Analysis of Travel Behavior by the “Color” of the City

15. the University of Tokyo A

Aoi Watanabe, Bingchang Shen, Hikaru Tsukida, Rena Koseki, Takuro Arai

Introduction

Difficulty of Data Acquisition for Route Choice Model

	Classical Data	Image Data
Example	“土地利用現況調査” “都市計画基礎調査”	Satellite Image Aerial Image
Explanatory Variable	Number of shops Floors of buildings Width of sidewalk	RGB Value Near infrared radiation

H27主要商店街の店舗数

	商業店舗数(店)
中央商店街	298
道後商店街	64
ロープウェー商店街	88
萱町商店街	33
花園町商店街	51
末広町商店街	48
柳井町商店街	27
河原町商店街	31

Location of shopping street
and the number of shops

Aerial Image

Introduction

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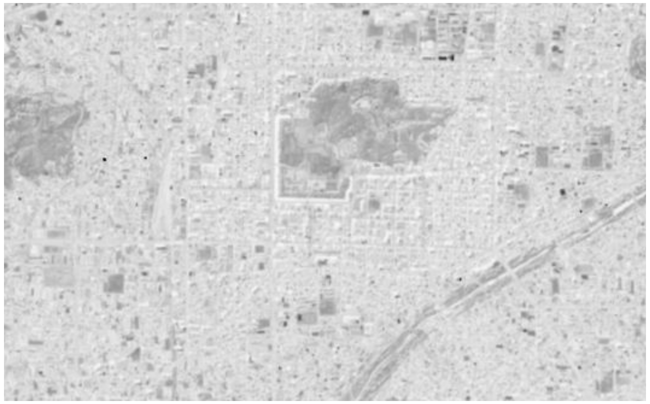
Explanatory Variable	Number of shops Floors of buildings Width of sidewalk	RGB Value Near infrared radiation
Space Resolution	○	△
Parameter Interpretation	○	×
Time Resolution	×	○
Acquision	×	○

Objective

Estimation method based on **aerial photos / satellite images**

- ▶ Easy and uniform estimation of various places / years
- ▶ Compensate the disadvantage of the classical data

Aerial photo



Satellite image (Near infrared)

Data

❑ **Grid Network**

grid size

900m

1200m

Matsuyama @ 2007

❑ **Grid Size (variable)**

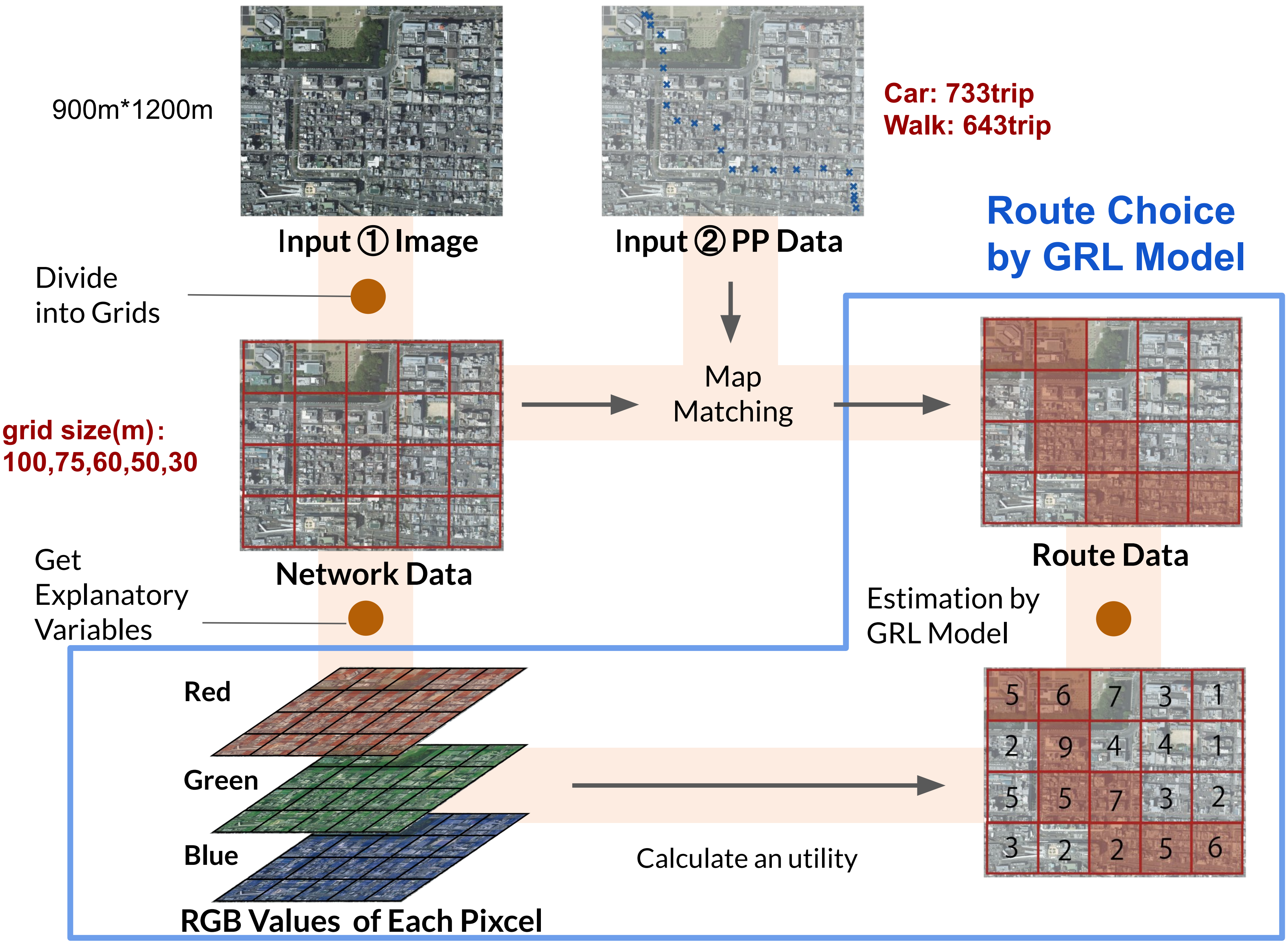
100m, 75m, 60m, 50m, 30m

❑ **PP data**

Car: 733 trips

Walk: 643 trips

Framework



900m*1200m
Input ① Image
Input ② PP Data
Car: 733trip
Walk: 643trip
Route Choice
by GRL Model
Divide
into Grids
grid size(m):
100,75,60,50,30
Map
Matching
Network Data
Route Data
Get
Explanatory
Variables
Estimation by
GRL Model
Red
Green
Blue
RGB Values of Each Pixcel
Calculate an utility
5 6 7 3 1
2 9 4 4 1
5 5 7 3 2
3 2 2 5 6

