The new modelling method in urban development between land use and energy consumption: case study in Rotterdam

Hungchu (Rainbow) Chen, Bauke de Vries, Qi Han

Design Systems Group/ Eindhoiven University of Technology, the Netherlands

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Research Question

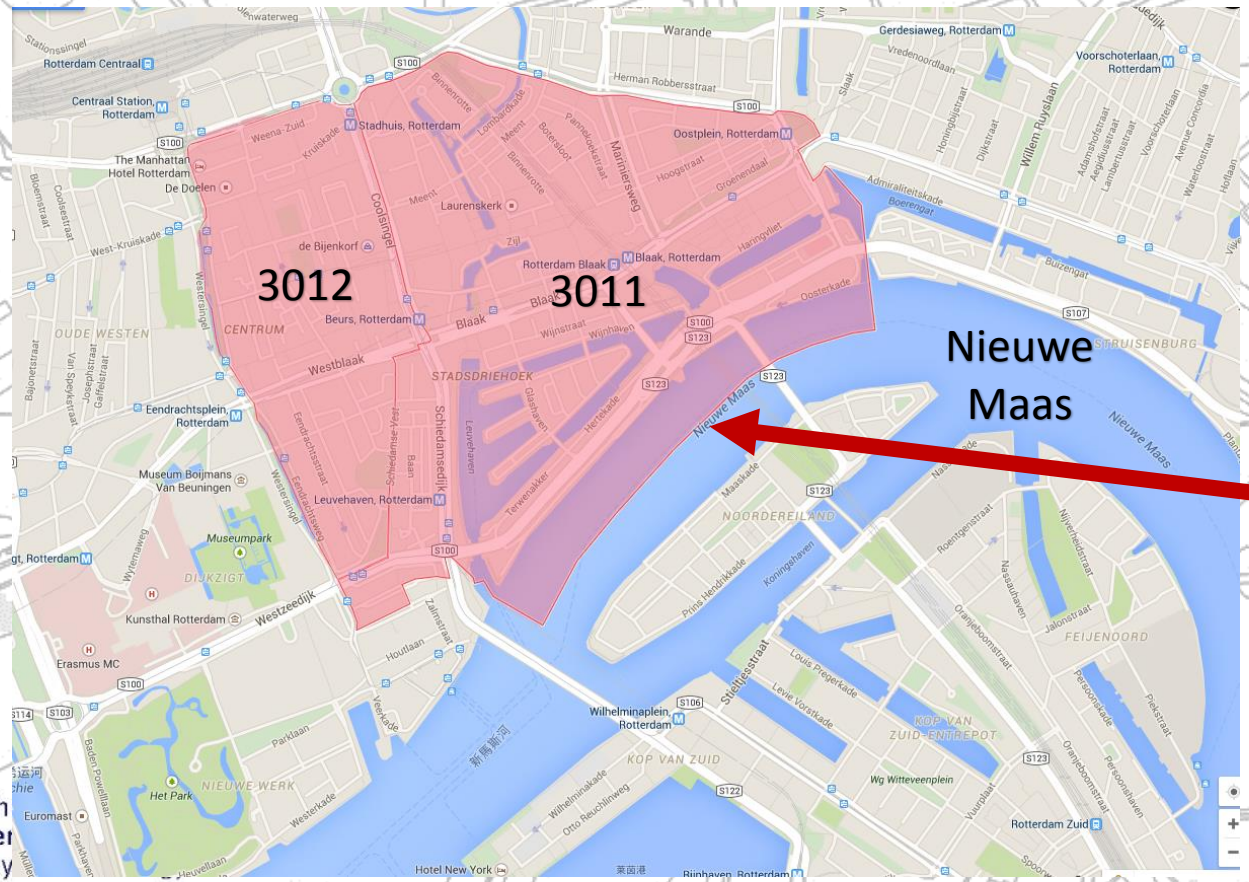
How can we plan the land use in a more sustainable way under the concern of temperature and energy consumption?

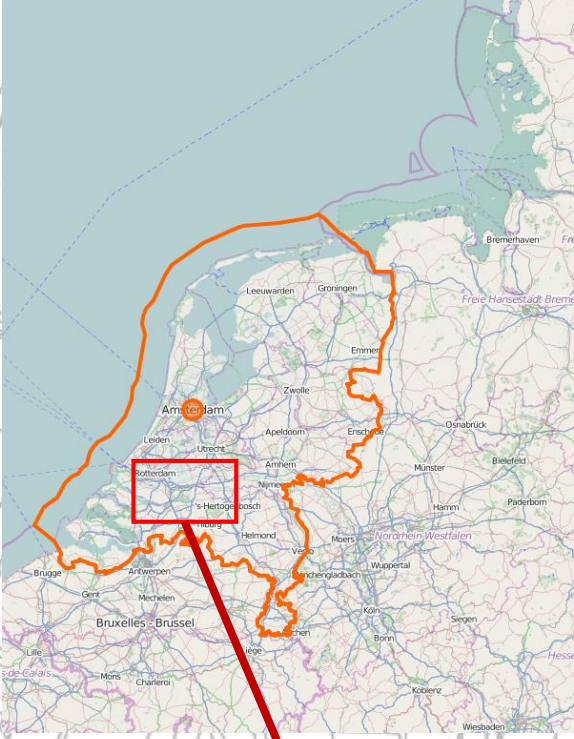
- City landscape structures & temperature change
- Optimal urban land use pattern (lowering the temperature & energy)
- Surface & layout changes (reduce UHI)
- A simulation tool (optimal land use pattern + balance between strategies)

