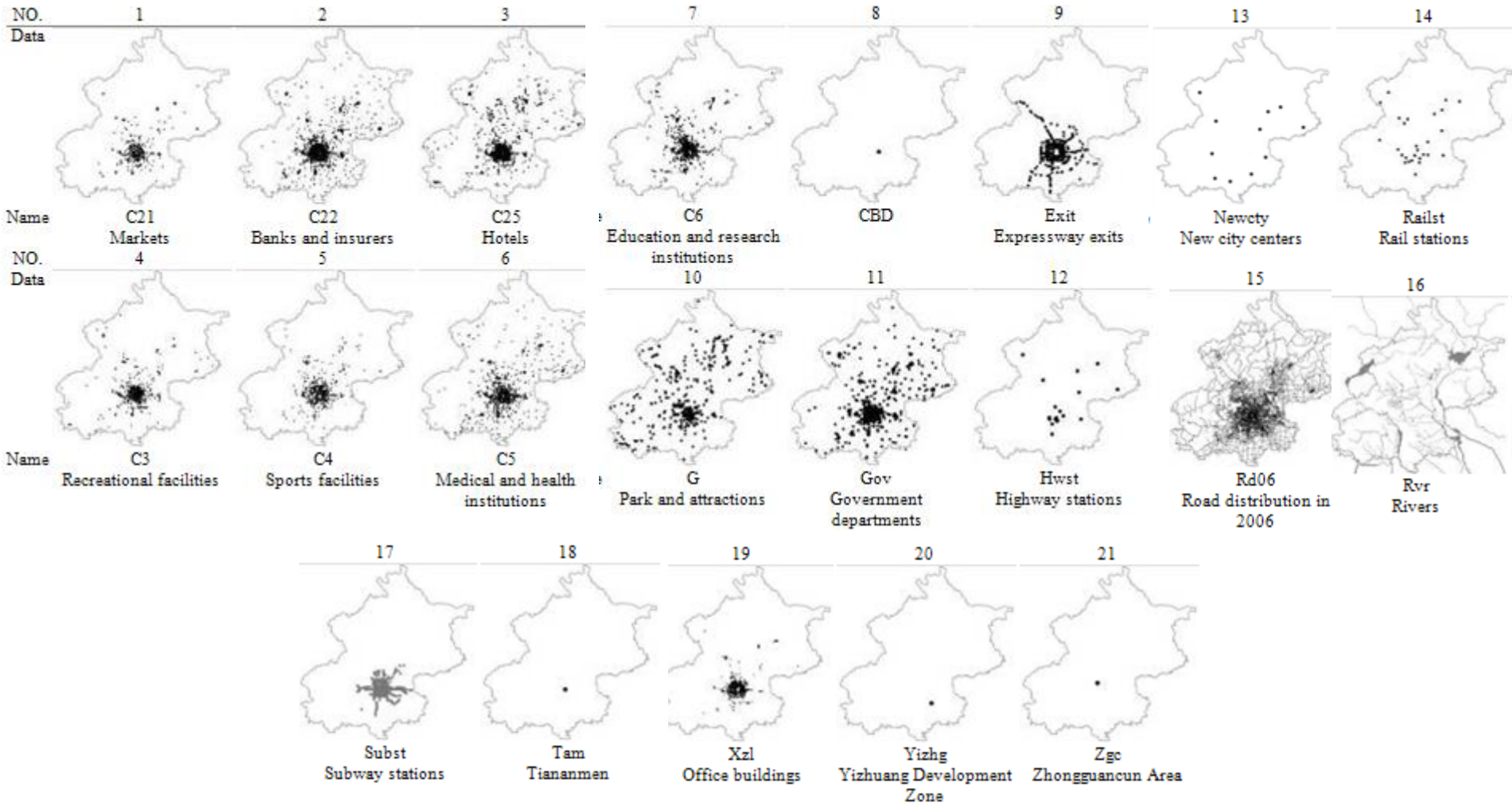
3 BEIJING APPLICATION



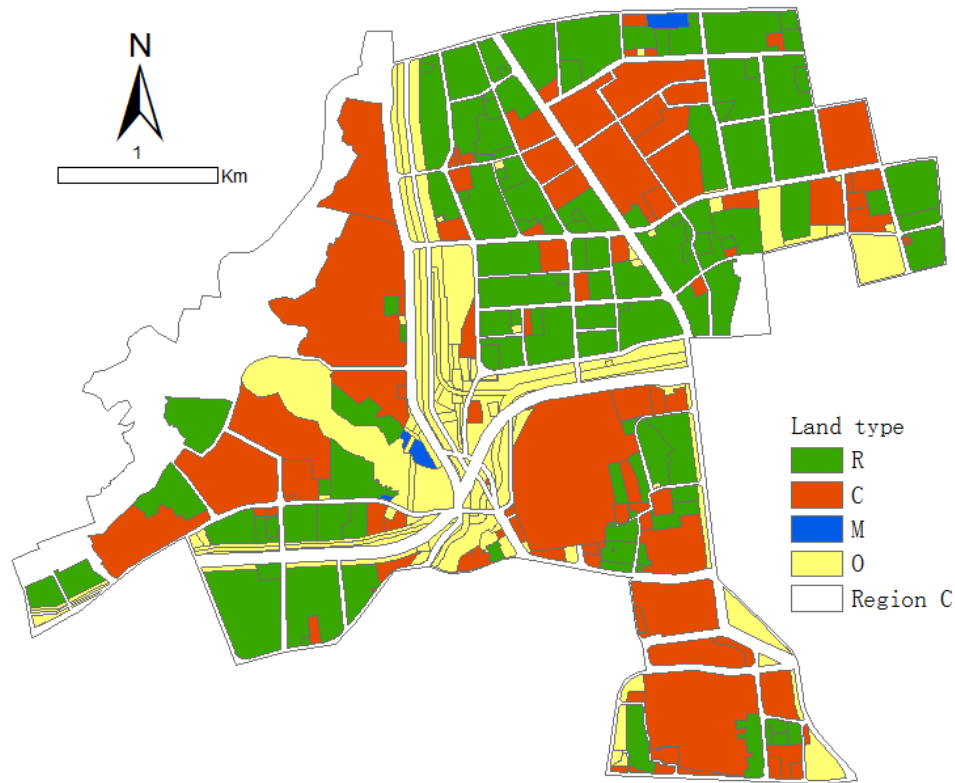
- Being Detailed Plan (-2020)
- Land use plan in each zone has been exclusively designed by a responsible planner, in 2007
- A perfect data for applying Planner Agents



21 factors

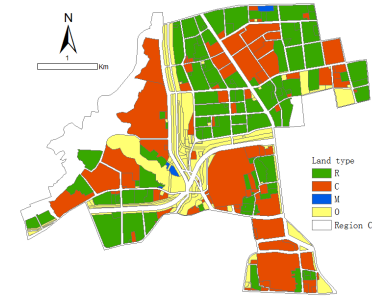


Zone 12 as an example



Land use type	Parcel distribution		
	Number	Area (km ²)	Percentage
R	114	43.85	0.41
C	97	44.41	0.41
M	4	0.47	0.004
O	121	18.94	0.18
Total	336	107.67	1.00

Constraints



Extracted from Urban Containment Plan of Beijing
See Long et al 2011 for details

Identified rules using multinomial regression

Parameter	Weight		
	R	C	M
Intercept	-.70203***	-2.24992***	-1.78990***
C21	.59824***	.10866	-1.50529***
C22	1.69092***	1.98993***	1.48453***
C25	.27165***	.63531***	-1.50131***
C3	.54465***	.53033***	.09401
C4	.19670**	.20072**	.34227
C5	1.01238***	.71570***	-.37010
C6	.59667***	.83476***	.57046***
CBD	-3.13736***	-.73107***	-7.74911***
Exit	-.77072***	-.81033***	.21059
G	.06680	.14353*	-.52322**
Gov	-.22590***	.11004	.78724***
Hwst	-.08708	-.28315**	-.95491*
Newcty	-8.33651**	-.01048	-1.21120
Railst	-.29179**	-.14296	.79214***
Rd06	-2.09906***	-1.19993***	-1.10308**
Rvr	-.26074***	-.71772***	-1.32691***
Subst	.36312***	.57882***	-.41520**
Tam	.52299	1.24361***	-39.32950***
Xzl	.31318***	.52759***	1.24840***
Yizhg	-91.77109***	-101.64079***	33.57548**
Zgc	-1.49658***	.16891	-23.24940***