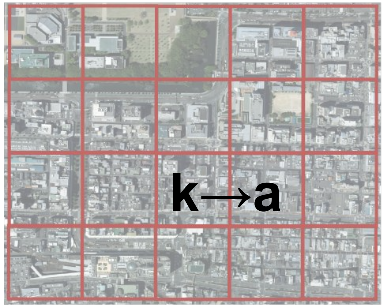
Formulation

β-scaled Recursive Logit

β: time discount rate

$v(a|k)$: instantaneous utility from grid k to grid a $\forall k, a \in G : set\ of\ grids$

$$V(k) = \mathrm{E}\left[\max_{a \in A(k)} \{v(a|k) + \beta V(a) + \varepsilon(k)\}\right]$$



Grid Network

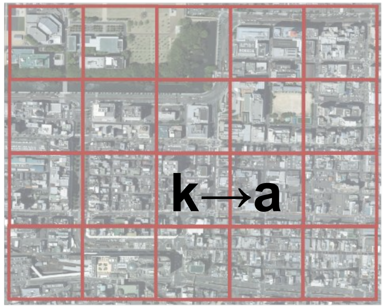
Explanatory variables:

① RGB

② RGB + other Bands

③ Category value

Formulation



Grid Network

β-scaled Recursive Logit

$v(a|k)$: instantaneous utility from grid k to grid a $\quad \forall k, a \in G : set\ of\ grids$

Explanatory variables:

① RGB

$$v(a|k) = \theta_1^1 \cdot AR_a + \theta_2^1 \cdot AG_a + \theta_3^1 \cdot AB_a + \theta_4^1 \cdot DR_a + \theta_5^1 \cdot DG_a + \theta_6^1 \cdot DB_a - 1$$

Red **Green** **Blue** **transition cost**

$\boldsymbol{\theta}^1$: parameter vector

AR_a : Ave of Red values in grid a

AG_a : Ave of Green values in grid a

AB_a : Ave of Blue values in grid a

DR_a : S.D. of Red values in grid a

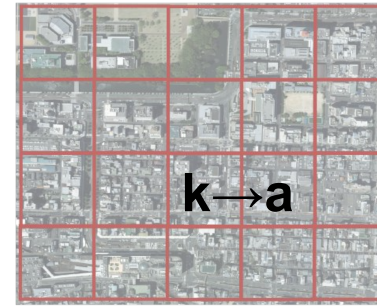
DG_a : S.D. of Green values in grid a

DB_a : S.D. of Blue values in grid a

Formulation

β-scaled Recursive Logit

$v(a|k)$: instantaneous utility from grid k to grid a $\quad \forall k, a \in G : set\ of\ grids$



Grid Network

Explanatory variables:

② RGB + other Bands

$$v(a|k) = \theta_1^2 \cdot AR_a + \theta_2^2 \cdot AG_a + \theta_3^2 \cdot AB_a + \theta_4^2 \cdot A\lambda_a^1 + \theta_5^2 \cdot A\lambda_a^2 + \theta_6^2 \cdot DR_a + \theta_7^2 \cdot DG_a + \theta_8^2 \cdot DB_a + \theta_9^2 \cdot D\lambda_a^1 + \theta_{10}^2 \cdot D\lambda_a^2 - 1$$

Red (AR, DR) **Green** (AG, DG) **Blue** (AB, DB) **B08** ($A\lambda_a^1$, $D\lambda_a^1$) **B11** ($A\lambda_a^2$, $D\lambda_a^2$) **transition cost** (−1)

$A\lambda_a^1$: Ave of B08 values in grid a

$A\lambda_a^2$: Ave of B11 values in grid a

$D\lambda_a^1$: S.D. of B08 values in grid a

$D\lambda_a^2$: S.D. of B11 values in grid a

B08: near infra-red,
Resolution 10m <Plants>

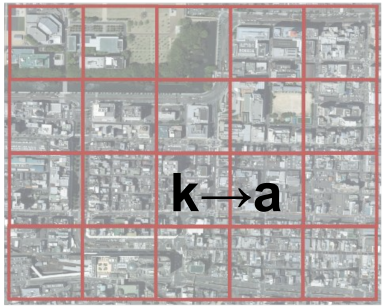
B11: SWIR,
Resolution 20m <Water>

B08

Formulation

β-scaled Recursive Logit

$v(a|k)$: instantaneous utility from grid k to grid a $\quad \forall k, a \in G : set\ of\ grids$



Grid Network

Explanatory variables:

③ Category value (N-categories)

$$v(a|k) = \theta_1^3 \cdot RC_a^1 + \theta_2^3 \cdot RC_a^2 + \ldots + \theta_{N-1}^3 \cdot RC_a^{N-1} - 1$$

transition cost

Category Values

$\boldsymbol{\theta}^3$: parameters

RC_a^i : Ratio of Category in grid a (i = 1,2,...,N-1)

Result ①: Comparison of three Formulations

mode = car, β = 0.1, grid = 100m

** 5% significant

variables	parameter	t-stat	
Ave. of Red	-51.06	-10.94	**
Ave. of Green	21.89	5.363	**
Ave. of Blue	30.76	10.99	**
S.D. of Red	0.3378	0.04553	
S.D. of Green	71.01	7.232	**
S.D. of Blue	-64.90	-12.45	**
L0		-6146.3	
LL		-4713.7	
ρ-square		0.233	
adjusted ρ-square		0.232	

① RGB

variables	parameter	t-stat	
Ave. of Red	-44.93	-8.904	**
Ave. of Green	27.25	4.463	**
Ave. of Blue	24.01	5.441	**
S.D. of Red	0.4833	0.05916	
S.D. of Green	86.16	8.211	**
S.D. of Blue	-82.67	-14.26	**
Ave. of B08	6.931	2.920	**
Ave. of B11	-14.90	-7.019	**
S.D. of B08	2.085	0.8095	
S.D. of B11	-10.92	-3.511	**
L0		-6138.0	
LL		-4660.5	
ρ-square		0.241	
adjusted ρ-square		0.239	

② RGB + other Bands

variables	parameter	t-stat	
ratio of category 1	4.805	5.182	**
ratio of category 2	7.630	9.829	**
ratio of category 3	1.682	2.242	**
ratio of category 4	7.102	18.11	**
ratio of category 5	0.6321	0.7439	
ratio of category 6	9.062	16.93	**
ratio of category 7	5.880	7.462	**
L0		-6064.5	
LL		-4702.5	
ρ-square		0.225	
adjusted ρ-square		0.223	