Research Area

Rotterdam: 51°55”51’N, 4° 28”45’E

Zip code: 3011, 3012





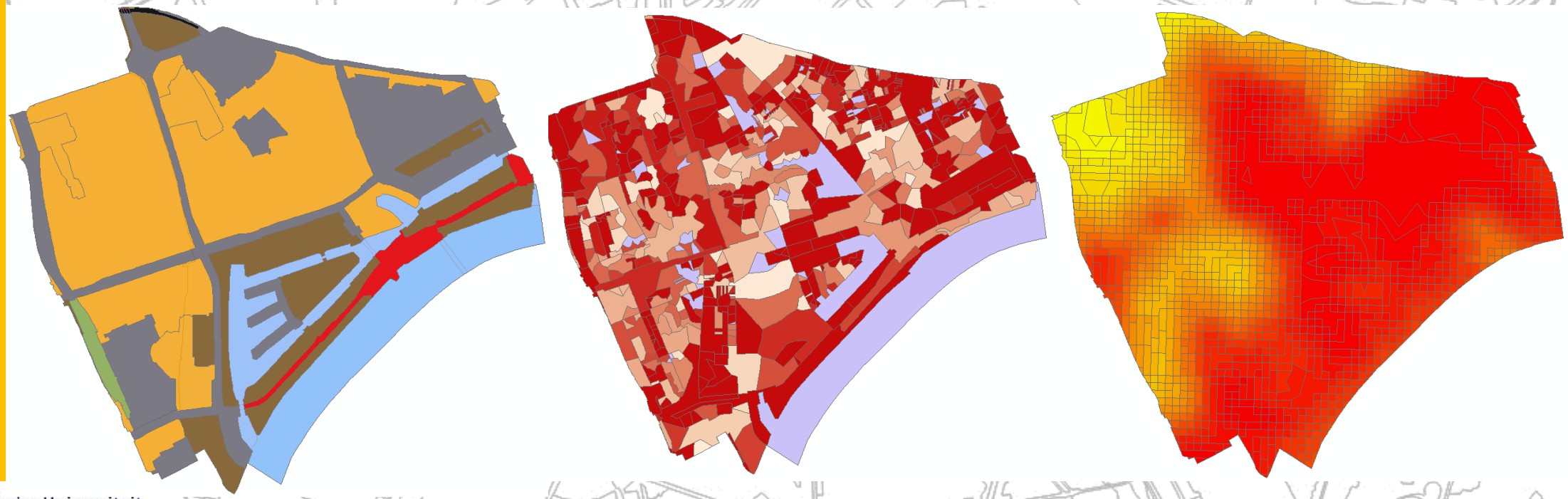
Source: Open Street Map

Land use & Energy & Temperature

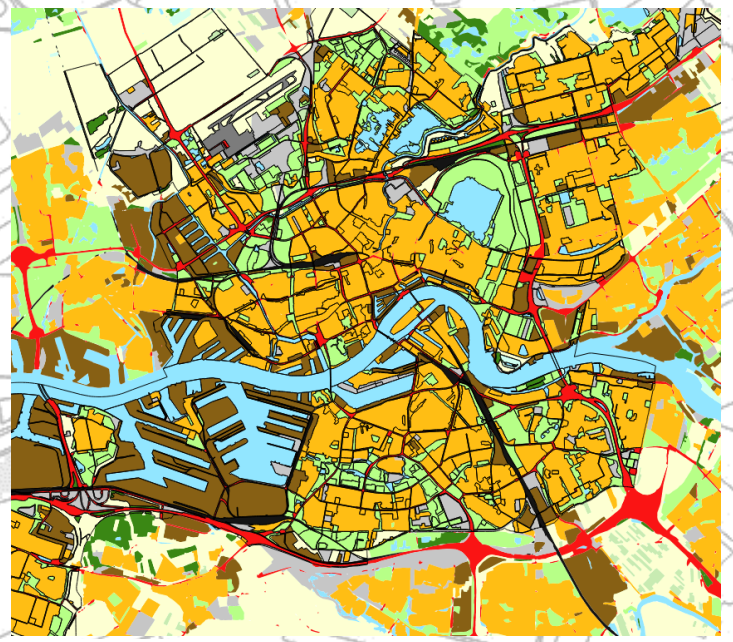
Land use (L): DANS (Data Archiving Networked Services)

