Urban Form, Travel Behavior, Air Quality, and Economic Value Outcomes: A Synthesis of Recent Research Projects

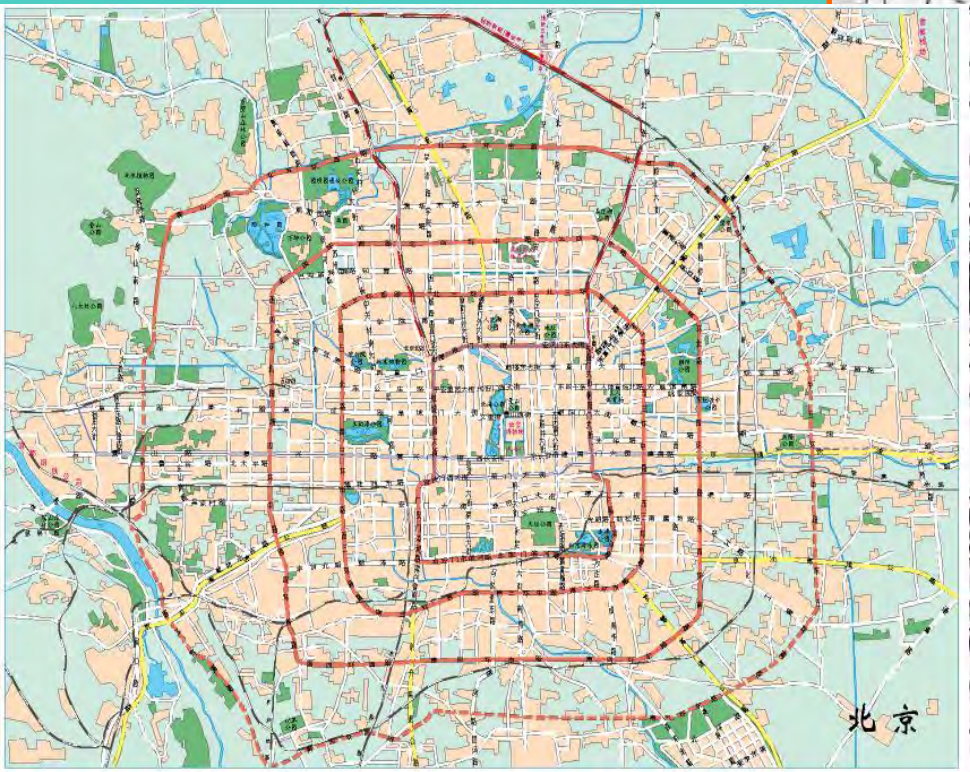
城市形态、出行行为、空气质量及经济价值影响：研究项目综述

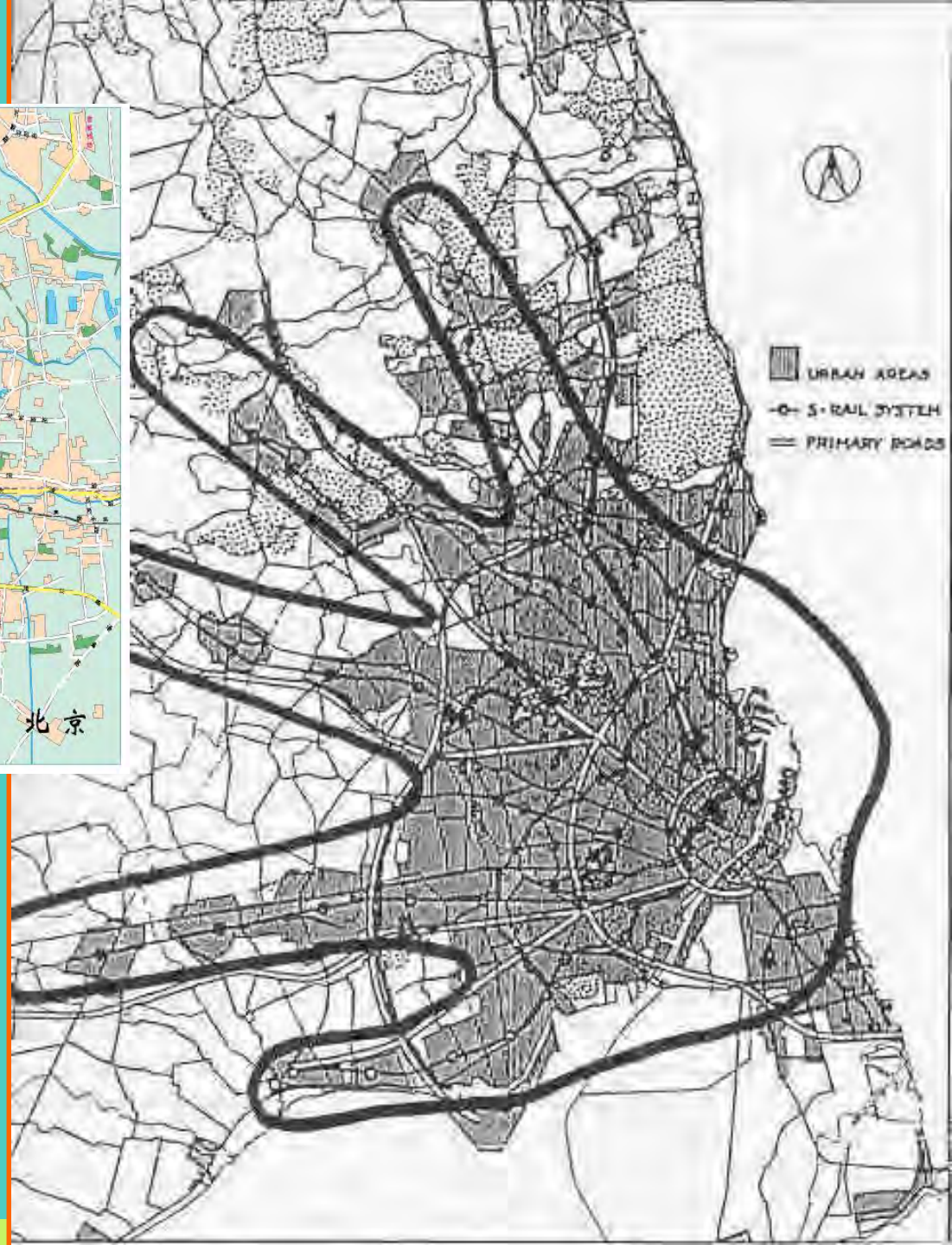
Yan Song
Department of City and Regional Planning
University of North Carolina at Chapel Hill
ys@email.unc.edu

- **Among your key urban sustainability research activities, what are the most significant outcomes of research in an interdisciplinary context?**

- **What are characteristics of urban sustainability programs at universities? For example, are these multi-disciplinary, cross-campus initiatives? Do they bring together research and practice? What disciplines are engaged and/or taking the lead?**
-
- **What key strategies have been developed for linking research to policy, promoting sustained collaboration, and making impacts on policy decisions?**

- **What are some of the key strategies that can be effectively implemented across universities? How have these efforts been developed and what makes them succeed?**

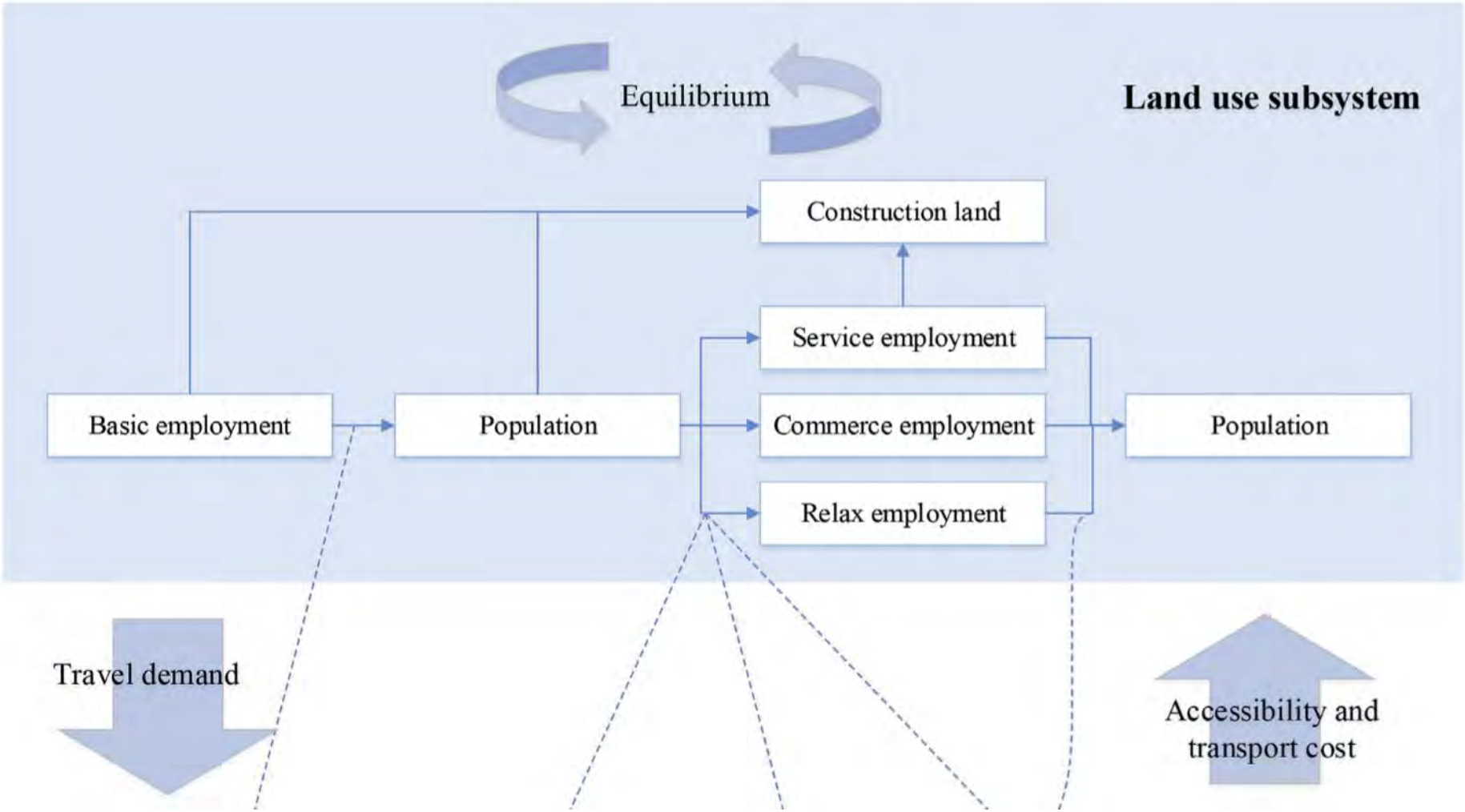

北京


URBAN AREAS
S-RAIL SYSTEM
PRIMARY ROADS

Research Projects, the Evolution

- Urban Form and Travel Behavior
- Urban Form and Air Quality
- Urban Form and Health Outcomes
- Urban Form, urban vibrancy, and economic values

The Influence of Compact Development on Travel Behavior and Tailpipe Emissions, a Case Study of Mecklenburg County in 2050


Equilibrium
Land use subsystem
Construction land
Service employment
Basic employment
Population
Commerce employment
Population
Relax employment
Travel demand
Accessibility and
transport cost