③ Category value

Fit: RGB + other Bands ＞ RGB ＞ Category value

Result ②：Comparison with conventional methods

mode = car, β = 0.1, grid = 100m

** 5% significant

classical data

variables	parameter	t-stat	
walkway dummy	0.4155	3.250	**
arcade dummy	0.01862	0.1318	
tramway dummy	-0.02935	-0.4657	
railway dummy	1.133	16.98	**
road width	0.2639	41.23	**
L0		-6285.7	
LL		-4811.3	
ρ-square		0.235	
adjusted ρ-square		0.234	

image data

variables	parameter	t-stat	
Ave. of Red	-44.93	-8.904	**
Ave. of Green	27.25	4.463	**
Ave. of Blue	24.01	5.441	**
S.D. of Red	0.4833	0.05916	
S.D. of Green	86.16	8.211	**
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S.D. of B08	2.085	0.8095	
S.D. of B11	-10.92	-3.511	**
L0		-6138.0	
LL		-4660.5	
ρ-square		0.241	
adjusted ρ-square		0.239	

combination

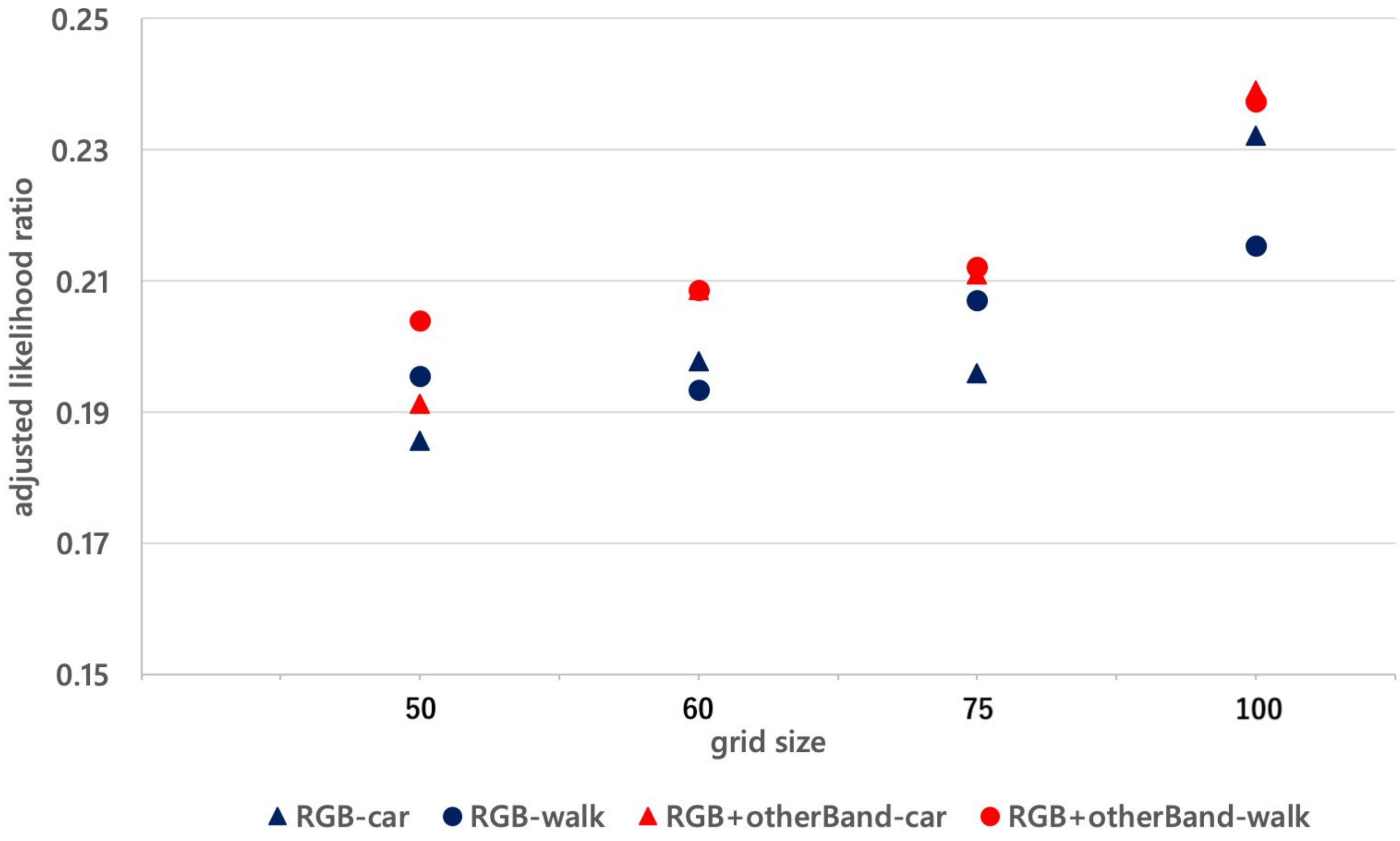
variables	parameter	t-stat	
Ave. of Red	-7.214	-1.275	
Ave. of Green	14.61	2.223	**
Ave. of Blue	0.8889	0.1877	
S.D. of Red	-53.88	-5.829	**
S.D. of Green	85.23	7.398	**
S.D. of Blue	-34.84	-5.144	**
Ave. of B08	3.816	1.386	
Ave. of B11	-10.40	-4.458	**
S.D. of B08	17.06	5.843	**
S.D. of B11	-10.06	-3.088	**
walkway dummy	-0.05845	-0.3205	
arcade dummy	0.1050	0.5234	
tramway dummy	-0.1461	-2.096	**
railway dummy	0.3122	4.042	**
road width	0.1776	18.89	**
L0		-6088.2	
LL		-4441.7	
ρ-square		0.270	
adjusted ρ-square		0.268	

Fit: combination ＞ classical data ≒ image data

Result ③

The Effect of Grid Size

β = 0.1



- Decreasing the grid size reduces accuracy
- Walk fits better than car on a small grid