Energy Consumption (E): City of Rotterdam

Temperature (T): Landsat-USGS

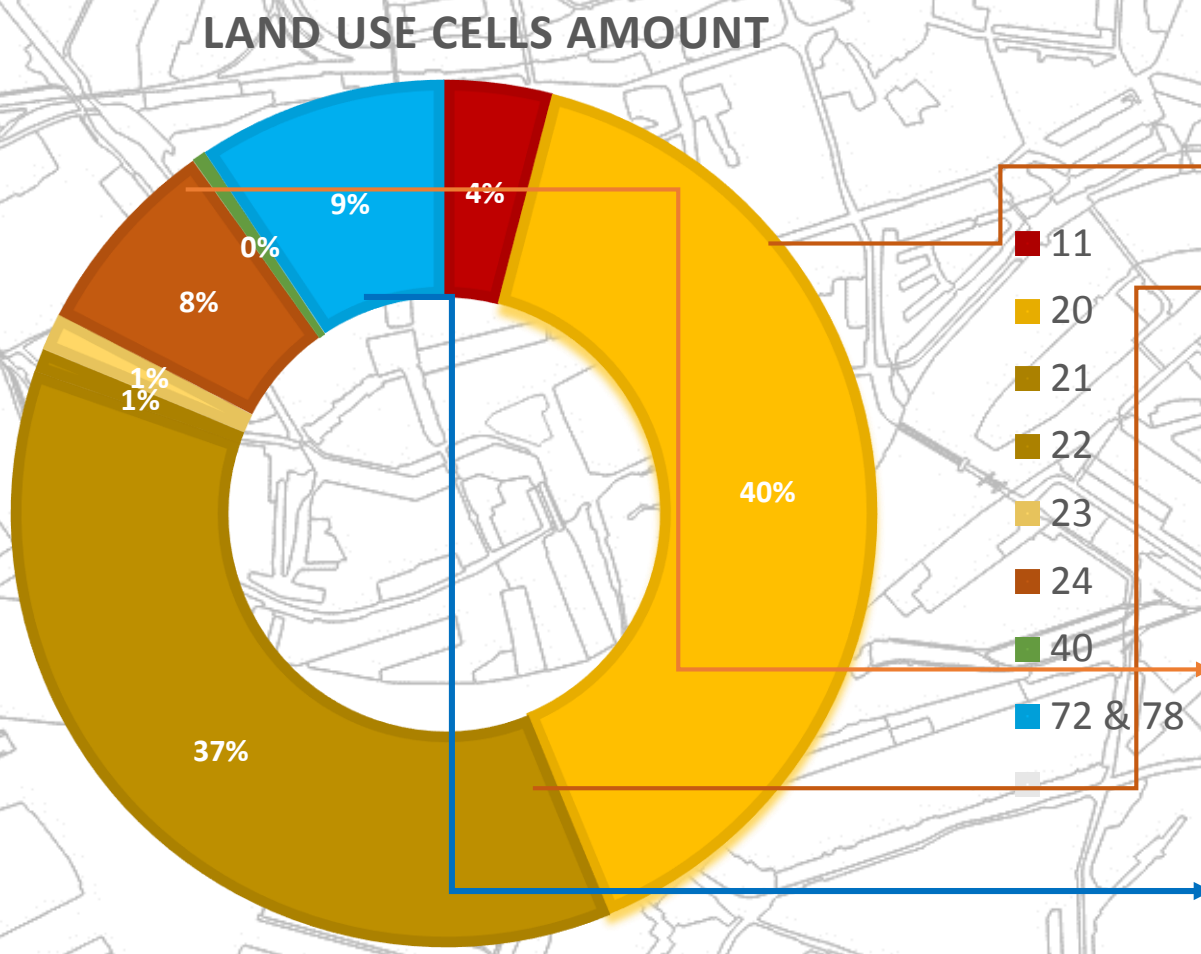


Land Use



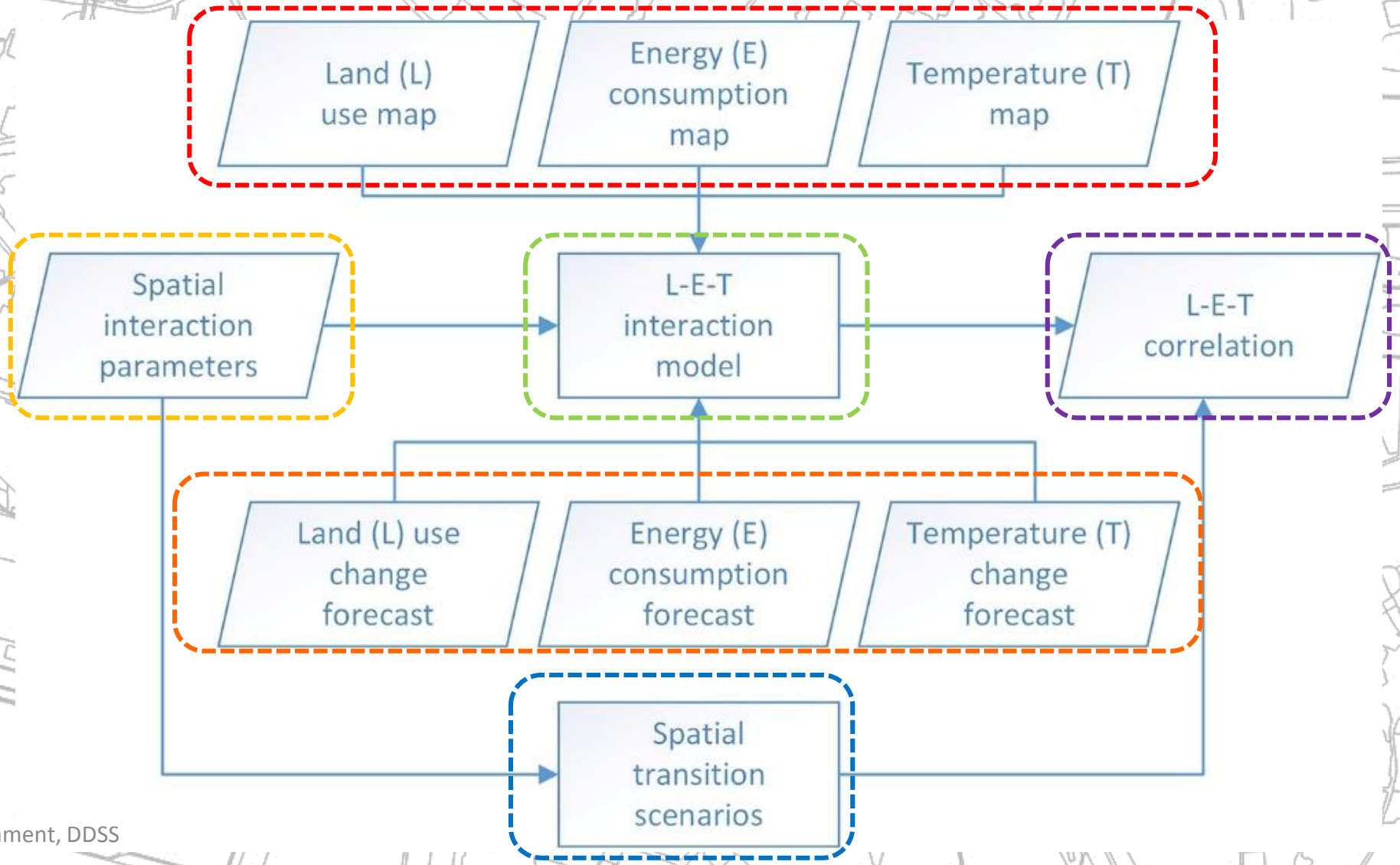
Coding group	Coding	Land use type	Coding group	Coding	Land use type
1	10	Rail area	5	50	Greenhouse cultivation
	11	Road area		51	Other agricultural area
	12	Airport	6	60	Forest
2	20	Residential area		61	Natural area, dry
	21	Retail and bars		62	Natural area, wet
	22	Public facilities	7	70	Ijsselmeer
	23	Social & cultural		71	Closed sea
	24	Industrial areas		72	Rijn & Maas
3	30	Dump		73	Border lake
	31	Wreck/storage place		74	Water winning area
	32	Cemetry		75	Water area for leisure
	33	Mineral production place		76	Enclosed water for mineral production
	34	Construction area		77	Overflow area
	35	Other open space		78	Other water
4	40	Park	8	80	Wadden sea, Eems, Dollard
	41	Sport		81	Oosterschelde
	42	Comminuty garden		82	Westerschelde
	43	Leisure (short stay)		83	North sea
	44	Leisure (long stay)	9	90	Foreign country