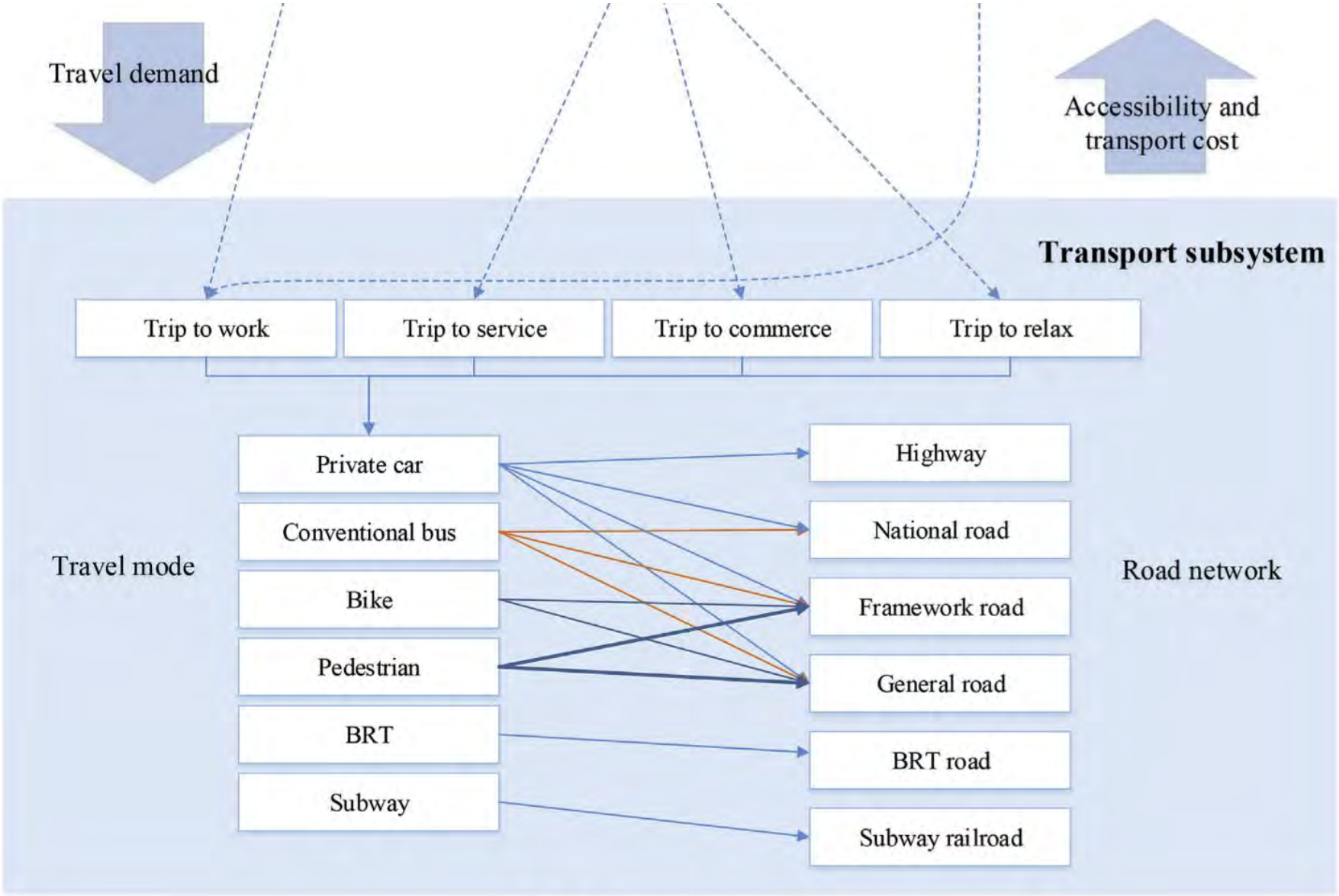
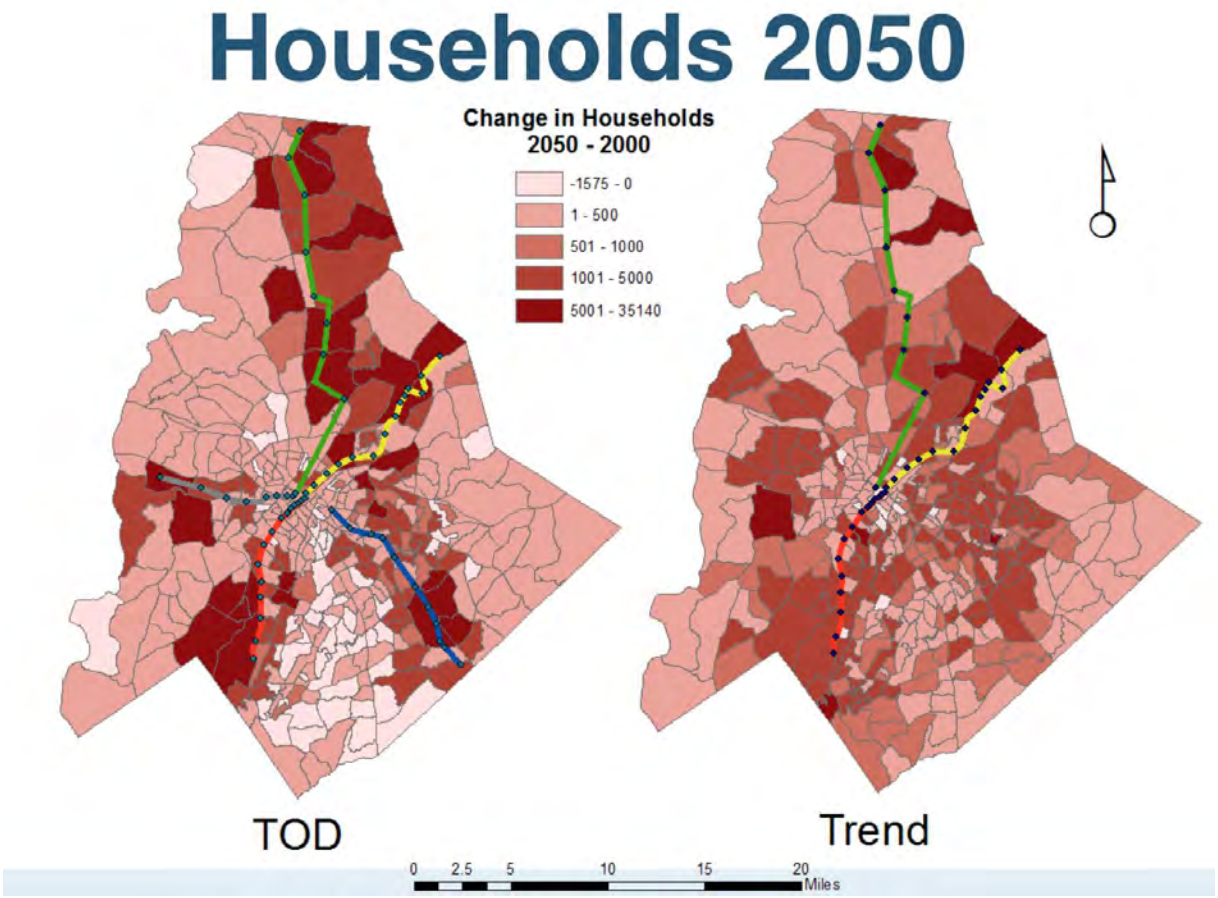
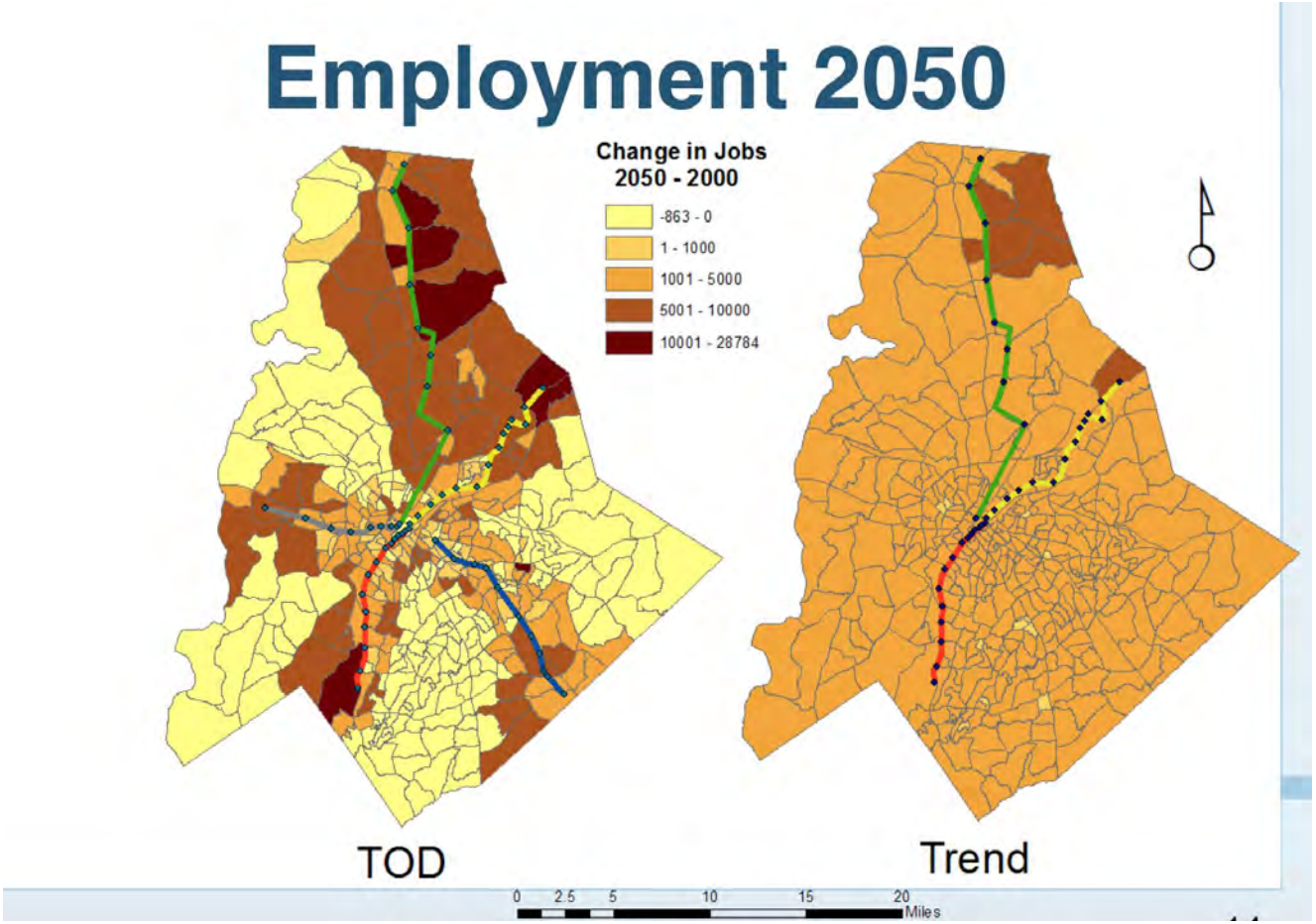


Fig. 4. Framework of TRANUS.

The Influence of Compact Development on Travel Behavior and Tailpipe Emissions, a Case Study of Mecklenburg County in 2050



The Influence of Compact Development on Travel Behavior and Tailpipe Emissions, a Case Study of Mecklenburg County in 2050



2050 Mode shares & travel

	Mode Share*		Passenger Miles		
	Trend	TOD	Trend	TOD	Difference w/ Trend
SOV	48.9%	38.7%	2,652,700	2,461,209	-7.8%
Carpool	34.7%	26.3%	1,975,681	1,800,564	-9.7%
Local bus	5.8%	12.3%	154,228	367,290	58.0%
Express bus	0.1%	0.2%	6,917	19,994	65.4%
Walk	9.5%	19.5%	17,723	38,589	54.1%
Light rail	0.8%	1.5%	26,125	57,729	54.7%
BRT	--	0.3%	--	7,812	
Commuter rail	0.3%	1.3%	22,566	110,240	79.5%

*Internal-internal HBW and HBO trips

On-road 2050 tailpipe emissions

Pollutant	Vehicle Fleet	Land Use Pattern	
		Trend	TOD
Hydrocarbons	100% conventional	Benchmark	-7.8%
Carbon monoxide (CO)	100% conventional	Benchmark	-6.3%
NOx	100% conventional	Benchmark	-5.5%
Carbon dioxide (CO_2)	100% conventional	Benchmark	-7.1%

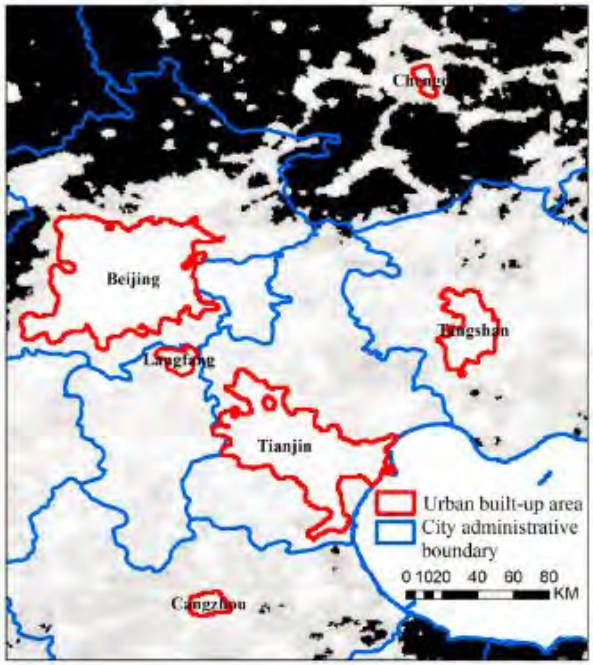
Link with Practice

Reference – Hong Kong: In 2017 there were approximately 45,879 premature non-external deaths and also 90,000 air pollution-related hospitalizations

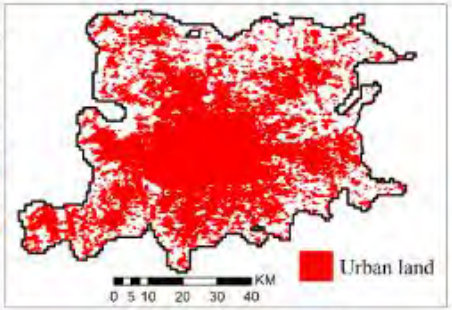
Health Impact Assessment

Δy	
Yearly non-external mortality	**1.53**
Yearly respiratory hospitalizations	**2.84**
Yearly cardiac hospitalizations	**1.50**

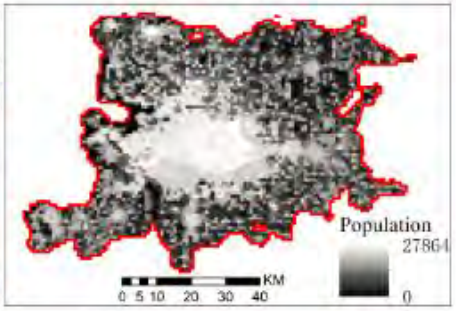
Urban Form and Air Quality



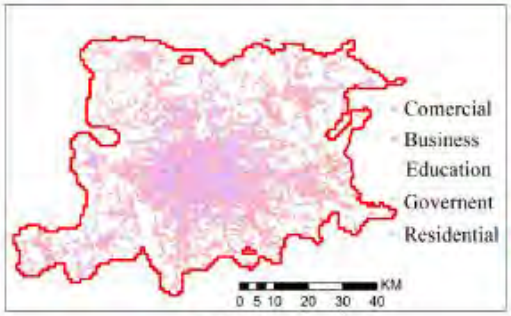
A. Urban built-up areas from nighttime light image