Policy Analysis

① Transition of Hanazonomachi Street

road width: 20m(before war) ⇨ 40m(after war) ⇨ redistribution of road space (2017)

classical data: we **have** “number of lanes” as explanatory variable

② Greenization of parking lots

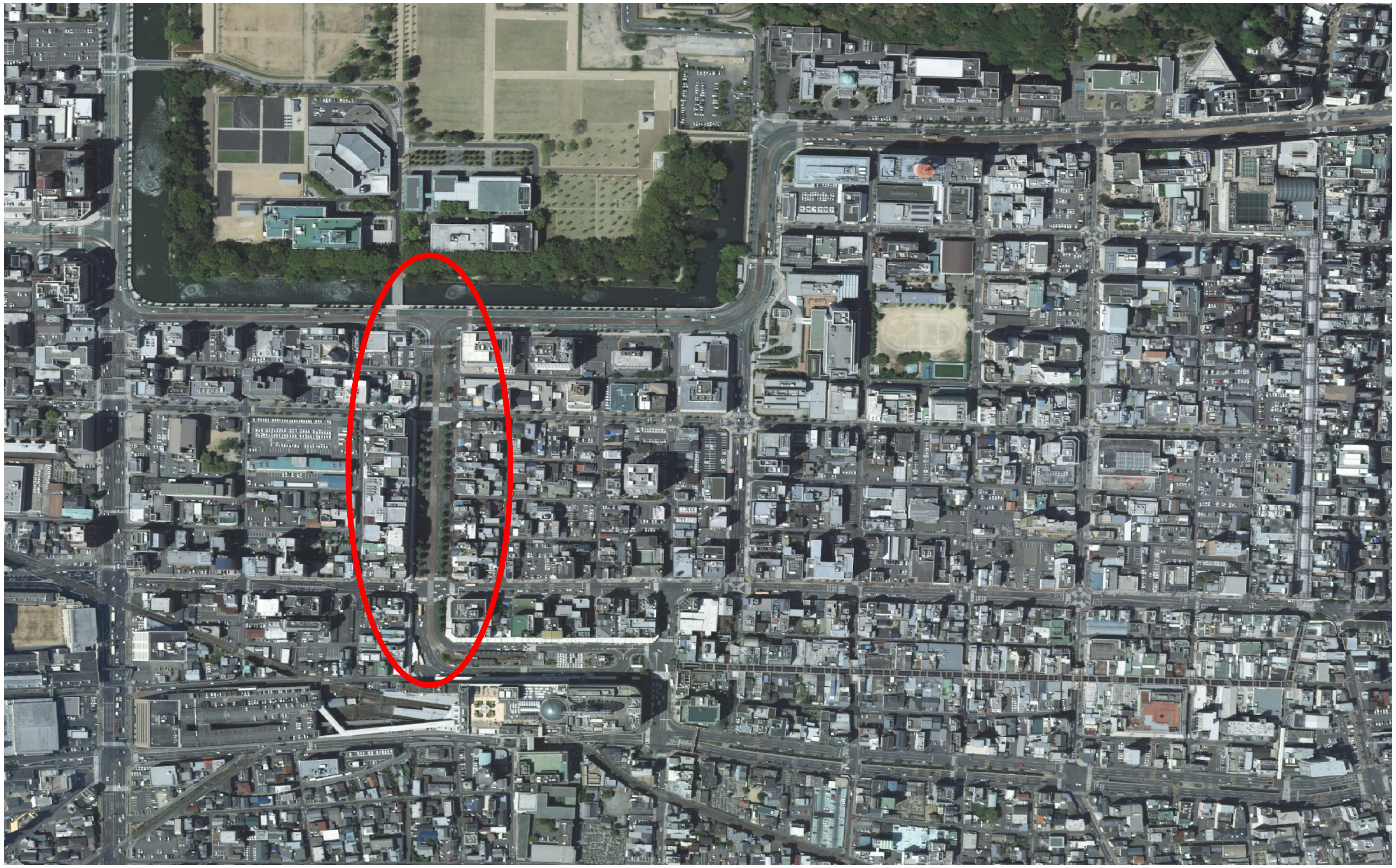
the parking lots scattered in the center of the area becomes green space

classical data: we **don’t have** “parking lot distribution” as explanatory variable