Land Use

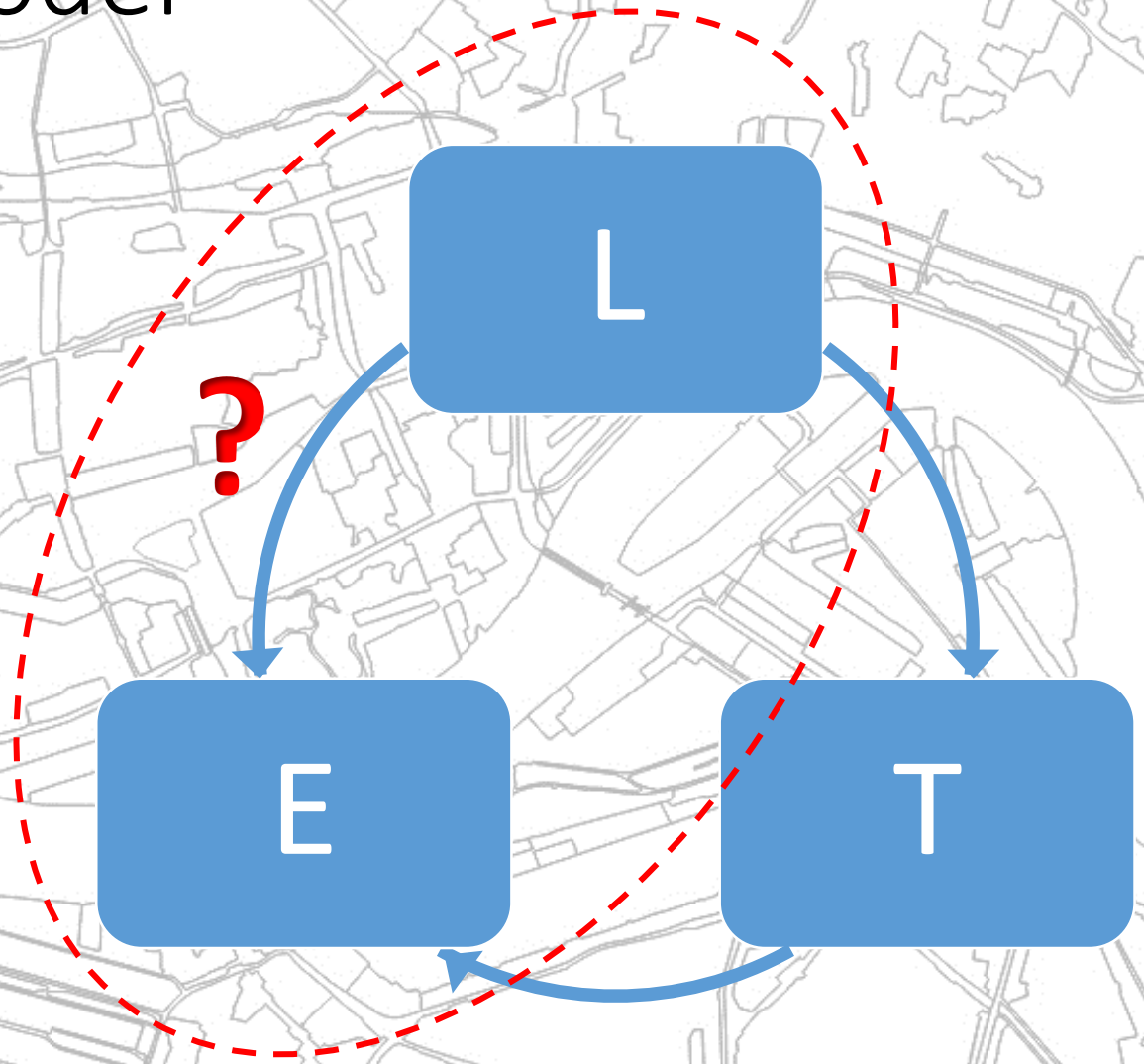


LAND USE	CODE	AMOUNT
Road area	11	23
Residential area	20	226
Retail and bars	21	208
Public facilities	22	5
Social/cultural facilities	23	8
Industrial areas	24	43
Park	40	3
Water	72& 78	53
Total		569