Rules of the same planner, by questionnaire

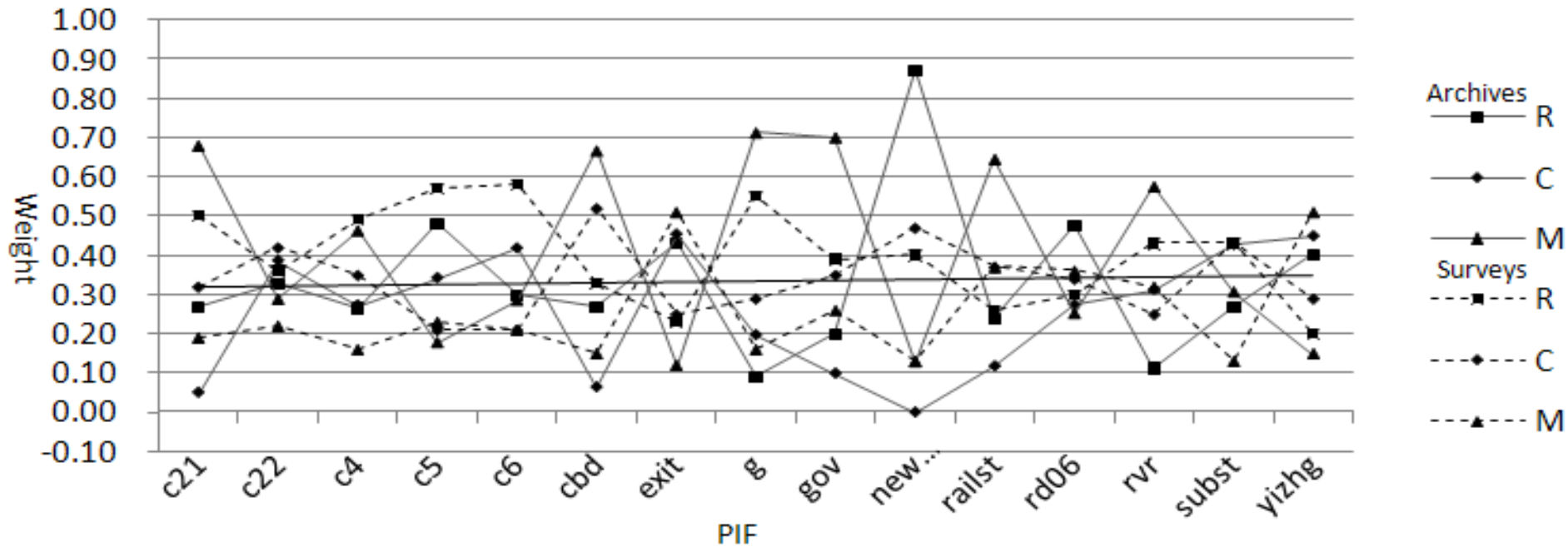
Category	PIF	Weight		
		R	C	M
1. Basic topography	1. Elevation	0.32	0.31	0.37
	2. Slope	0.30	0.32	0.39
2. Accessibilities				
2.1 Transport facilities	3. Airports	0.26	0.31	0.43
	4. Rail stations	0.26	0.37	0.37
	5. Highways	0.23	0.25	0.51
	6. Main roads	0.30	0.34	0.36
	7. Subway stations	0.43	0.43	0.13
	8. Bus stops	0.42	0.40	0.19
2.2 Public facilities	9. Government departments	0.39	0.35	0.26
	10. Entertainment facilities	0.49	0.35	0.16
	11. Amenities (such as supermarkets)	0.50	0.32	0.19
	12. Medical and health institutions	0.57	0.21	0.23
	13. Educational and research institutions	0.58	0.21	0.21
	14. Banks and insurers	0.36	0.42	0.22
2.3 Location	15. Parks and attractions	0.55	0.29	0.16
	16. CBD	0.33	0.52	0.15

Total 20 planners surveyed in BICP (planners) and PKU (plan students)
Comparison to be conducted