Policy Analysis

① Transition of Hanazonomachi Street

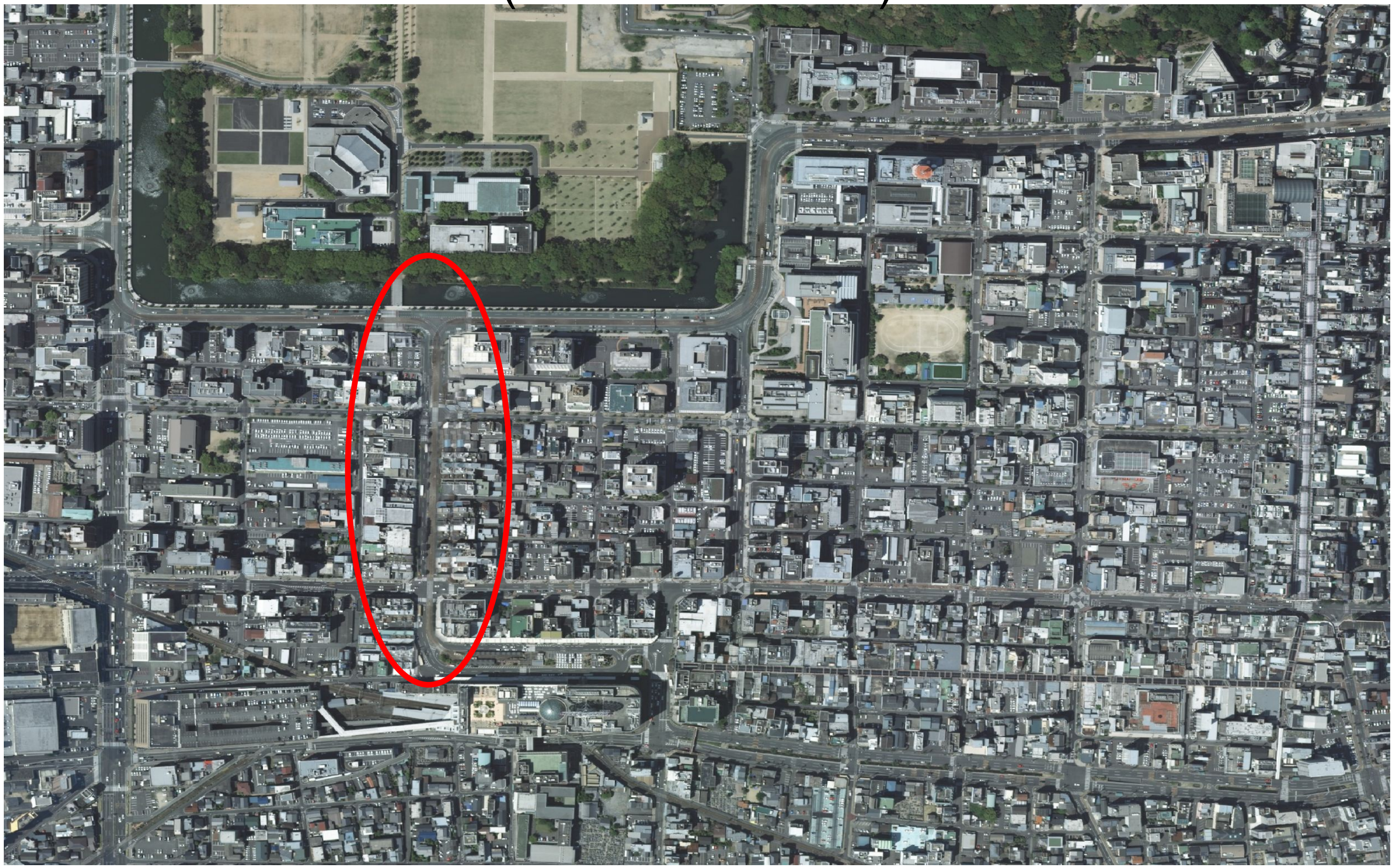
Aerial Image taken in 2007



Policy Analysis

① Transition of Hanazonomachi Street

Aerial Image with narrowed Hanaoznomachi Street
(road width: 20m)