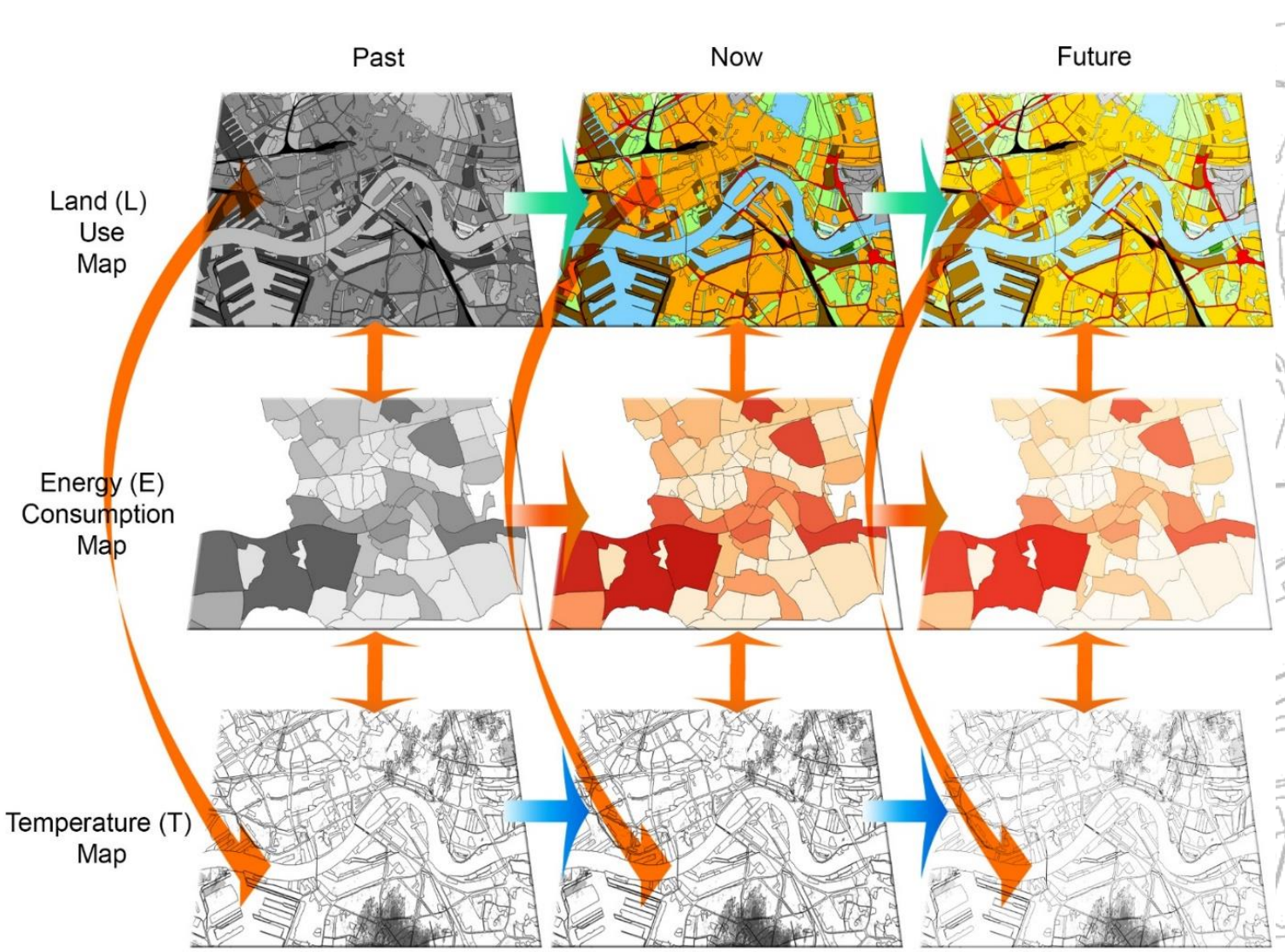
Research Framework



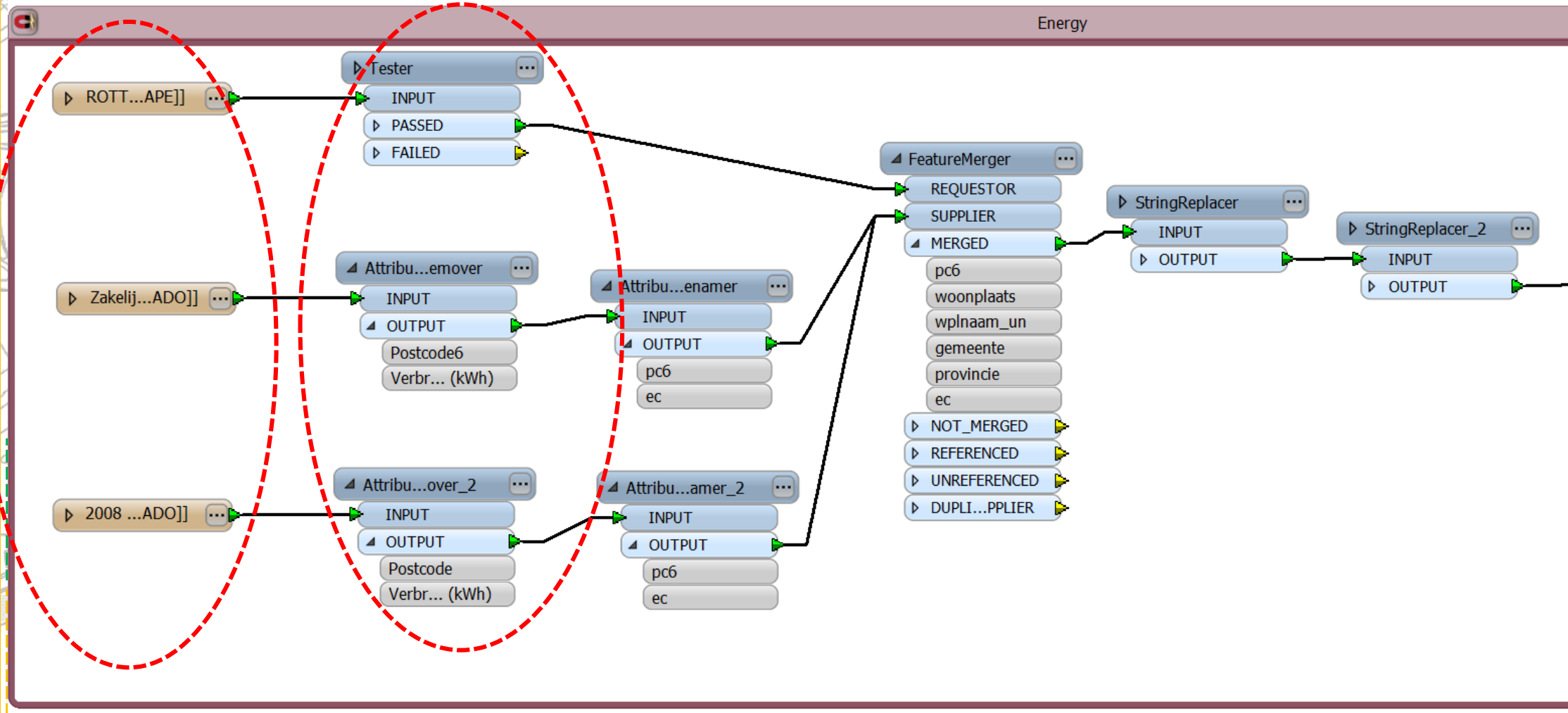
L-E-T Model



L-E-T Model


Past
Now
Future
Land (L) Use Map
Energy (E) Consumption Map
Temperature (T) Map

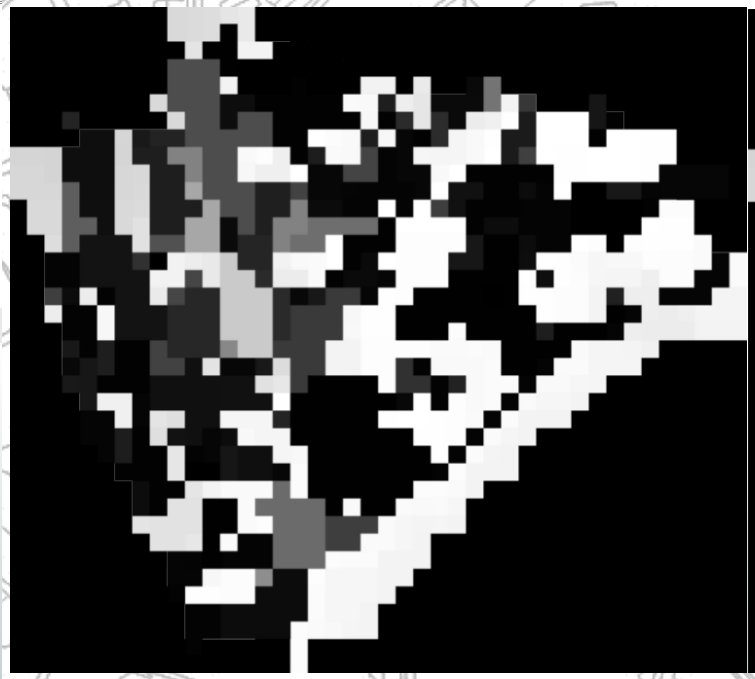
FME (File Management Engine)