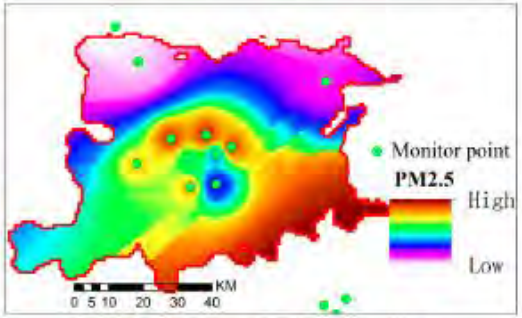
B. Urban land of Beijing



C. Population pattern of Beijing



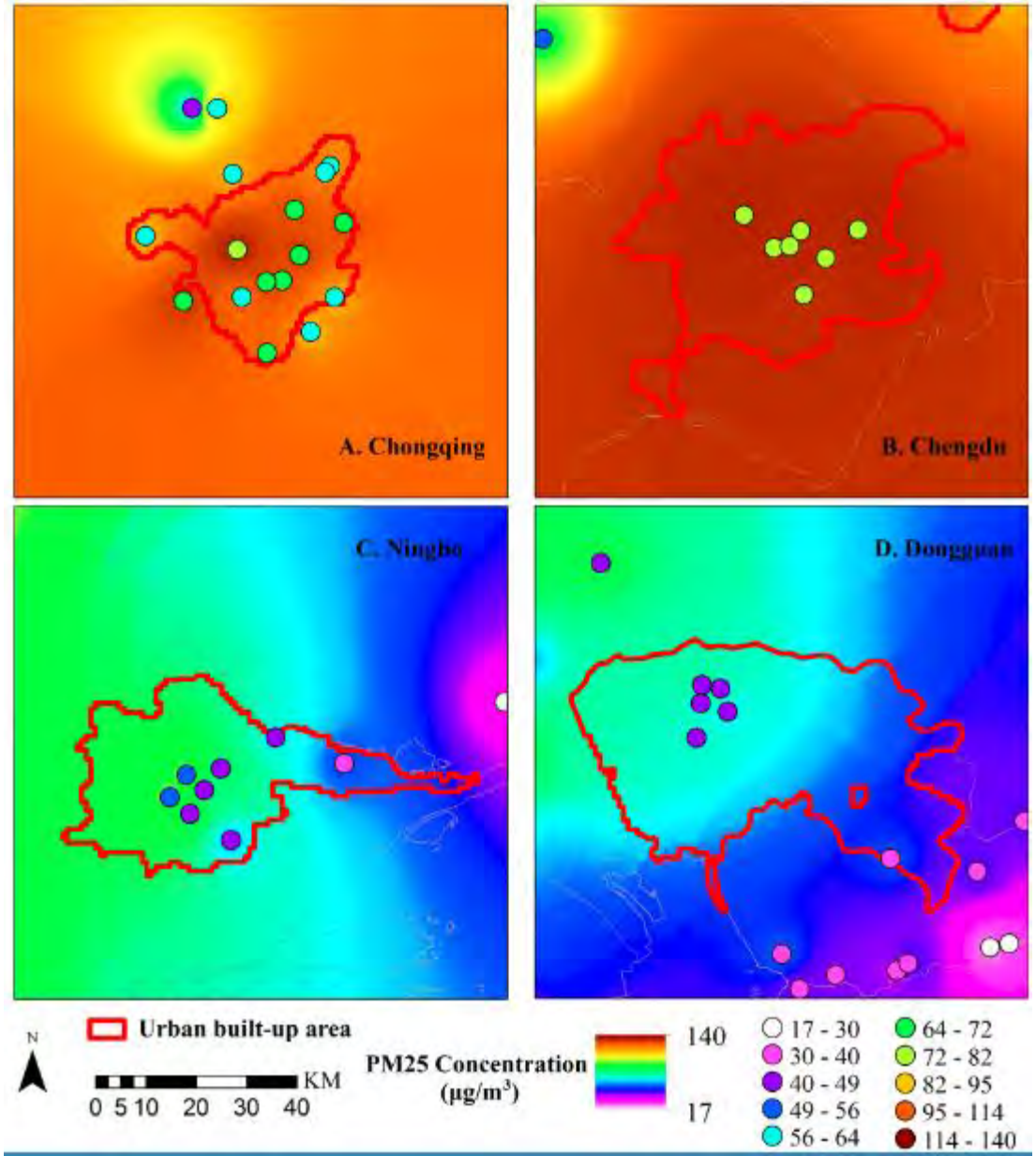
D. POI of Beijing



E. PM2.5 interpolation of Beijing

152 cities

Data and Method



Pollution weighted by Population exposure 人口权重的污染程度

① (PM2.5)
② (PM10)
③ (NO_2)
④ (SO_2)
⑤ (CO)
⑥ ozone (O_3)

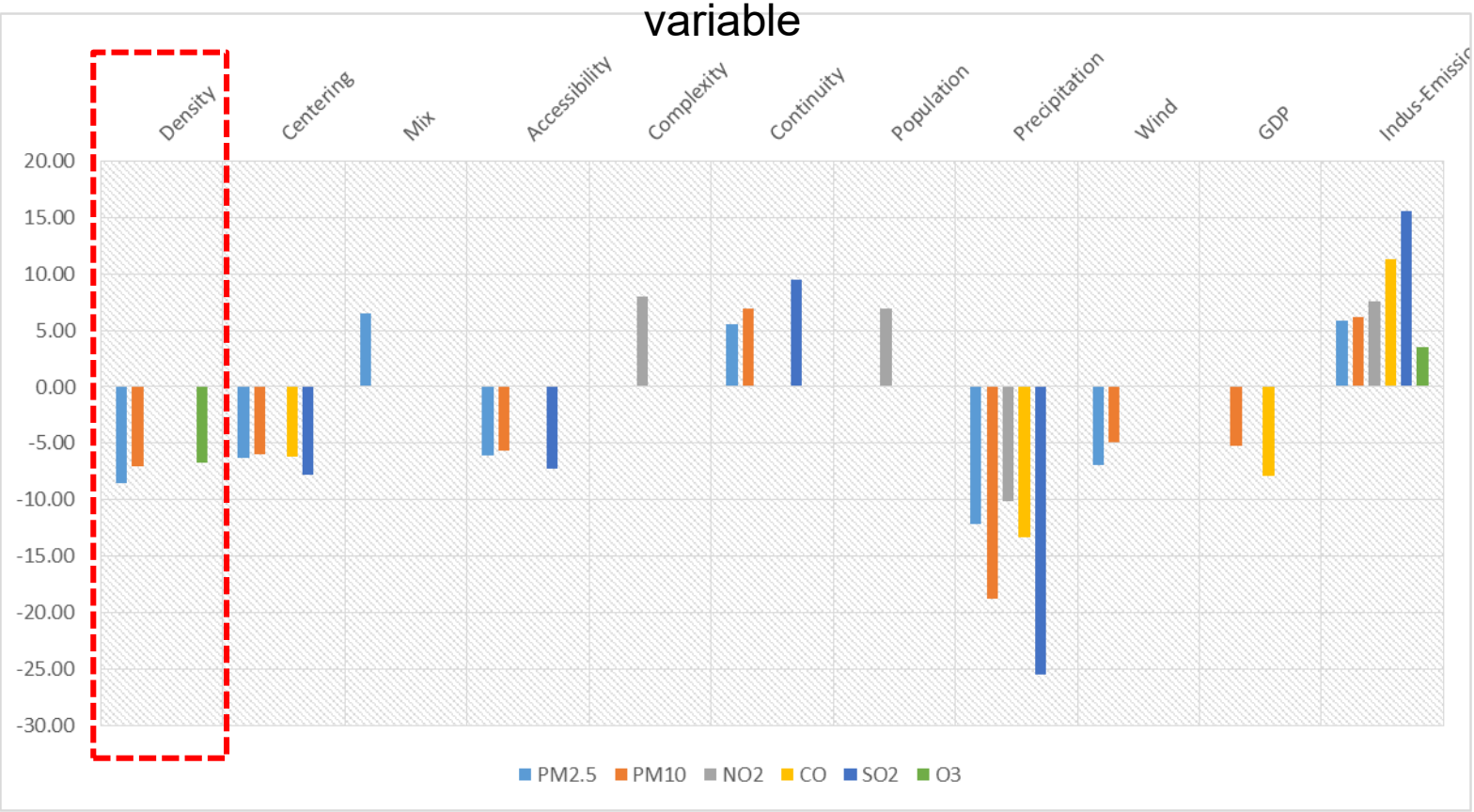
Interpolation:
Inverse Distance Weighted (IDW)

Varibles 变量

	Variables	Minimum	Maximum	Mean	Std. Deviation	Unit
Dependent variable	PM2.5	7	129	61	22	$\mu g/m^3$
	PM10	12	232	103	38	$\mu g/m^3$
	NO_2	4	63	37	11	$\mu g/m^3$
	SO_2	2	118	35	21	$\mu g/m^3$
	CO	0	6	2	1	mg/m^3
	O_3	20	255	160	33	$\mu g/m^3$
Urban form	Density	1114	9626	3552	1366	persons/km^2
	Centering	0.20	3.82	1.87	0.52	
	Mix	0.00	0.80	0.53	0.11	
	Accessibility	2.66	442.95	17.25	35.71	m^2
	Complexity	1.92	23.11	5.46	3.30	
	Continuity	66.69	93.83	84.13	4.73	
Control variable	Population	143926	21652722	1982132	2799707	persons
	Precipitation	1006.0	28577.0	9992.8	5689.1	0.1mm
	Wind speed	8.5	52.3	22.7	5.6	0.1m/s
	GDP	24188	467749	90517	60968	yuan
	Indus-Emission	224	761380	101441	98111	ton

Results 研究结果

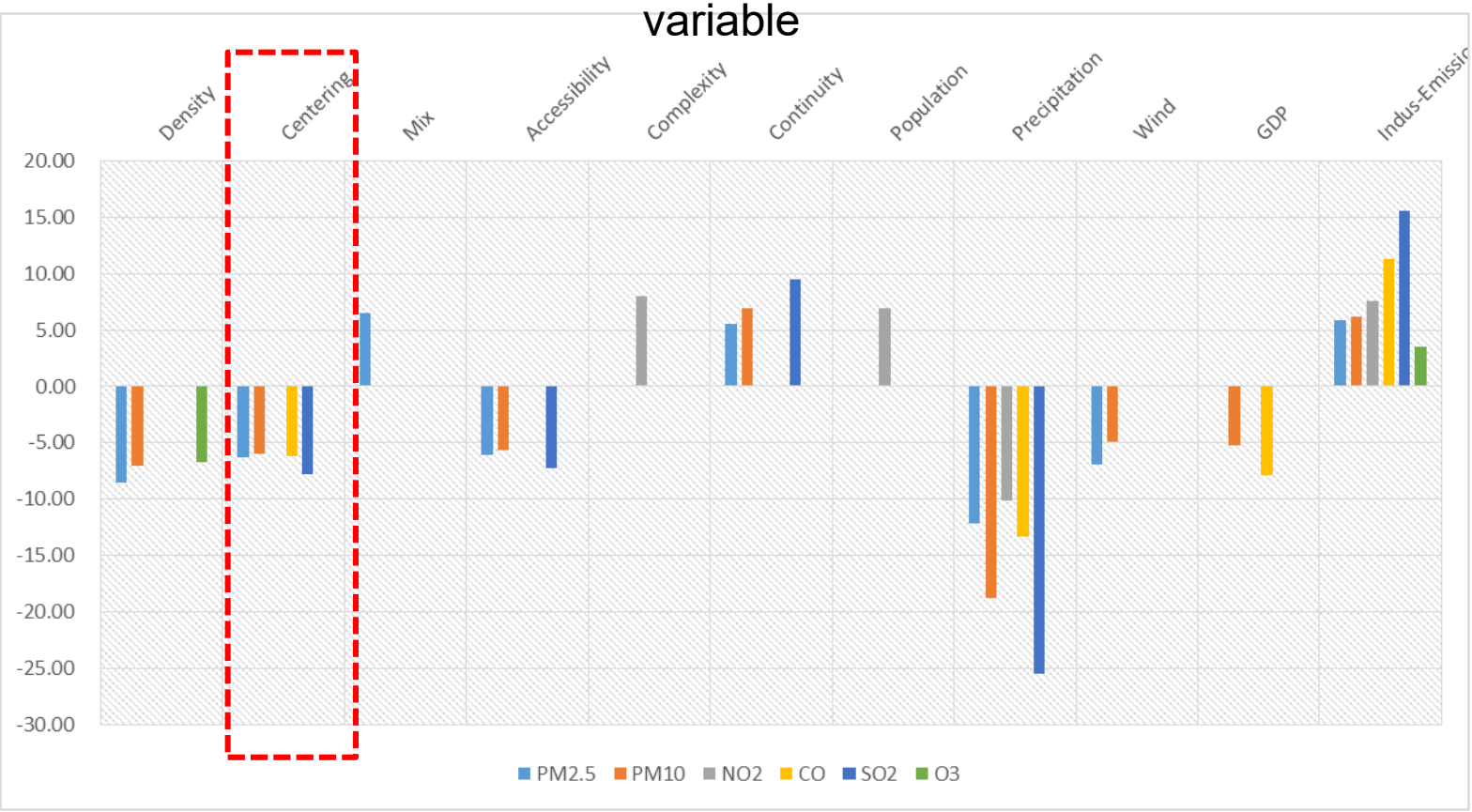
Percentage change in concentrations of pollutants for one std. D increase in each variable