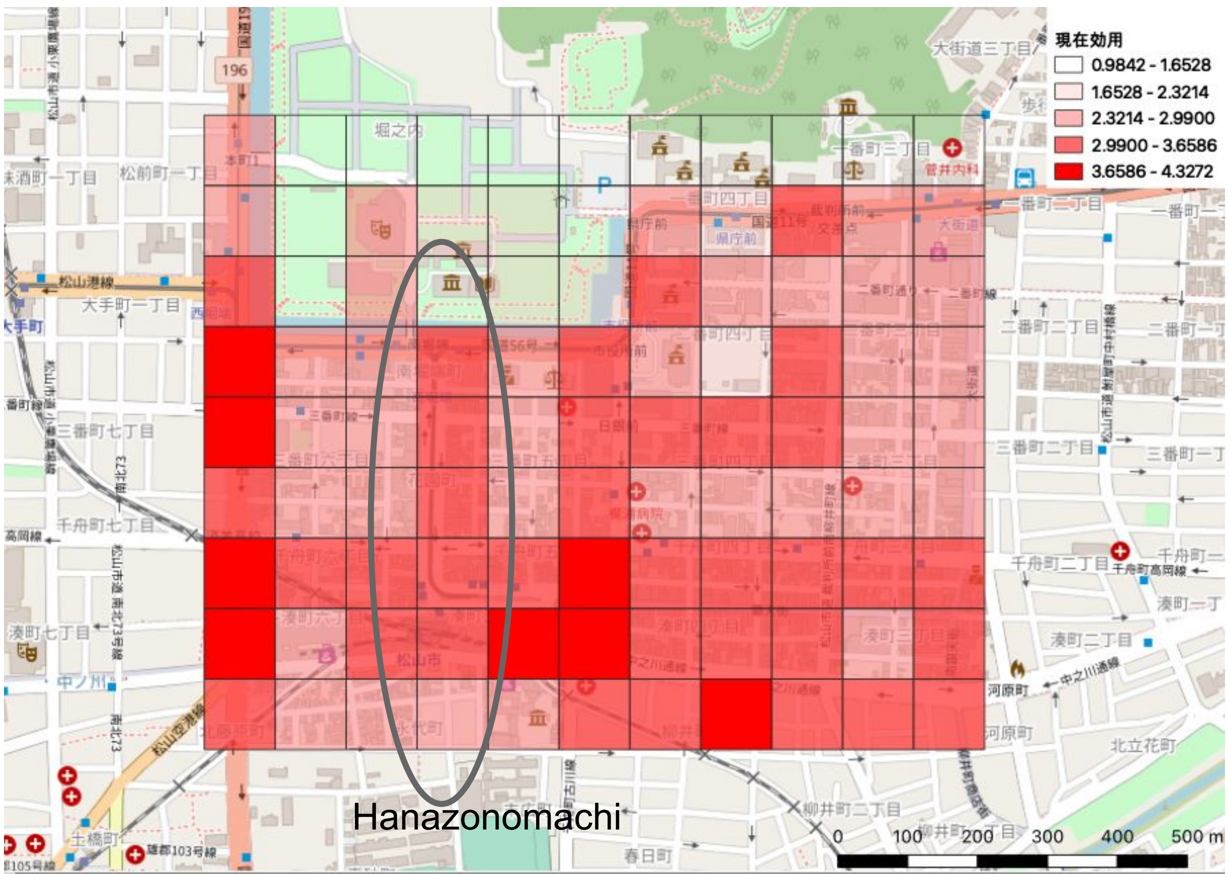
Policy Analysis

① Transition of Hanazonomachi Street

* Assignment using Combinational Method

The instantaneous utility (Car) of Aerial Image taken in 2007

2007



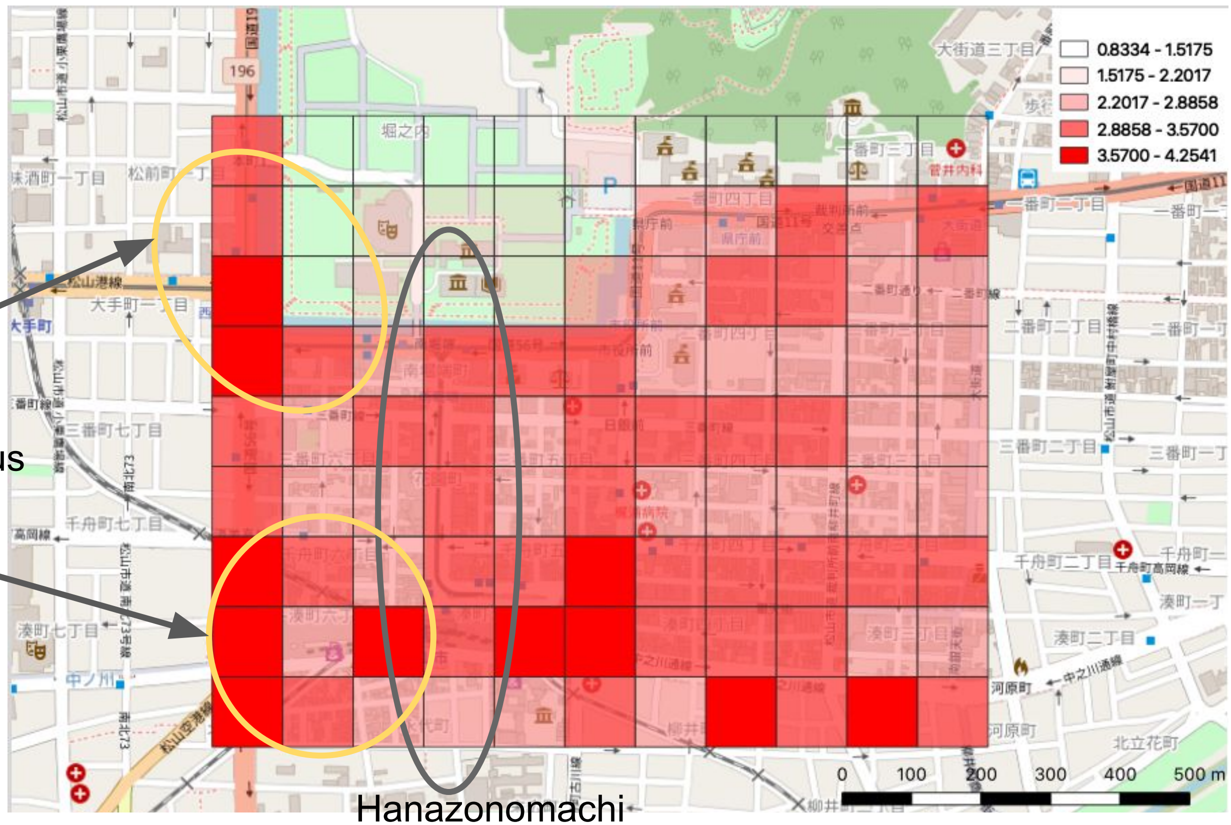
Policy Analysis

① Transition of Hanazonomachi Street

* Assignment using Combinational Method

The instantaneous utility (Car) of Aerial Image
with narrowed Hanaozonomachi Street (road width: 20m)