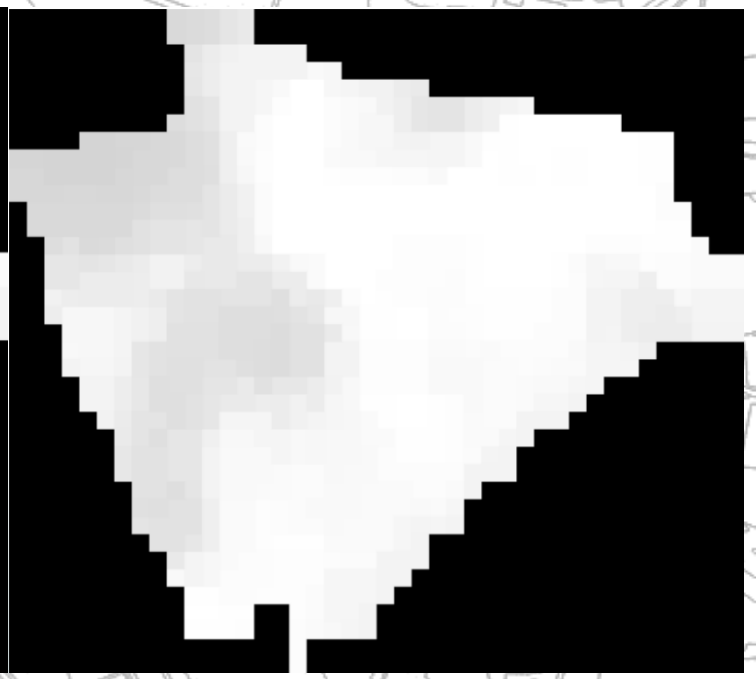


FME

Cell size: 50*50 m^2

Selected Area: 25,075 m^2

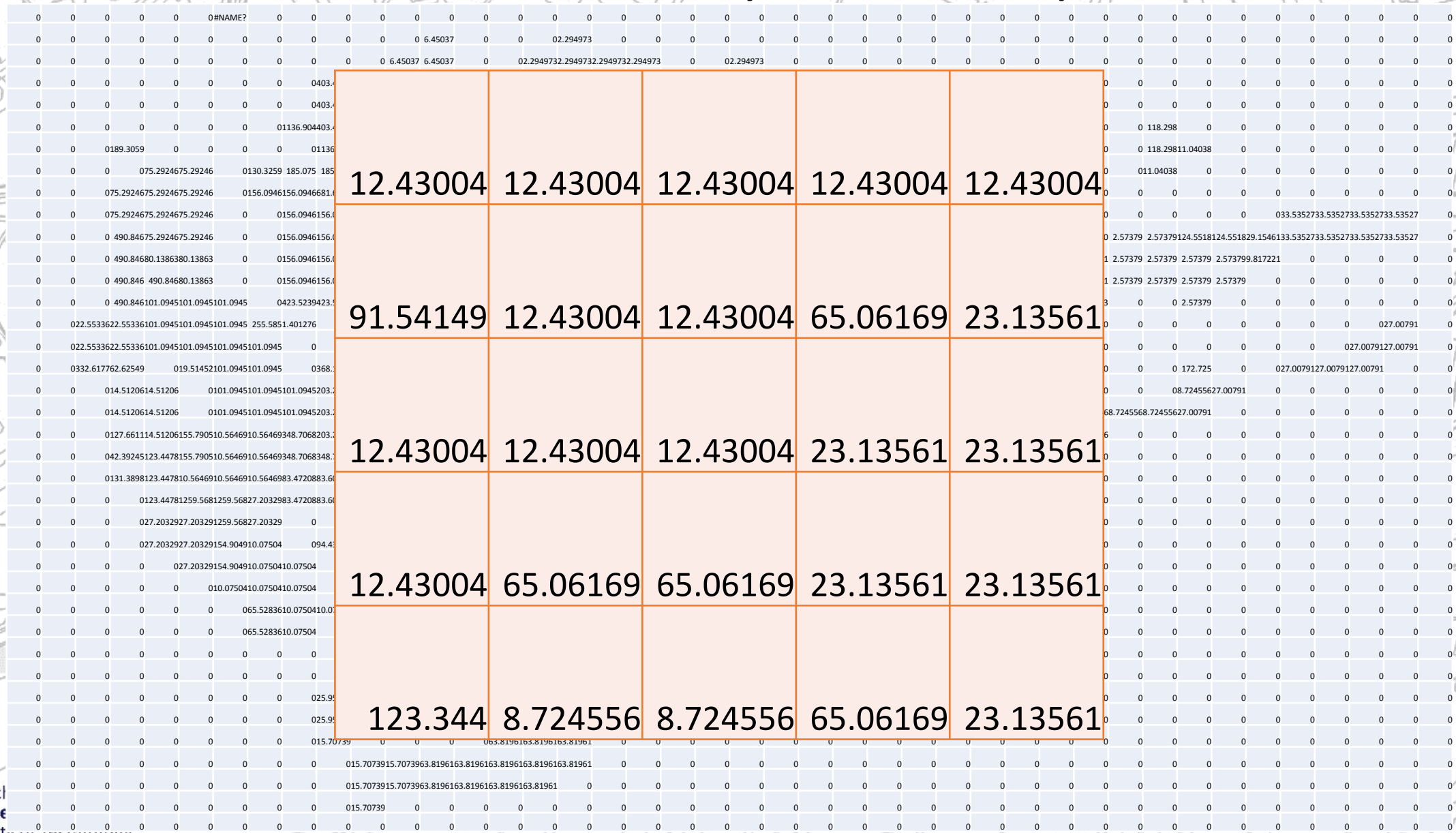




FME to Excel- Land Use

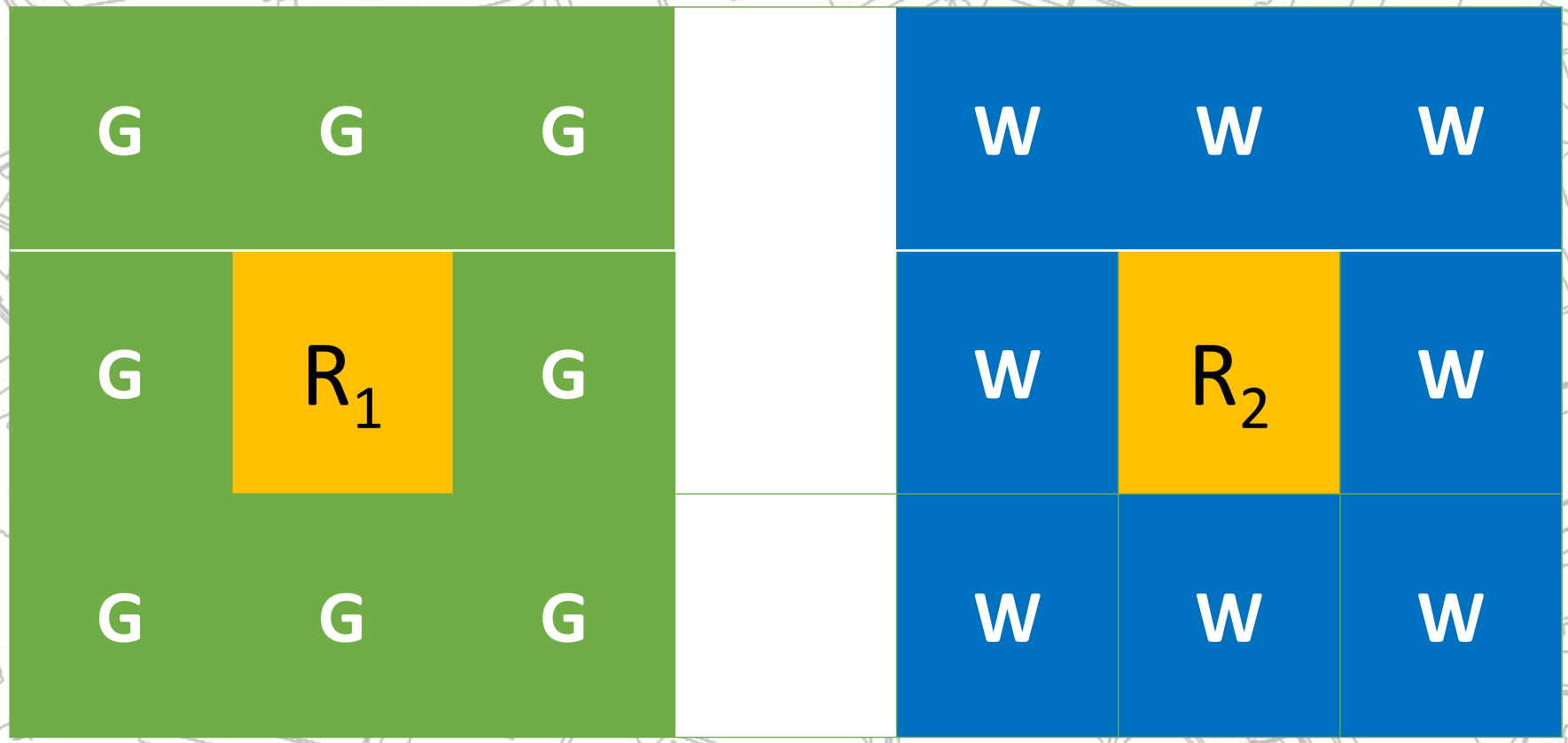
20	20	20	20	20
21	20	20	20	20
21	20	20	20	20
21	20	20	20	24
20	20	78	21	20

FME to Excel- Electricity Consumption



Hypothetical Model

Difference between R_1 and R_2 ?