High density is associated with less air pollutants

Results 研究结果

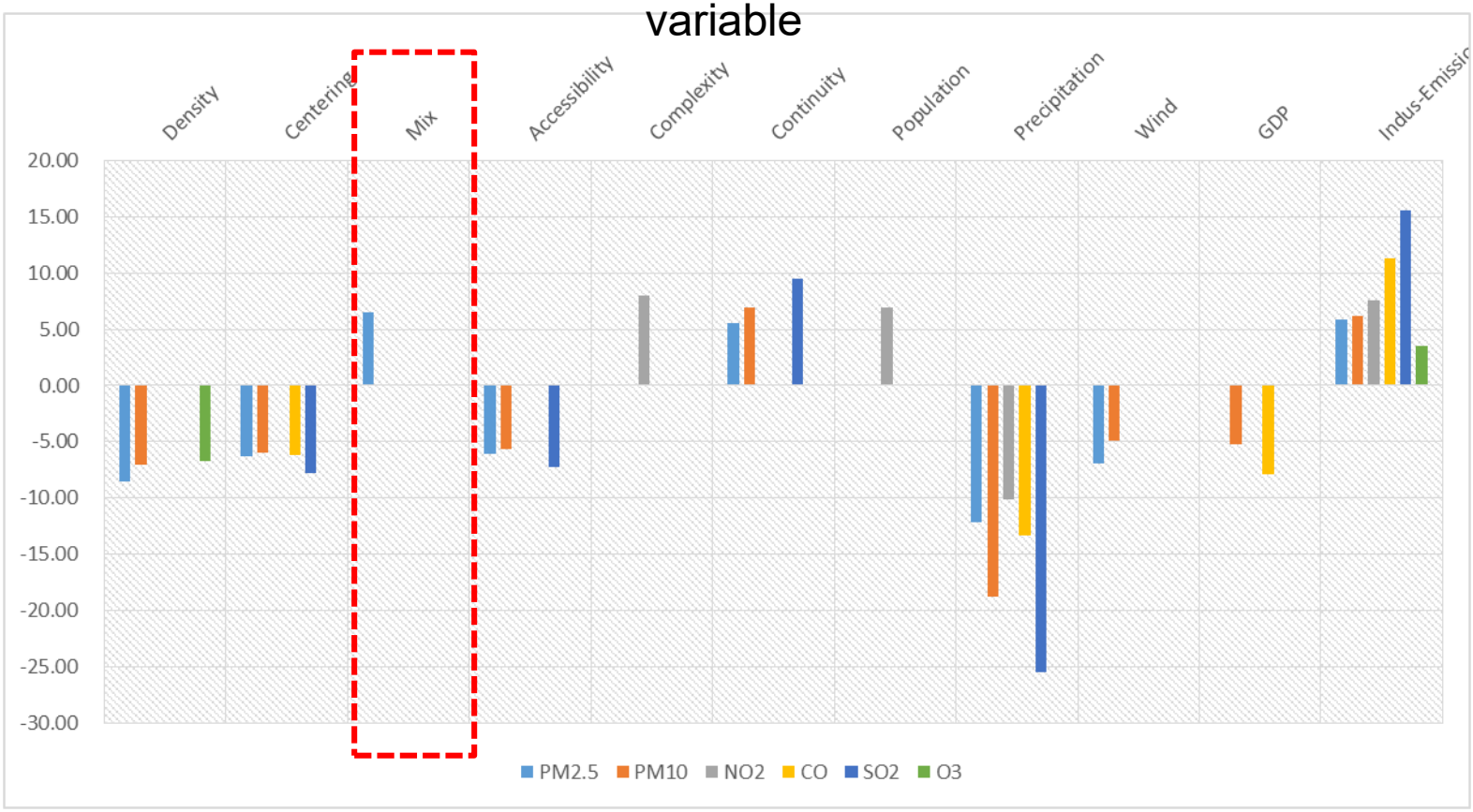
Percentage change in concentrations of pollutants for one std. D increase in each variable



Having a strong center is associated with less air pollutants

Results 研究结果

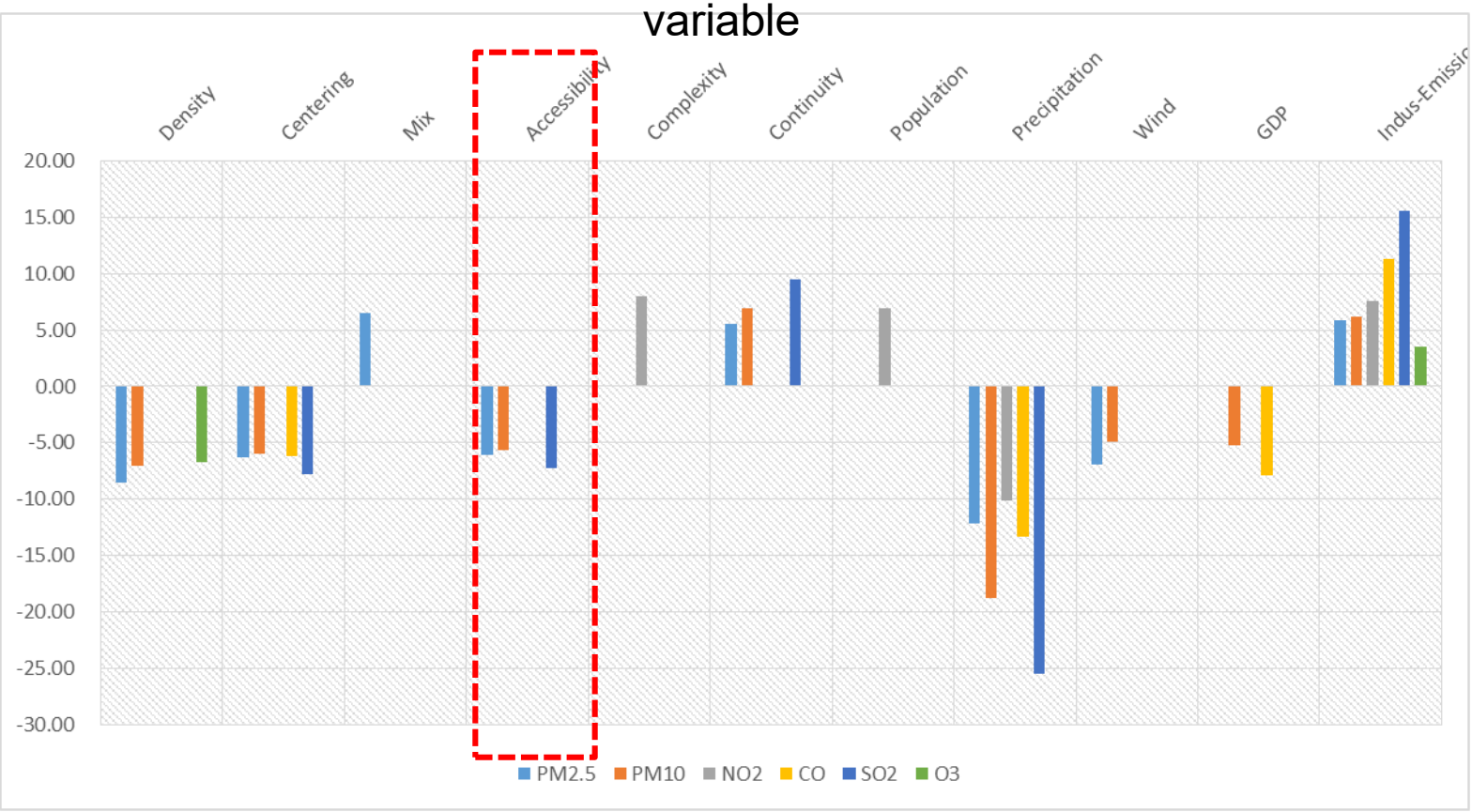
Percentage change in concentrations of pollutants for one std. D increase in each variable



Excessive or even chaotic land use mixture is associated with more air pollutants

Results 研究结果

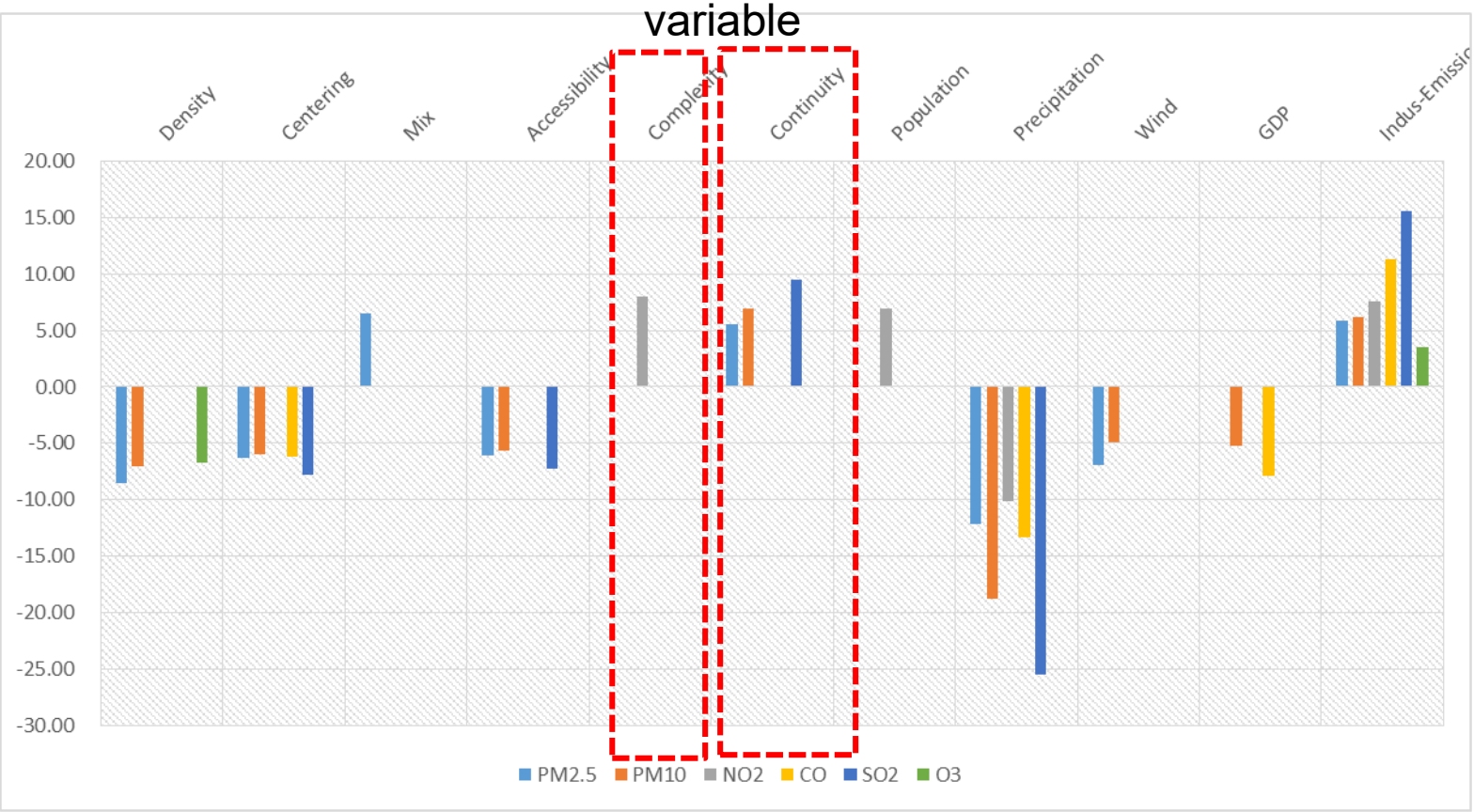
Percentage change in concentrations of pollutants for one std. D increase in each variable