Pre-War



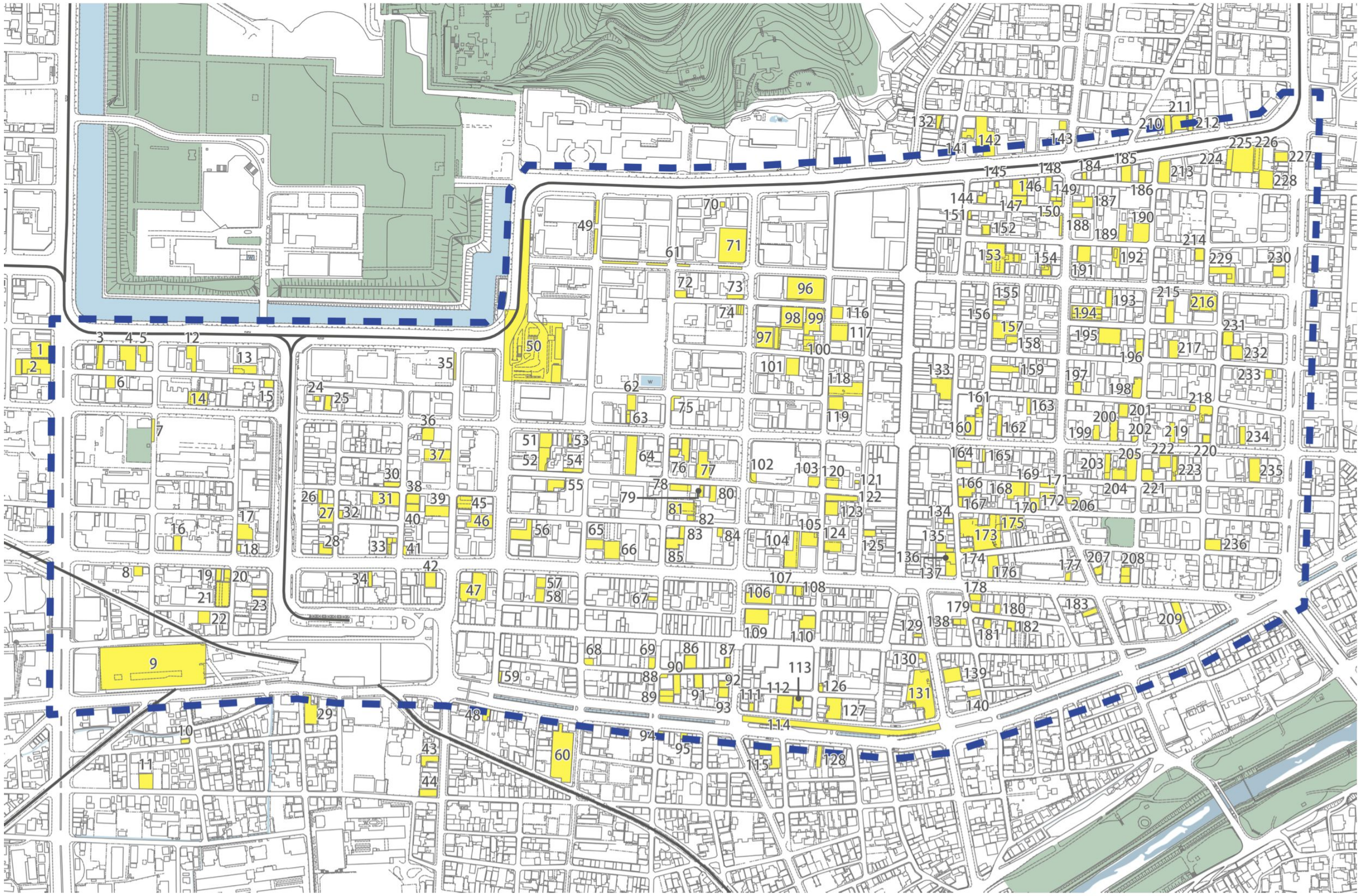
Increase in the instantaneous utility

Increase in the utility **outside** of the Hanazonomachi Street

Policy Analysis

② Greenization of parking lots

The Parking Lots Distribution



Policy Analysis

② Greenization of parking lots

Aerial Image taken in 2007

Policy Analysis

② Greenization of parking lots

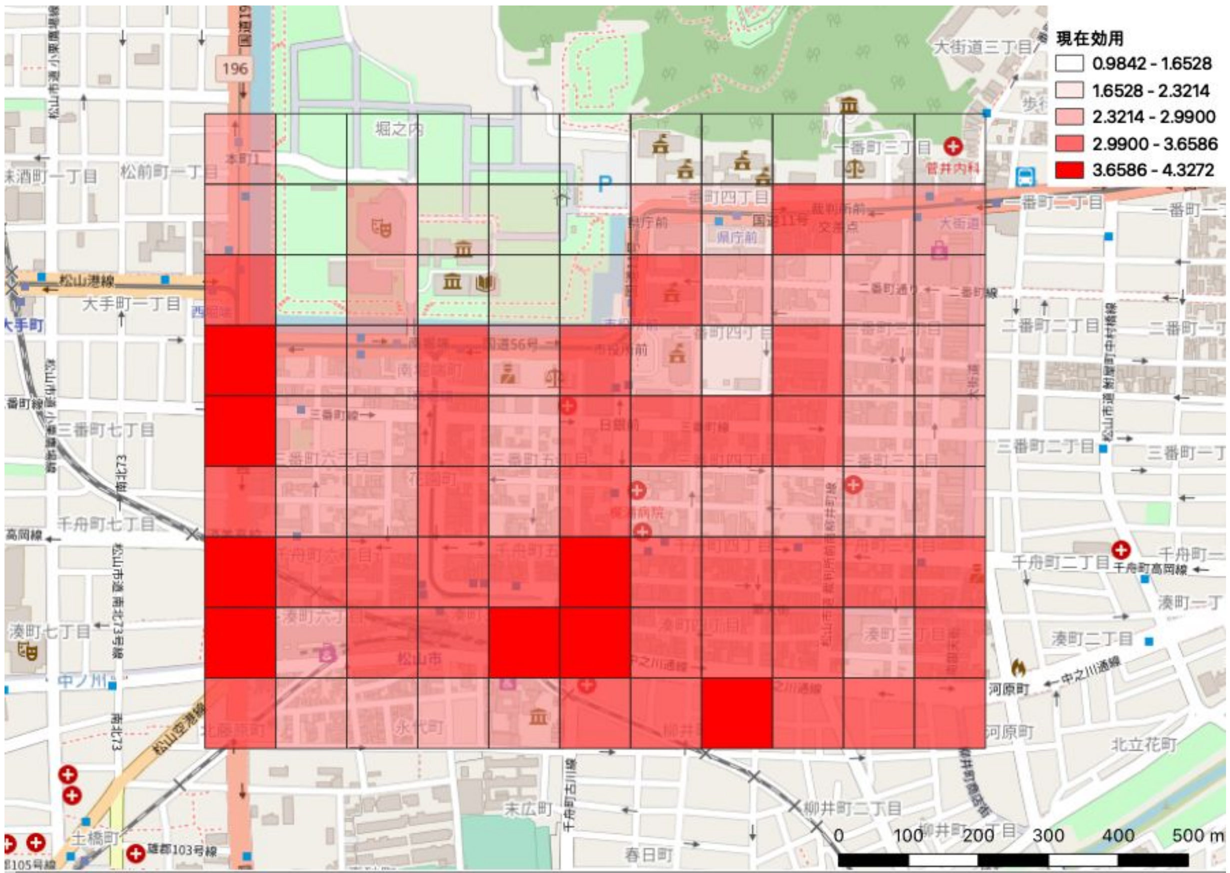
Image after greenizing parking lots

Policy Analysis

② Greenization of parking lots

* Assignment using Combinational Method

The instantaneous utility (Car) of Aerial Image taken in 2007

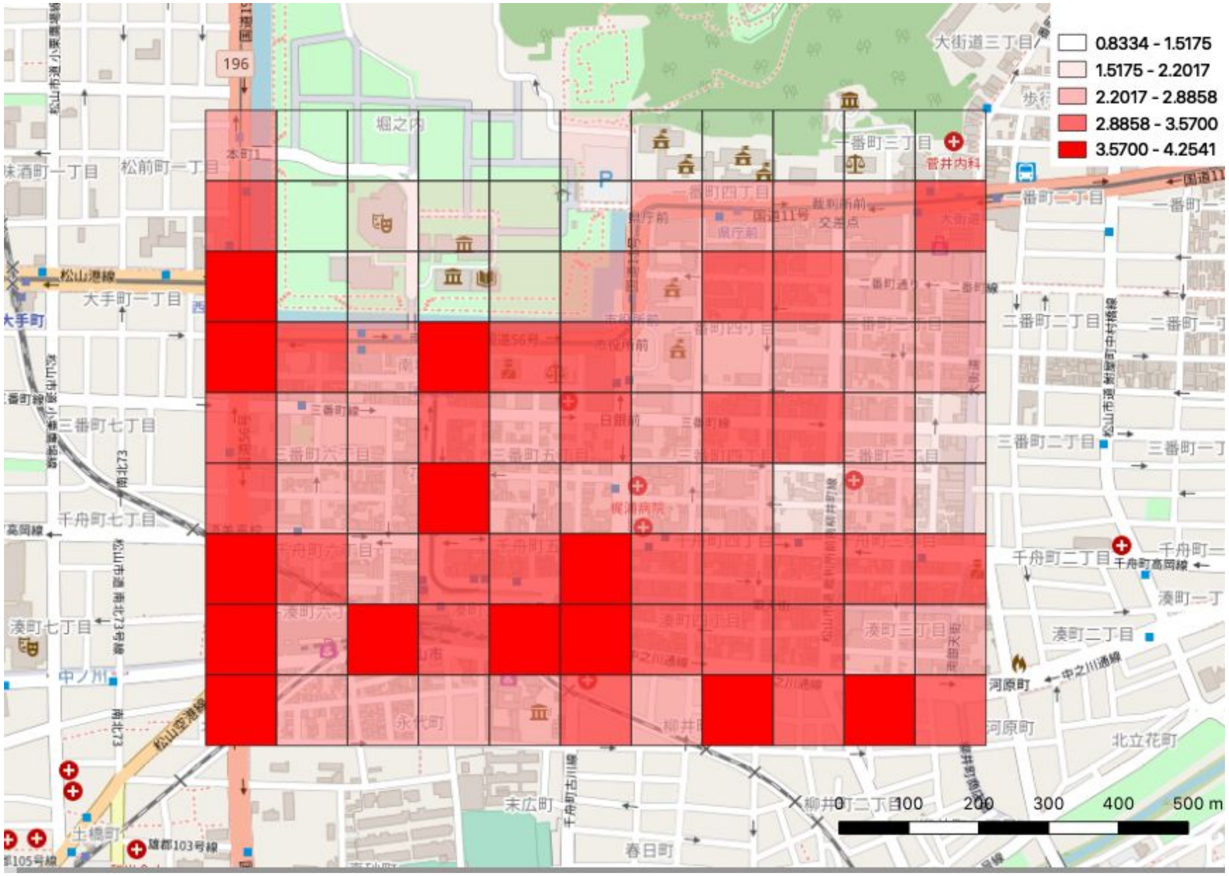


Policy Analysis

② Greenization of parking lots

* Assignment using Combinational Method

The instantaneous utility (Car) of image after Greenization



Changes in the instantaneous utility **in various areas**

Conclusion

- Estimation basing on Aerial Image and Satellite Image is proposed

- The proposed method has the almost same accuracy as the classical method

- with the combination of classical data and image data, improved fitness and interpretability coexist in the limited data