Algorithm

$$y = \beta_1 x_1 + \beta_2 x_2$$

y : *natural logarithm of electricity consumption in central cell*

β_1 : *electricity consumption regression correlation of central land use to central cell*

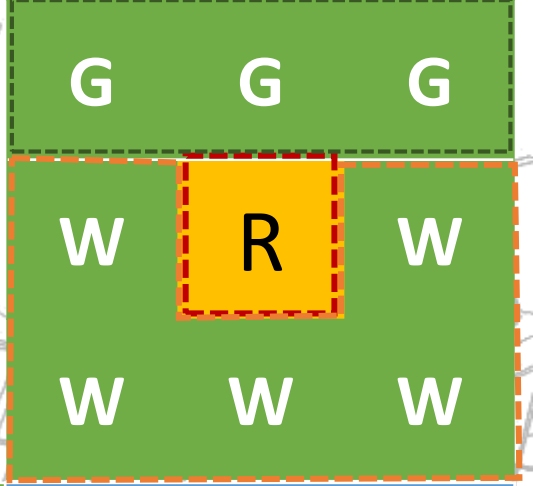
β_2 : *electricity consumption regression correlation of neighboring land use to central cell*

x_1 : *land use % of central cell*

x_2 : *land use % of neighboring cell*

Algorithm-example

$$y = \beta_1 x_1 + \beta_2 x_2$$



		Residential	Green	Water
y	*natural logarithm of electricity*			
β_1	*regression correlation of central cell*	*regression correlation of residental to residential*		
β_2	*regression correlation of neighboring cell*		*regression correlation of green to residential*	*regression correlation of water to residential*
x_1	*land use % of central cell*	1	0	0
x_2	*land use % of neighboring cell*	0	3/8	5/8

Regression Modelling

High significance define:
R square > 0.2
test>1.96 or t test<-1.96
p value < 0.05

Regression Statistics	
Multiple R	0.491332652
R Square	0.241407775
Adjusted R Square	0.219419595
Standard Error	1.544699589
Observations	569

Regression Modelling

High significance define:
R square > 0.2
test>1.96 or t test<-1.96
p value < 0.05

β_1 : correlation coefficient of central land use

β_2 : correlation coefficient of neighbouring land use

Land use	code	β_1	β_2
Road area	11	10.52885	-0.66383
Residential area	20	9.396524	-0.24409
Retail and bars	21	10.83827	-0.00795
Public facilities	22	13.73704	0.303195
Social cultural facilities	23	10.27889	-0.16988
Industrial areas	24	10.48764	-0.15209
Park	40	9.622928	-1.06544
Water	72& 78	7.794501	-0.34353

Regression Modelling-central

High significance define:
R square > 0.2
test>1.96 or t test<-1.96
p value < 0.05

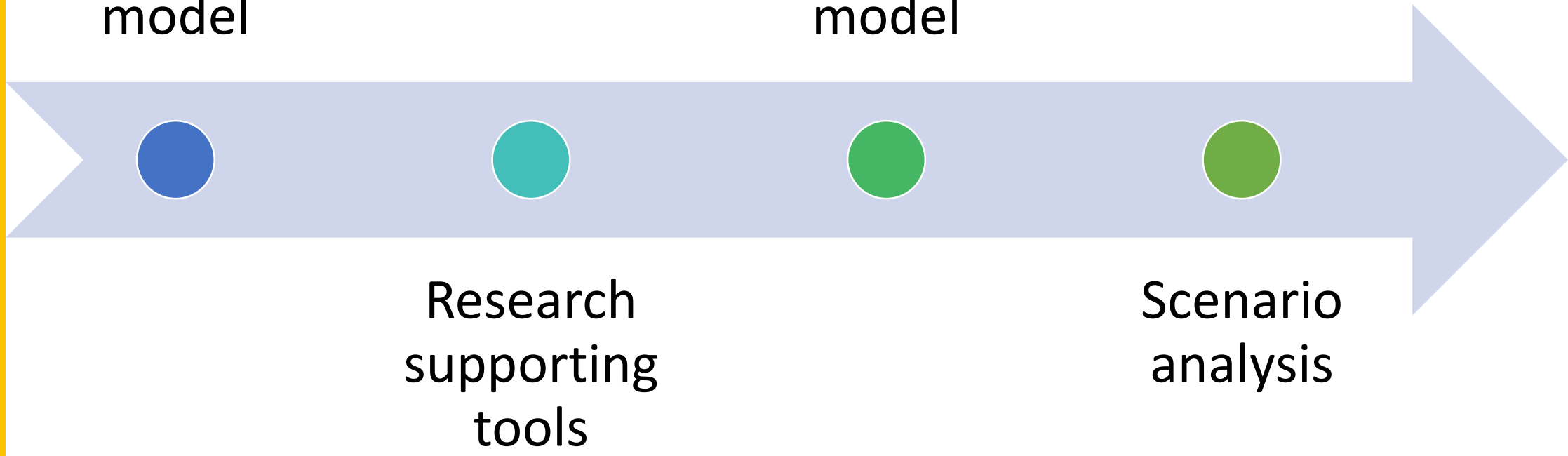
	x_1	Coefficients (β_1)	Standard Error	t Stat	P-value
	11/C	-0.663831548	1.599193	-0.4151	0.678227
Road area	**20/C**	-0.244085855	1.60822	-0.15177	0.879421
Residential area	**21/C**	-0.007954989	1.620318	-0.00491	0.996085
Retail and bars	**22/C**	0.303194934	1.817922	0.166781	0.867603
Public facilities	**23/C**	-0.169884075	1.728524	-0.09828	0.921743
Social cultural facilities	**24/C**	-0.152090499	1.581986	-0.09614	0.923445
Industrial areas	**40/C**	-1.065437898	1.858563	-0.57326	0.566703
Park	**72.78/C**	-0.343528329	1.571168	-0.21865	0.827007

Regression Modelling-neighboring

High significance define:
R square > 0.2
test>1.96 or t test<-1.96
p value < 0.05

	x_2	Coefficients (β_2)	Standard Error	t Stat	P-value
	Intercept	-5.855241964	4.9628	-1.17983	0.238578
Road area	**11**	10.52884566	4.767451	2.208485	0.027621
Residential area	**20**	9.396524327	4.686032	2.00522	0.045427
Retail and bars	**21**	10.83826509	4.690315	2.310776	0.021213
Public facilities	**22**	13.73704354	4.897517	2.8049	0.005211
Social cultural facilities	**23**	10.27889124	4.802743	2.140213	0.032775
Industrial areas	**24**	10.4876404	4.789716	2.189616	0.02897
Park	**40**	9.622928113	4.86789	1.976817	0.04856
Water	**72.78**	7.794500563	4.708256	1.655496	0.098392

Further steps



Thank you for your attention

Q & A