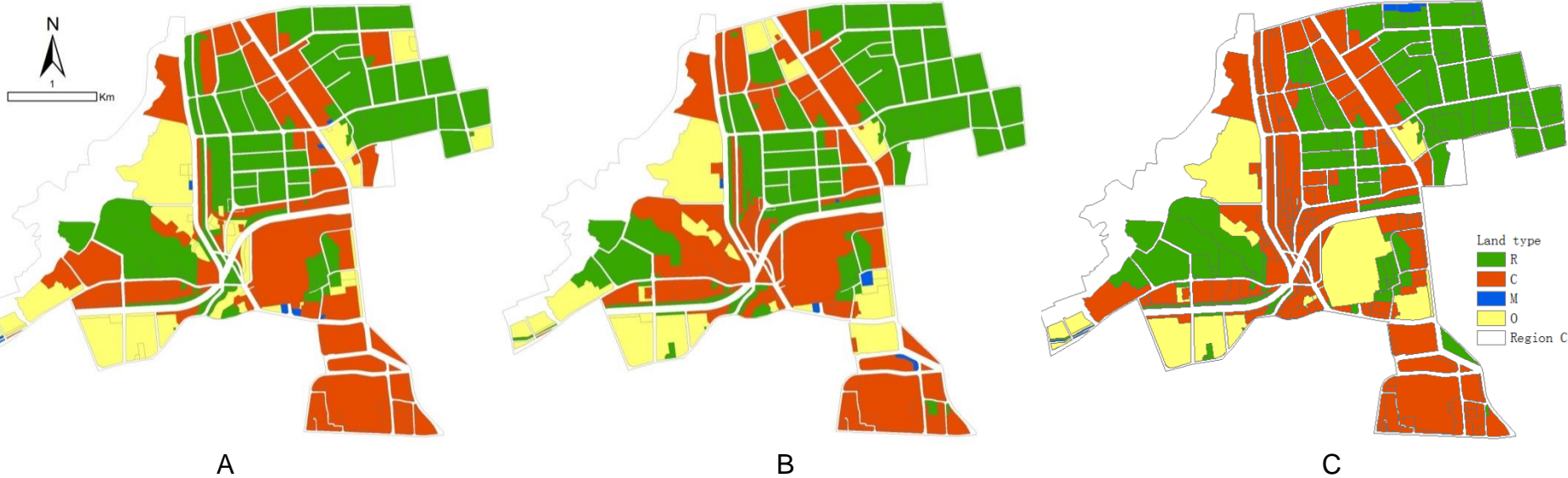
	22. Land price	0.33	0.32	0.35
4. Socioeconomic characteristics	23. Population density	0.36	0.41	0.23
	24. Employment rate	0.30	0.37	0.32
5. Environment	25. Air quality	0.46	0.34	0.21
	26. Traffic noise	0.56	0.28	0.17
	27. Vegetation coverage	0.49	0.28	0.23
	28. NIMBY facilities	0.46	0.36	0.18

Comparison of mined and surveyed rules

What has done and will do are generally different, in terms of taste of each land use on various factors.



Three scenarios by different planners



Land use type	Parcel number (scenario A)	Parcel number (scenario B)	Parcel number (scenario C)
R	163	157	130
C	116	146	182
M	11	7	8
O	46	26	16
Total	336	336	336

Evaluating scenarios

- A framework for energy consumption and carbon emission based on planned land use patterns
 - 1.1 Population synthesis for generating resident and business agents (finished in BUDEM2)
 - 1.2 Building reconstruction for planned parcels (in progress)
 - 2 Activity- and agent-based impact simulation (challenging)
 - 3 Impact accounting
- Commuting section finished
 - Long Y, Mao Q, Shen Z, 2012, “**Urban form, transportation energy consumption, and environmental impact integrated simulation: A multi-agent model**” in Zhenjiang Shen (ed.) *Sustainable Development and Spatial Plan*, Springer-Verlag Berlin Heidelberg.
- **A low carbon scenario is possible to be identified**

Ideas could be borrowed from other talks, e.g.

- **Yang Jiang**
 - Proposal of a Modeling Approach to Assess Urban Energy Consumption and Carbon Emissions based on Spatial Structure and Form
- **Tony Hargreaves**
 - Estimating the building stock from regional model forecasts and its low carbon potential
- **ZHANG Jie, XIE Yang**
 - Urban spatial morphology's impact on household transportation energy consumption
- **Feifei Yu, Chris Zegras**
 - An integrated behavioral model for estimating energy consumption at the neighborhood scale

4 CONCLUSIONS

Conclusions

- Planner Agents for supporting land use pattern scenario analysis (LUPSA)
 - Limited to land use plan in the master plan level
 - A tool
 - Identified rules by questionnaire and data mining
 - **A very preliminary research in its first step**
- Tested in the hypothetical space and applied in Beijing
 - Compile and evaluate land use plan quantitatively
- Promising in promoting working efficiency of planners
 - **Jobless planners?**
- Expected to support planning low carbon a urban form

Next steps

- Polish existing work
- Evaluate simulated patterns
- Rules for density distribution

Limited spatial plan implementation effectiveness in **China**
(around **50% outside** planned urban growth **boundaries**).

See Han et al, 2009; Long et al, 2012; Tian and Shen, 2011

The **value** for promoting urban plan compilation efficiency?

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THANKS FOR YOUR ATTENTION!