Appendix

Result ③: The Effect of Grid Size

mode = car, β = 0.1, method = ① RGB

Grid size	100m	t- value	75m	t- value	60m	t- value	50m	t- value
Ave.of Red	-51.06	-10.95	-55.36	-16.61	-47.04	-16.12	-40.28	-19.72
Ave.of Green	21.89	5.36	27.80	9.12	26.99	9.51	26.45	12.48
Ave.of Blue	30.76	10.99	31.97	14.70	25.78	13.94	19.73	12.67
S.D. of Red	0.341	0.046	34.12	6.60	11.73	2.42	15.68	4.40
S.D. of Green	71.016	7.23	19.76	2.64	46.17	6.95	27.71	6.16
S.D. of Blue	-64.907	-12.45	-57.30	-12.11	-64.28	-17.88	-50.44	-17.80
L0	-6146.3		-9076.44		-12270.29		-15079.38	
LL	-4713.8		-7291.87		-9838.06		-12274.72	
ρ-square	0.2331		0.1966		0.1982		0.1860	
Adjusted ρ-square	0.2321		0.1960		0.1978		0.1856	

Appendix

Result ③: The Effect of Grid Size

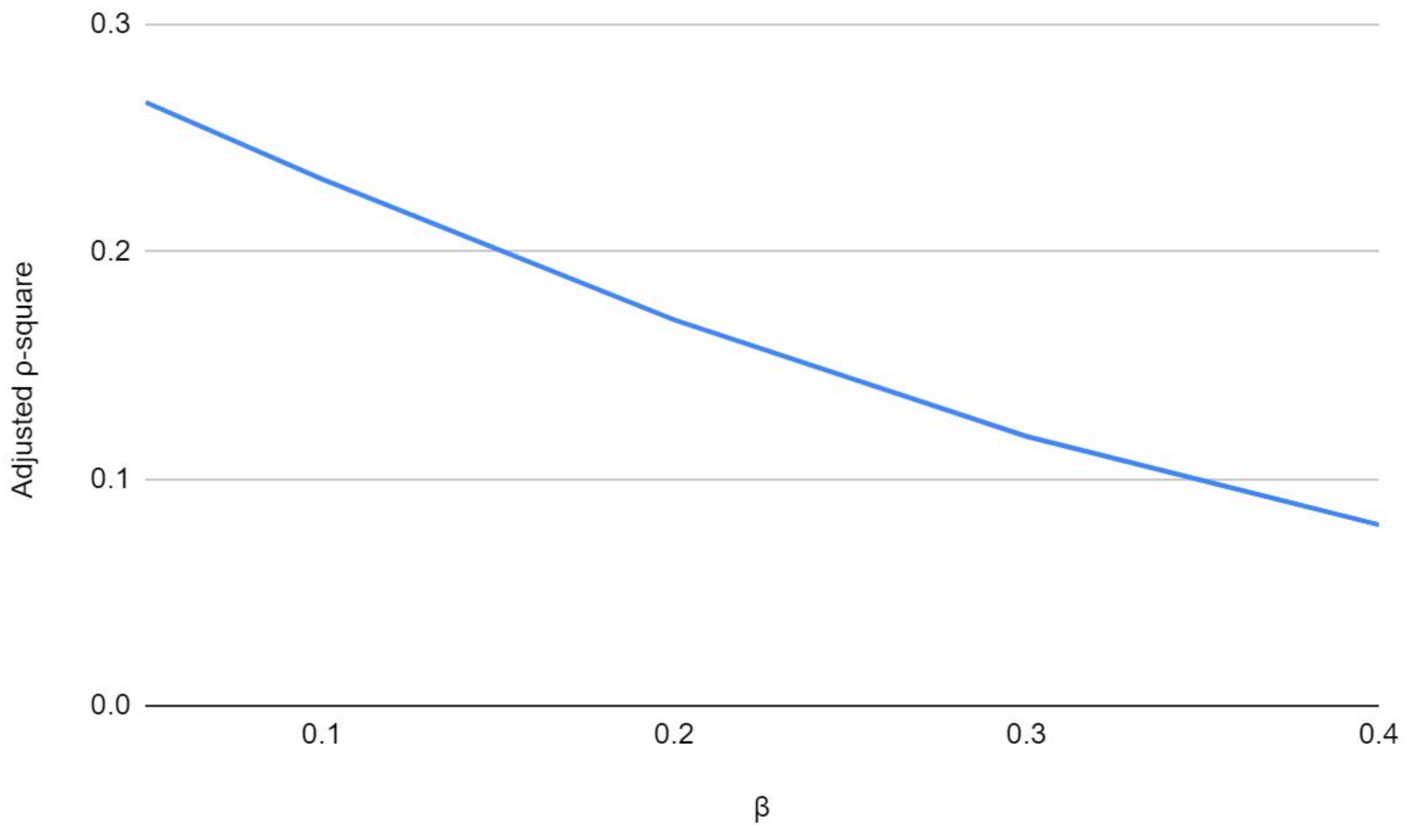
mode = walk, β = 0.1, method = ① RGB

Grid size	100m	t- value	75m	t- value	60m	t- value	50m	t- value
Ave.of Red	-5.04	-0.79	1.18	-0.79	-17.11	-4.85	-10.59	-3.63
Ave.of Green	5.82	0.88	1.83	0.88	19.04	4.28	5.22	1.35
Ave.of Blue	5.63	1.53	3.85	1.53	2.69	1.00	11.97	5.19
S.D. of Red	-14.71	-1.44	-45.22	-1.44	1.70	0.25	16.23	2.85
S.D. of Green	24.26	1.72	78.48	1.72	19.29	1.95	8.65	1.13
S.D. of Blue	-4.67	-0.61	-32.04	-0.61	-2.93	-2.98	-25.65	-5.42
L0	-2379.12		-3791.01		-5184.53		-6503.12	
LL	-1860.71		-3000.08		-4175.75		-5225.44	
ρ-square	0.2179		0.2086		0.1946		0.1965	
Adjusted ρ-square	0.2154		0.2071		0.1934		0.1955	

Appendix

Comparison of the Time Discount Rate β

mode = car, grid = 100m, method = ③ RGB



Appendix

Comparison of the Time Discount Rate β

mode = car, grid = 50m, method = ③ RGB