Higher level of accessibility is associated with less air pollutants

Results 研究结果

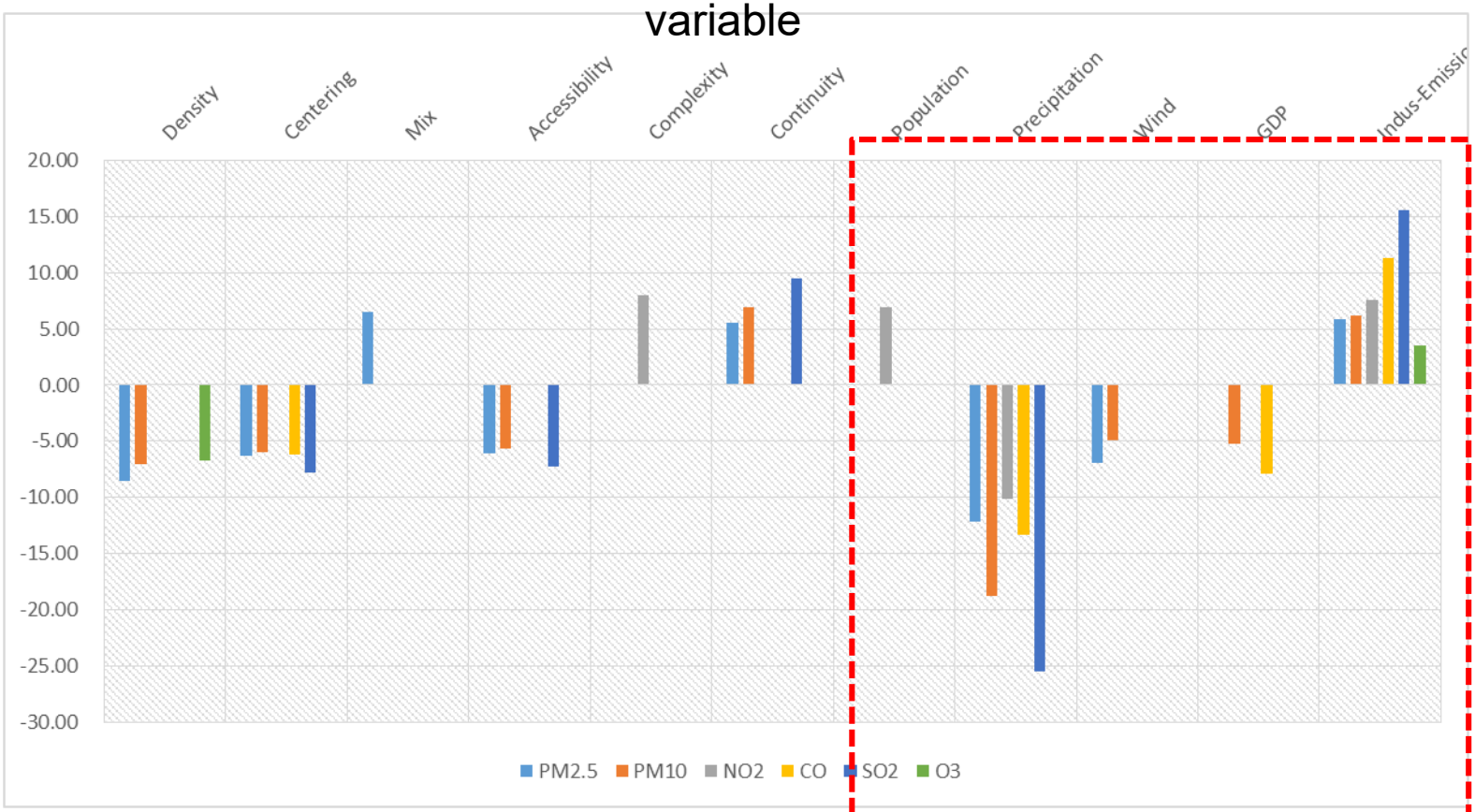
Percentage change in concentrations of pollutants for one std. D increase in each variable



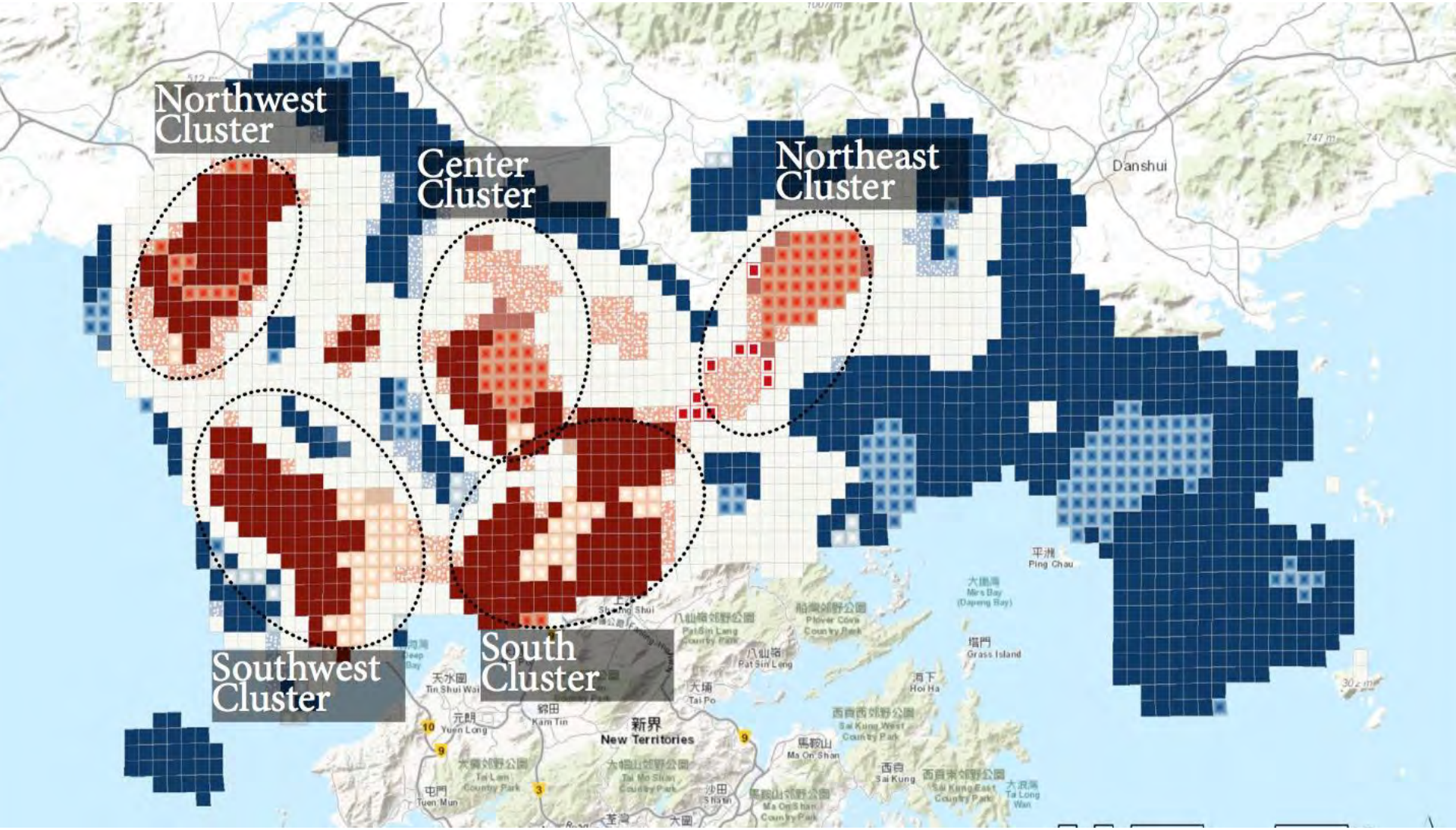
- Comlexity
- Leapfrogging: associated with more air pollutants

Results 研究结果

Percentage change in concentrations of pollutants for one std. D increase in each variable



New Approach:
Subcenters (big data) and exposure to pollutants

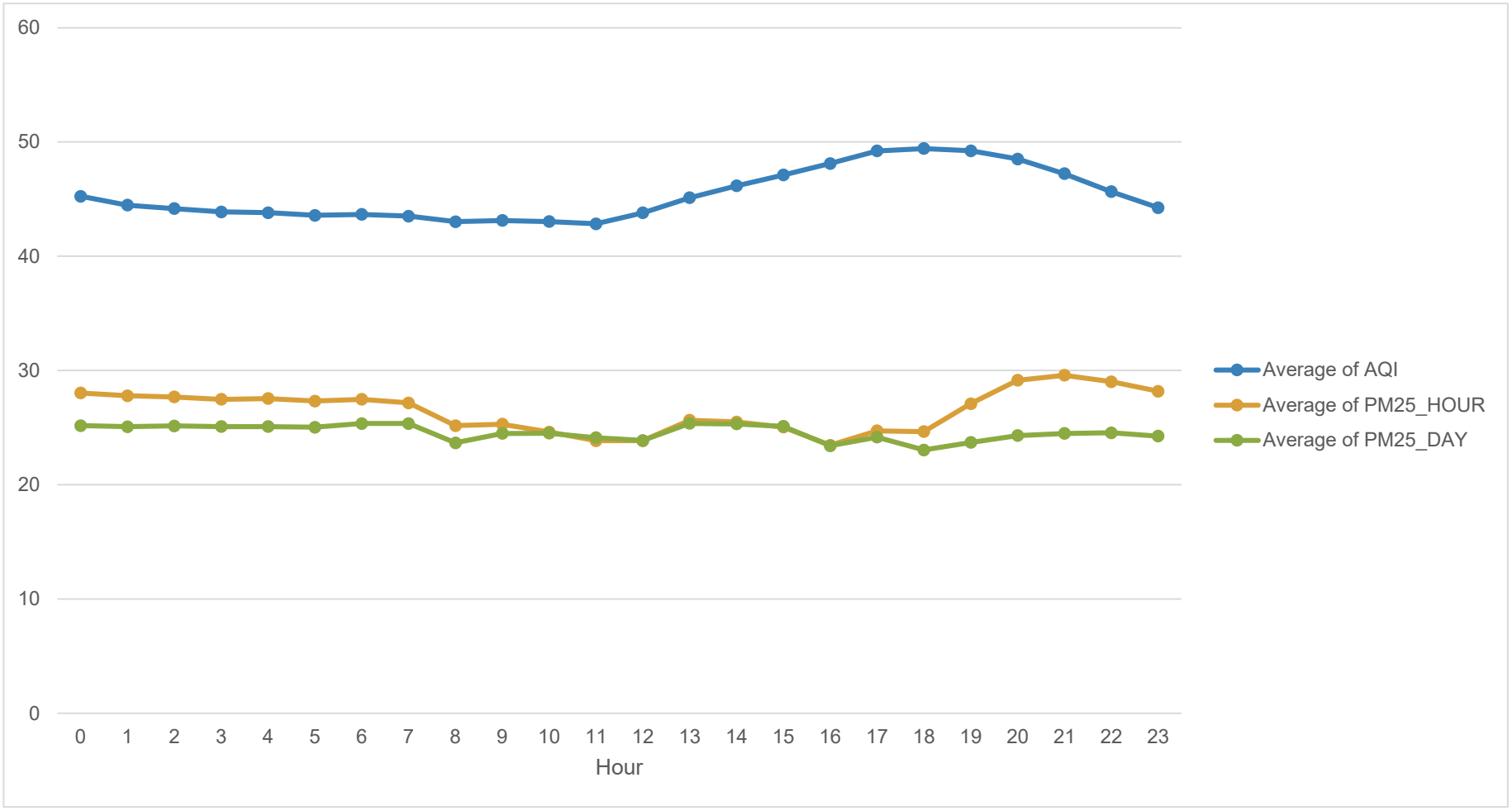


深圳“一街一站”空气监测体系上线 PM2.5数据实时可查

2018-06-06 21:55:27　来源：新华网

新华社深圳6月6日电（记者 王丰）记者6日从深圳市人居环境委员会获悉，深圳市“一街一站”网格化空气监测体系6日正式启动上线，全市74个街道的PM2.5监测站点的监测数据均已接入该系统。

XH	JCDWMC	JCSJ	AQI	SYWRW	ZSJB	ZSLB	PM25_HOUR	PM25_DAY
0125e04f-d402-4f08-b28f-103f2	洪湖	2016-05-10 04:0	23	-	一级	优	14	16
0125edfb-ee7b-4cec-b70f-04c08	下陂	2016-03-17 15:0	72	细颗粒物	二级	良	31	52
0125ff4b-76b6-4c0c-92a1-7e687	华侨城	2016-09-19 03:0	50	-	一级	优	33	29
012604e3-8385-4775-a3c3-de7f2	荔园	2016-01-02 17:0	97	细颗粒物	二级	良	57	72
159c4cea-38a4-47e6-9301-a15ea	下陂	2016-05-08 21:0	—	—	-	-	-	—
01264a2e-a3ed-4bb1-b41d-0ac4a	福永	2016-08-04 04:0	24	-	一级	优	14	13
0126e08f-1805-4181-9195-7c882	葵涌	2015-12-06 03:0	37	-	一级	优	9	24
01275ba2-4f2e-4985-b2da-62290	盐田	2015-12-28 13:0	23	-	一级	优	16	15
01275bd4-4d91-4a3e-b9b7-227b1	南油	2016-02-19 09:0	60	细颗粒物	二级	良	23	43
01277331-03e6-472c-bb75-ba4ca	南澳	2016-04-29 08:0	50	-	一级	优	37	27
0127f46b-35a1-4288-b5e4-95376	洪湖	2016-05-06 23:0	32	-	一级	优	14	22
01285f44-9d40-4fcd-afb5-fce32	南澳	2016-02-17 08:0	39	-	一级	优	27	27
0128945f-cfba-4918-83ee-22df1	观澜	2017-01-06 04:0	109	细颗粒物	三级	轻度污染	127	82
012895b1-6a76-4928-8a3a-9f335	盐田	2015-12-14 01:0	45	-	一级	优	22	26
01289892-7453-4bdc-8e45-f3228	荔园	2016-04-09 04:0	28	-	一级	优	20	19
159cff69-3b61-4067-9fd8-5ecac	福永	2016-04-06 09:0	—	—	-	-	-	—
0128d9af-498f-4279-947c-5b0c0	南油	2016-05-05 09:0	28	-	一级	优	21	19
0129026d-f7b2-4414-9c64-12faf	梅沙	2015-10-25 05:0	49	-	一级	优	24	32
0129850c-b2cd-41fb-8e92-41a9a	坪山	2017-10-17 01:0	22	-	一级	优	10	12
0129989e-1085-4500-9baa-b5f70	福永	2015-10-19 00:0	112	细颗粒物	三级	轻度污染	103	84
012a4342-f8e2-4fdc-90ed-f5d46	荔园	2016-04-28 11:0	68	细颗粒物	二级	良	20	49
012a5b3c-79f2-436a-bf61-2e32e	下陂	2016-07-26 00:0	50	-	一级	优	21	27
159d1a5f-bb68-494f-996e-559fd	松岗	2016-06-12 01:0	—	—	-	-	-	—
012b0422-fcf3-4dcb-94ac-68807	南澳	2015-11-12 11:0	43	-	一级	优	18	25
012b0c81-9458-433f-875f-4fffe	松岗	2016-02-13 20:0	29	-	一级	优	13	13
012b89b6-9102-40d9-90ac-256a6	西乡	2017-03-24 02:0	52	可吸入颗粒物	二级	良	21	32
012bb380-74aa-46df-936a-71cb0	南油	2015-06-05 02:0	37	-	一级	优	14	17
012cd83e-89ae-47cd-bb72-9a0f6	观澜	2016-01-28 04:0	62	细颗粒物	二级	良	65	44
012d452f-0335-4877-818a-dffle	洪湖	2016-01-24 09:0	52	细颗粒物	二级	良	22	36


60
50
40
30
20
10
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hour
Average of AQI
Average of PM25_HOUR
Average of PM25_DAY

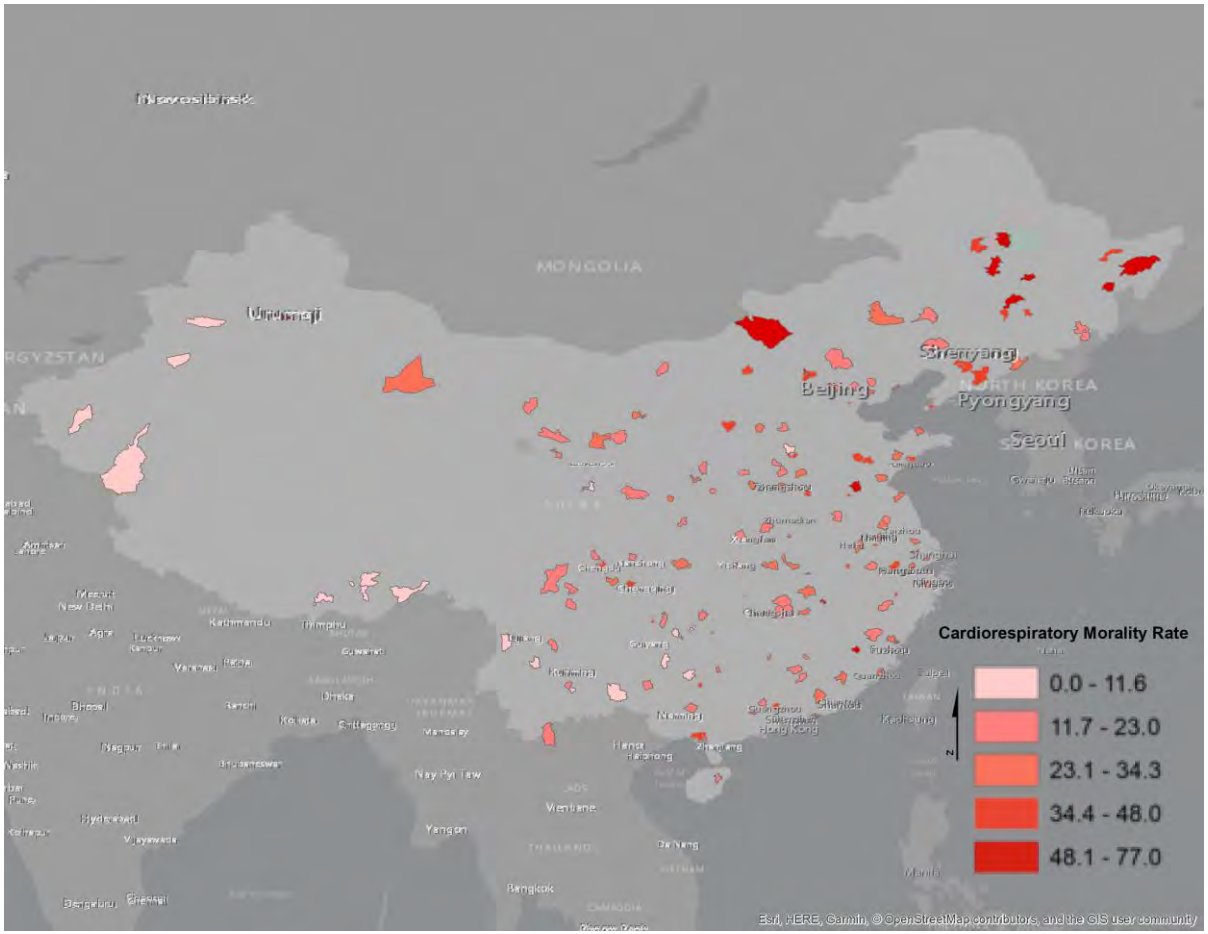

a
BC
NO
NO2
West Oakland
Bay Bridge
I-880
I-80
N
Downtown
Port
b
X
Y
c. Concentration Summary
BC
NO
NO2
Highways
Arterials
Residential
Legend
BC (μg m-3)
0
0.5
1.0
1.5
2.0
NO, NO2 (ppb)
0
10
20
30
40
= concentration Cave at fixed-site monitor
240 m

Urban Form and Health Outcomes

- Disease Surveillance Points (DSP) system, which forms a nationally-representative sample of mortality for 2005 (Sample size=158).

- The categories are selected from the International Classification of Disease Revision 9 (ICD-9). Cardiorespiratory causes of death are lung cancer , heart diseases, vascular disease , and respiratory diseases.

Spatial Distribution of Cardiorespiratory Mortality Rate/DSP sample sites



Data Source: China's Disease Surveillance Points (DSP) system, 2005

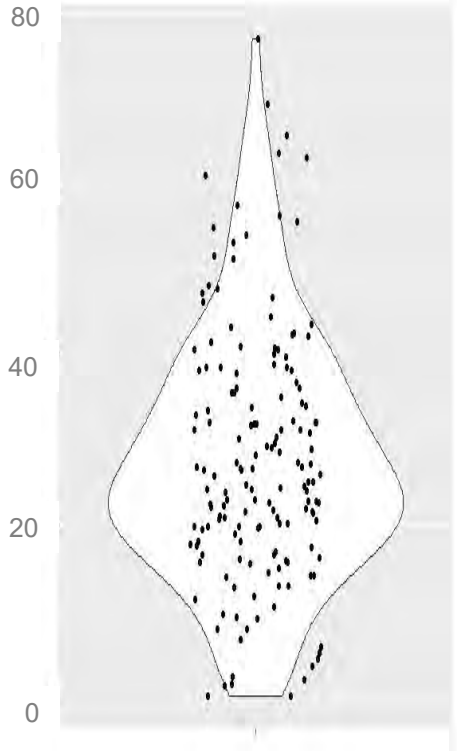
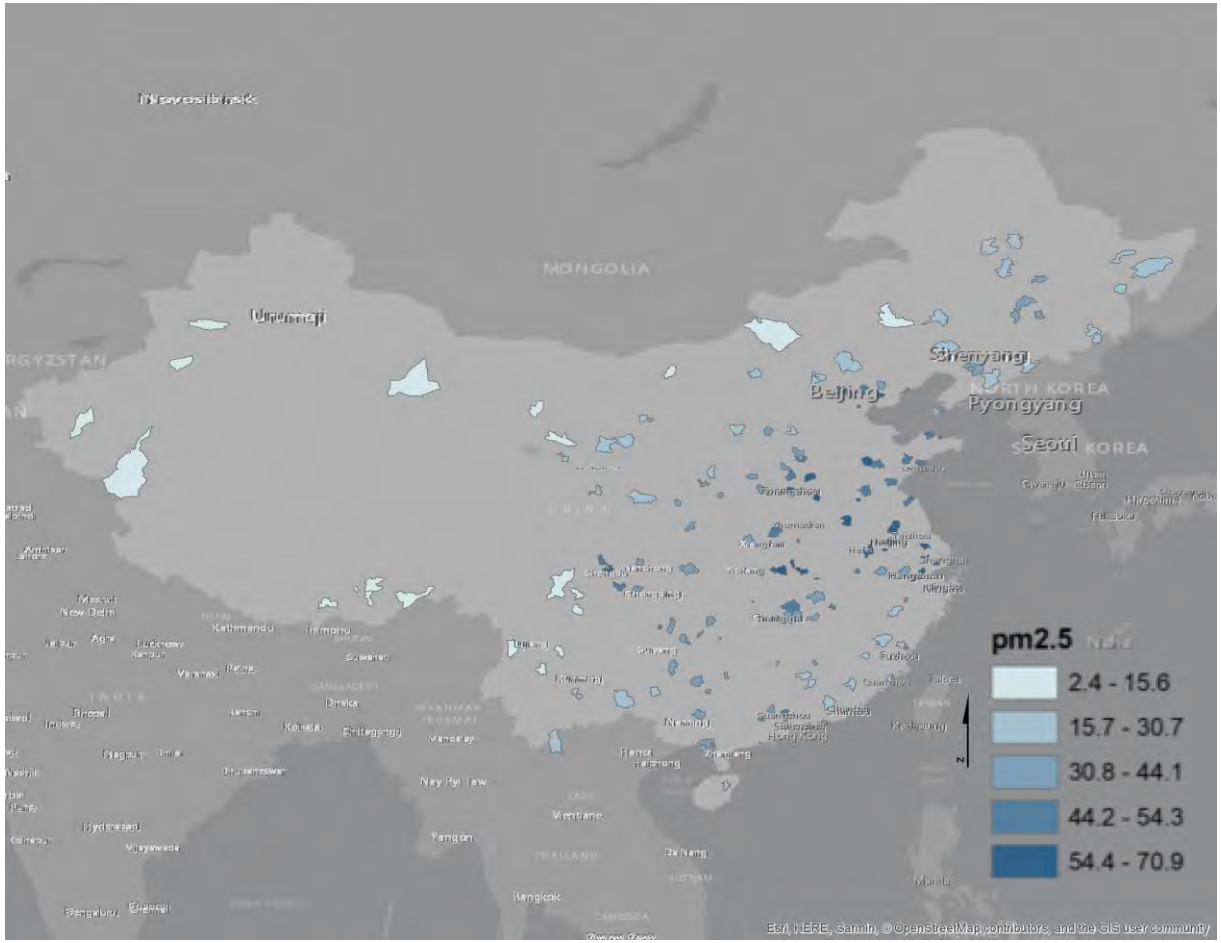


Fig. 3. Spatial distribution of cardiorespiratory mortality rate (incidences/100,000 population) Of DSP sample sites

Spatial Distribution of $PM_{2.5}$/DSP sample sites



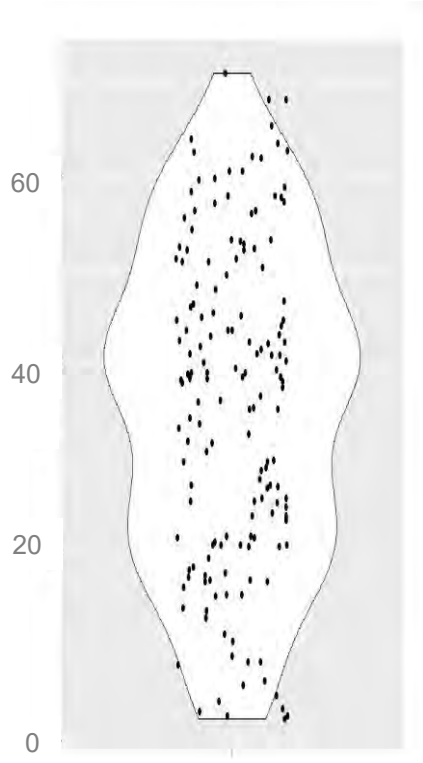
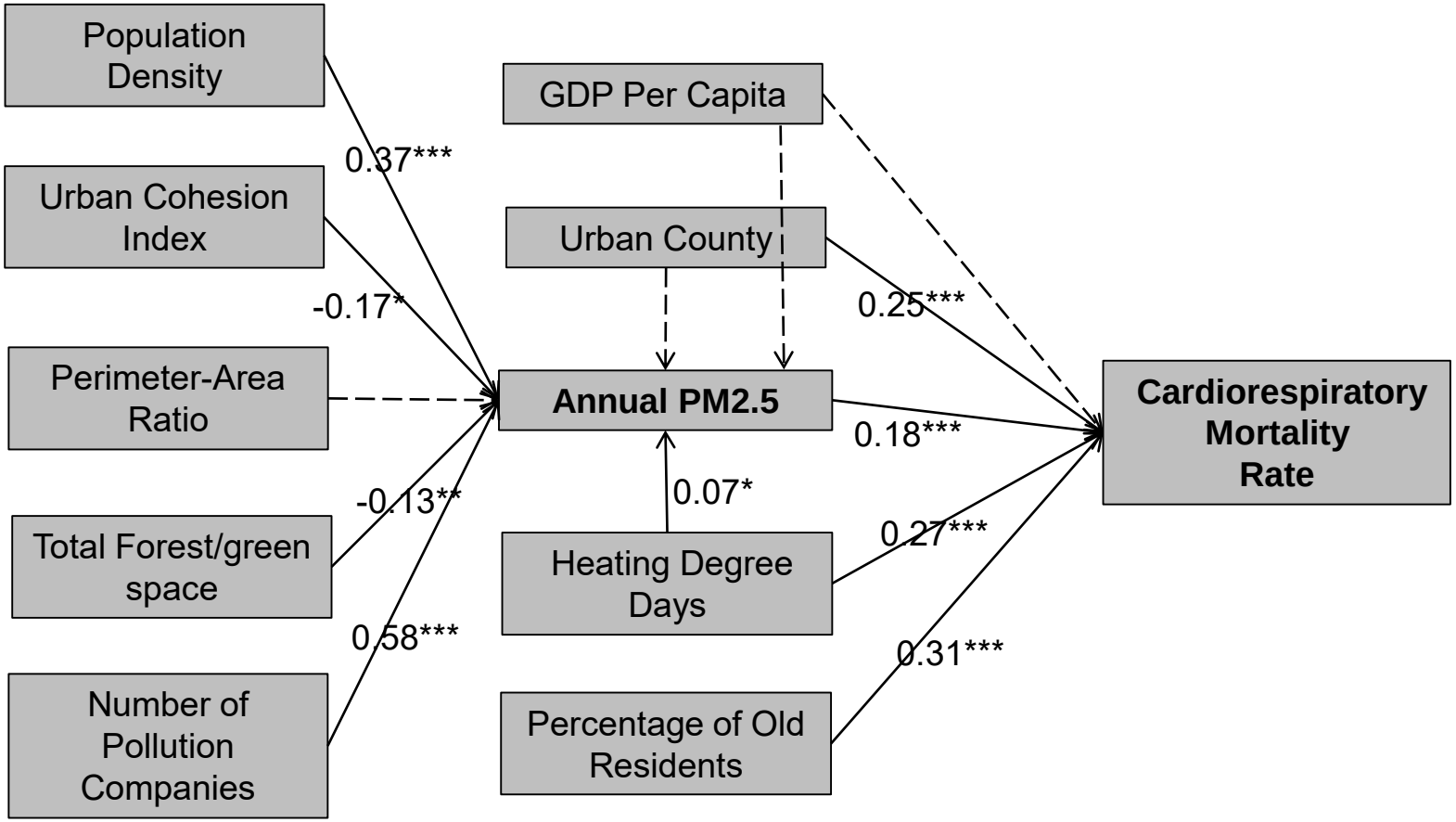


Fig. 2. Spatial distribution of annual average $PM_{2.5}$ Of DSP sample sites

Data Source: Global Annual PM2.5 Grids from MODIS, MISR and SeaWiFS Aerosol Optical Depth (AOD) with GWR (2005)

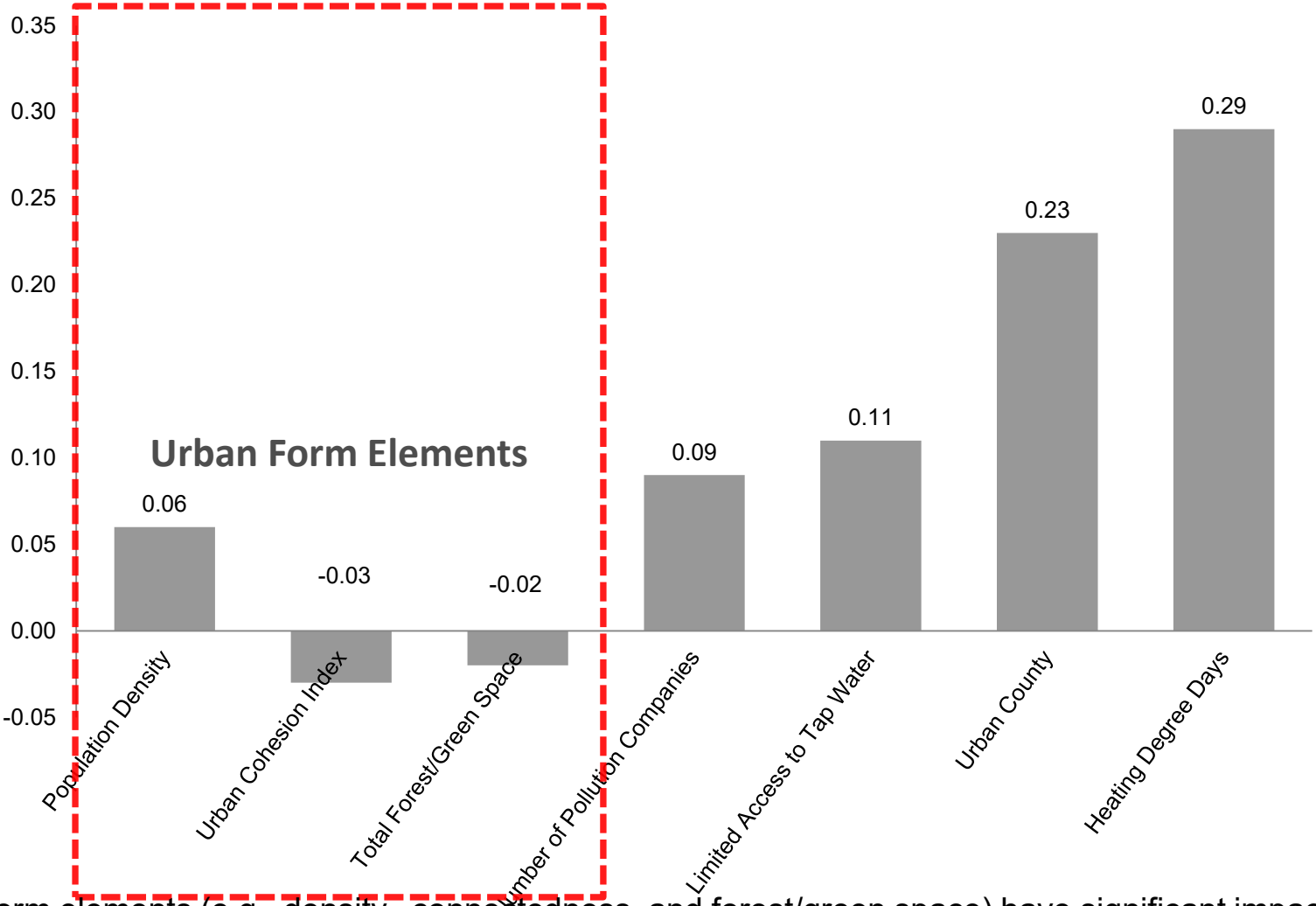
Preliminary Results: Path Model



●Note: Standardized coefficient; '***' denotes P<0.01; '**'P<0.05; '*' P<0.1.

N=158

Standardized Effects of Urban form and Other Factors on Cardiorespiratory Mortality Rate



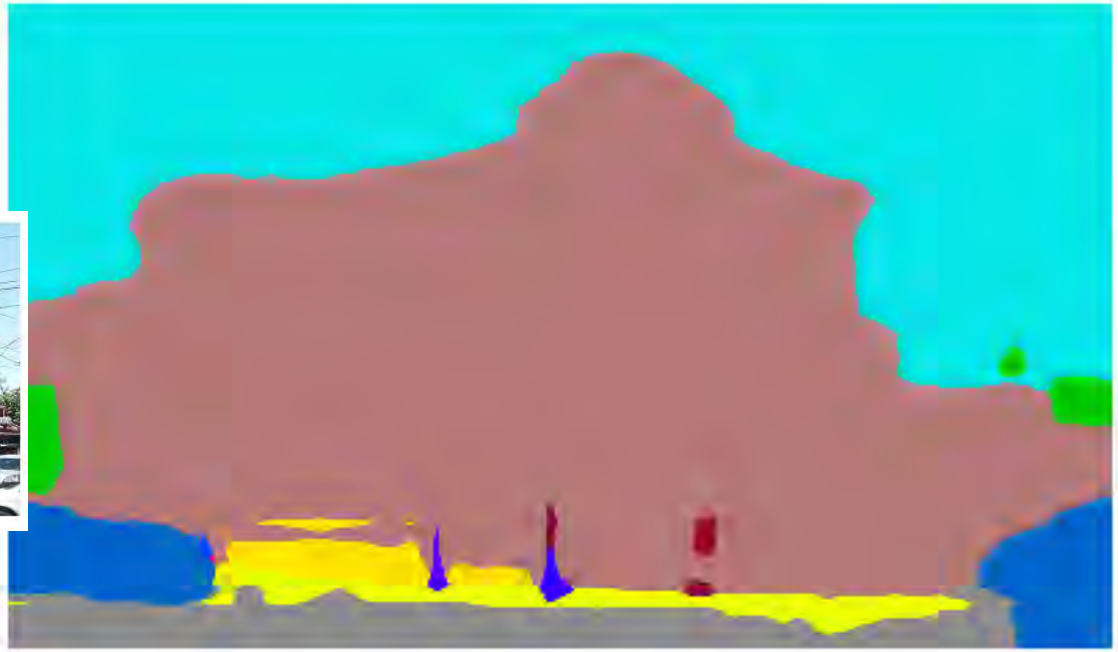
Urban form elements (e.g., density, connectedness, and forest/green space) have significant impacts on $PM_{2.5}$ concentration, thus influencing the incidence of cardiorespiratory mortality at the county level.

Sacramento

Nashville

Urban Form, urban vibrancy, and economic values

Segmentation:



Objects and their pixel ratios:

52.29% building

31.83% sky

6.25% road

4.40% car

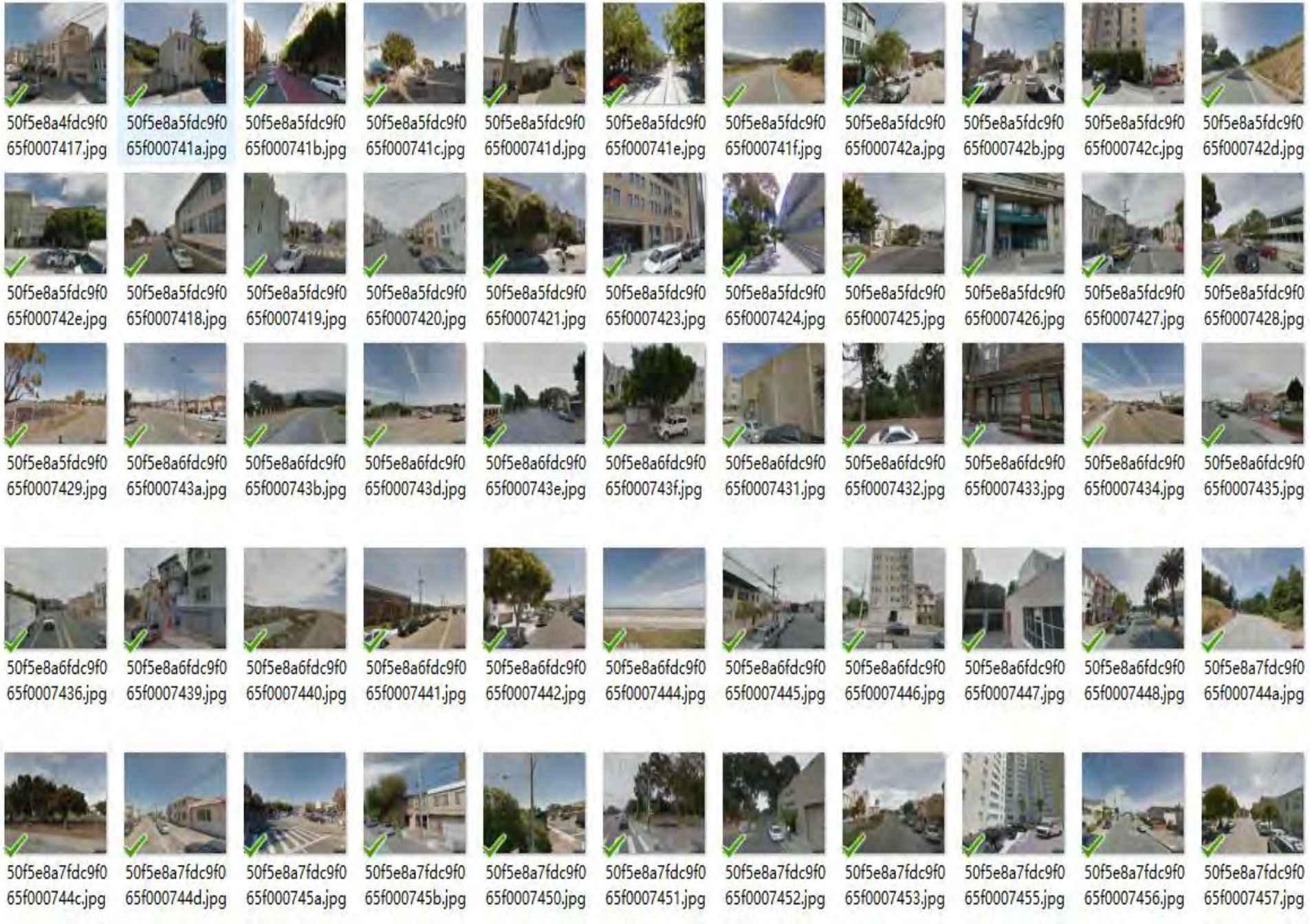
2.23% sidewalk

1.30% stairs

1.26% tree

0.21% pole

0.20% person


50f5e8a4fdc9f065f0007417.jpg
50f5e8a5fdc9f065f000741a.jpg
50f5e8a5fdc9f065f000741b.jpg
50f5e8a5fdc9f065f000741c.jpg
50f5e8a5fdc9f065f000741d.jpg
50f5e8a5fdc9f065f000741e.jpg
50f5e8a5fdc9f065f000741f.jpg
50f5e8a5fdc9f065f000742a.jpg
50f5e8a5fdc9f065f000742b.jpg
50f5e8a5fdc9f065f000742c.jpg
50f5e8a5fdc9f065f000742d.jpg
50f5e8a5fdc9f065f000742e.jpg
50f5e8a5fdc9f065f0007418.jpg
50f5e8a5fdc9f065f0007419.jpg
50f5e8a5fdc9f065f0007420.jpg
50f5e8a5fdc9f065f0007421.jpg
50f5e8a5fdc9f065f0007423.jpg
50f5e8a5fdc9f065f0007424.jpg
50f5e8a5fdc9f065f0007425.jpg
50f5e8a5fdc9f065f0007426.jpg
50f5e8a5fdc9f065f0007427.jpg
50f5e8a5fdc9f065f0007428.jpg
50f5e8a5fdc9f065f0007429.jpg
50f5e8a6fdc9f065f000743a.jpg
50f5e8a6fdc9f065f000743b.jpg
50f5e8a6fdc9f065f000743d.jpg
50f5e8a6fdc9f065f000743e.jpg
50f5e8a6fdc9f065f000743f.jpg
50f5e8a6fdc9f065f0007431.jpg
50f5e8a6fdc9f065f0007432.jpg
50f5e8a6fdc9f065f0007433.jpg
50f5e8a6fdc9f065f0007434.jpg
50f5e8a6fdc9f065f0007435.jpg
50f5e8a6fdc9f065f0007436.jpg
50f5e8a6fdc9f065f0007439.jpg
50f5e8a6fdc9f065f0007440.jpg
50f5e8a6fdc9f065f0007441.jpg
50f5e8a6fdc9f065f0007442.jpg
50f5e8a6fdc9f065f0007444.jpg
50f5e8a6fdc9f065f0007445.jpg
50f5e8a6fdc9f065f0007446.jpg
50f5e8a6fdc9f065f0007447.jpg
50f5e8a6fdc9f065f0007448.jpg
50f5e8a7fdc9f065f000744a.jpg
50f5e8a7fdc9f065f000744c.jpg
50f5e8a7fdc9f065f000744d.jpg
50f5e8a7fdc9f065f000745a.jpg
50f5e8a7fdc9f065f000745b.jpg
50f5e8a7fdc9f065f0007450.jpg
50f5e8a7fdc9f065f0007451.jpg
50f5e8a7fdc9f065f0007452.jpg
50f5e8a7fdc9f065f0007453.jpg
50f5e8a7fdc9f065f0007455.jpg
50f5e8a7fdc9f065f0007456.jpg
50f5e8a7fdc9f065f0007457.jpg

中央商务区活力指数
Ranking of Vibrancy

Table 4: Vibrancy Index Values

Rank	City	Value	Rank	City	Value	Rank	City	Value
1	Chicago	1.482	23	St. Paul	0.145	45	Las Vegas	-0.343
2	Boston	1.369	24	San Antonio	0.081	46	Oklahoma City	-0.368
3	Seattle	1.180	25	Detroit	0.074	47	Reno	-0.379
4	Philadelphia	1.150	26	Miami	0.062	48	Orlando	-0.396
5	San Francisco	1.134	27	Richmond	0.033	49	Fresno	-0.397
6	Washington, D.C.	0.911	28	San Diego	0.025	50	Nashville	-0.422
7	Portland, OR	0.889	29	Kansas City	0.018	51	Phoenix	-0.427
8	Oakland	0.664	30	Santa Ana	0.017	52	Tampa	-0.458
9	Los Angeles	0.637	31	Boise	0.015	53	Columbus	-0.476
10	Denver	0.577	32	Buffalo	-0.045	54	Cleveland	-0.520
11	Houston	0.504	33	Grand Rapids	-0.046	55	Lansing	-0.538
12	Sacramento	0.458	34	Salem, OR	-0.103	56	Raleigh	-0.584
13	Austin	0.442	35	Louisville	-0.117	57	Salt Lake City	-0.628
14	Minneapolis	0.402	36	St. Louis	-0.126	58	Indianapolis	-0.640
15	Providence	0.387	37	Fort Lauderdale	-0.128	59	Akron	-0.650
16	New Orleans	0.371	38	Cincinnati	-0.134	60	Springfield, IL	-0.696
17	Pittsburgh	0.341	39	Lexington, KY	-0.221	61	Birmingham	-0.703
18	Dallas	0.267	40	Rochester, NY	-0.229	62	Wichita	-0.717
19	Hartford	0.216	41	Des Moines	-0.257	63	Memphis	-0.773
20	Baltimore	0.194	42	Pasadena	-0.262	64	Fort Worth	-0.804
21	San Jose	0.163	43	Charlotte	-0.287	65	Columbia, SC	-1.159
22	Milwaukee	0.148	44	Atlanta	-0.318			

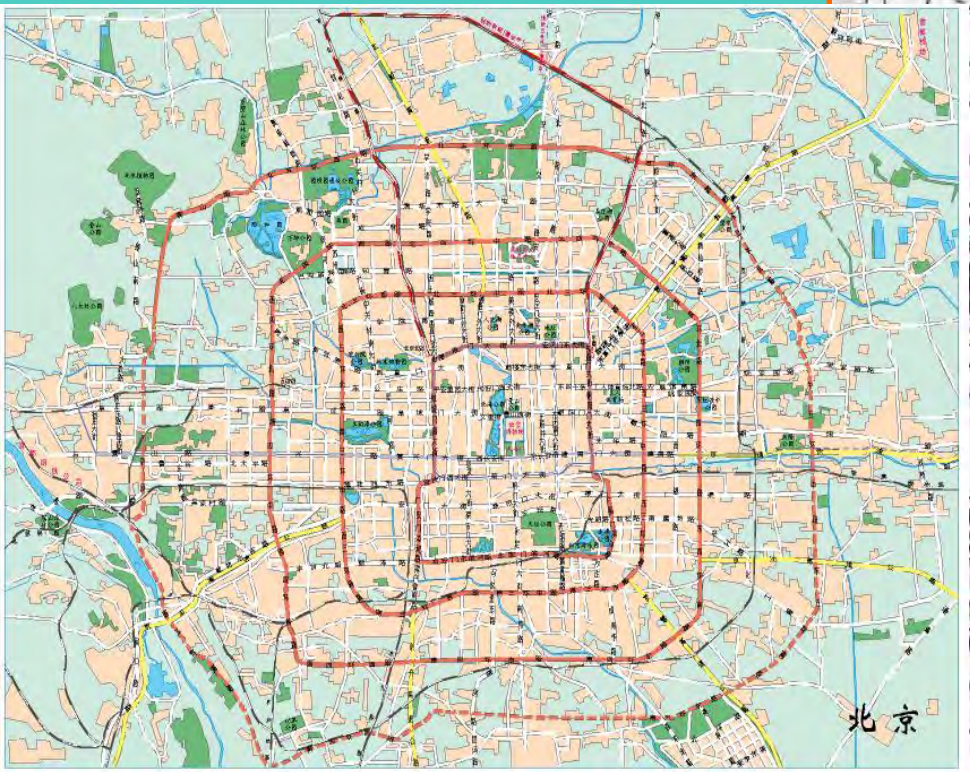
	Log Office Rent
Vibrancy	0.153**
	(0.061)
Mfg. Emp.	-0.419
	(0.554)
Sci./Tech.	4.954***
	(1.173)
Office Age	-0.007***
	(0.002)
Poverty	0.389
	(0.306)
HH in 5 mi.	0.001**
	(0.000)
Region (base case = Midwest)	
East	0.132*
	(0.075)
South	0.132**
	(0.058)
West	0.091
	(0.065)
constant	2.731***
	(0.212)
R-squared	0.758
Adjusted R-squared	0.719

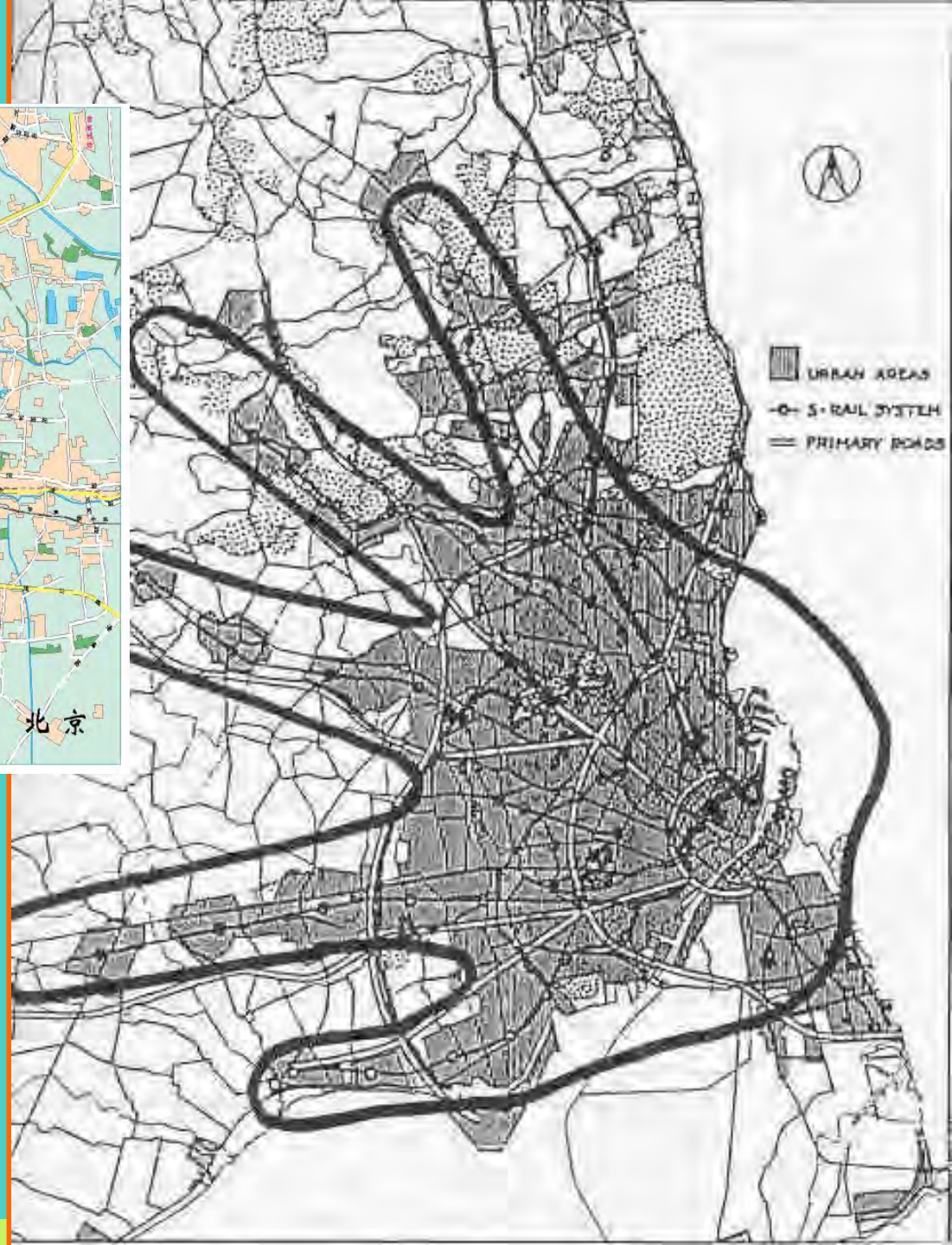
16% price premium

Office rent in the more vibrant downtown is $22.3, compared to $19.1 per square foot in the less vibrant downtown.

Vibrant?

Sustainable？


北京


URBAN AREAS
S-RAIL SYSTEM
PRIMARY ROADS

Pollution prevention and mitigation (10)
Air pollution mitigation program
Superfund site remediation
Asbestos abatement program
Household solid waste recycling
Household hazardous waste recycling
Household green waste recycling
Commercial solid waste recycling
Commercial hazardous waste recycling
Industrial recycling
City government recycled product purchase

Economic development/redevelopment (9)
Eco-industrial park development
Cluster or targeted economic development
Infill financial incentives
Impact fees
Mandatory dedications
Negotiated exactions
Public redevelopment investment
Redevelopment authority
Brownfield redevelopment

Land use (8)
Comprehensive land use plans identify Environmentally Sensitive Areas (ESAs)
Habitat conservation planning under ESA
Encourages conservation easements
Williamson Act lands in jurisdiction
Williamson Act support
Minimum density standards
Eco-village project or program
Growth phasing

Zoning (6)
Green zoning
Agricultural zoning
Up zoning
Inclusive use zoning
Mixed-use zoning
Urban growth boundary

Transportation (6)
Traffic impact analysis
Public transit system
Downtown parking limits
Carpool program
Alternative fuel fleet vehicles
Bicycle ridership program

Resource conservation (5)
Commercial green building program
Energy conservation programs
Renewable energy use by city government
Consumer alternative energy
Water conservation program

Green symbols and membership (4)
Green symbol logos
Member, International Council for Local Environmental Initiatives
Member, Cities for Climate Protection Campaign
Signatory, Mayors' Climate Protection

Administration and coordination (2)
Sustainability agency/nonprofit
Sustainability goals in comprehensive plan

- 污染控制
- 经济可持续
- 土地利用
- 区划
- 交通
- 资源
- 绿色地位
- 组织能力
- 50项公共政策

Thanks! 非常感谢！

Q&A

Yan Song 宋彦
University of North Carolina at Chapel Hill 北卡罗来纳大学城市规划系
Program on Chinese Cities 北卡罗来纳大学中国城市研究中心 主任
Email: ys@email.unc.edu