

Parametric Modelling with GIS

Assoc. Prof. Patrick Janssen

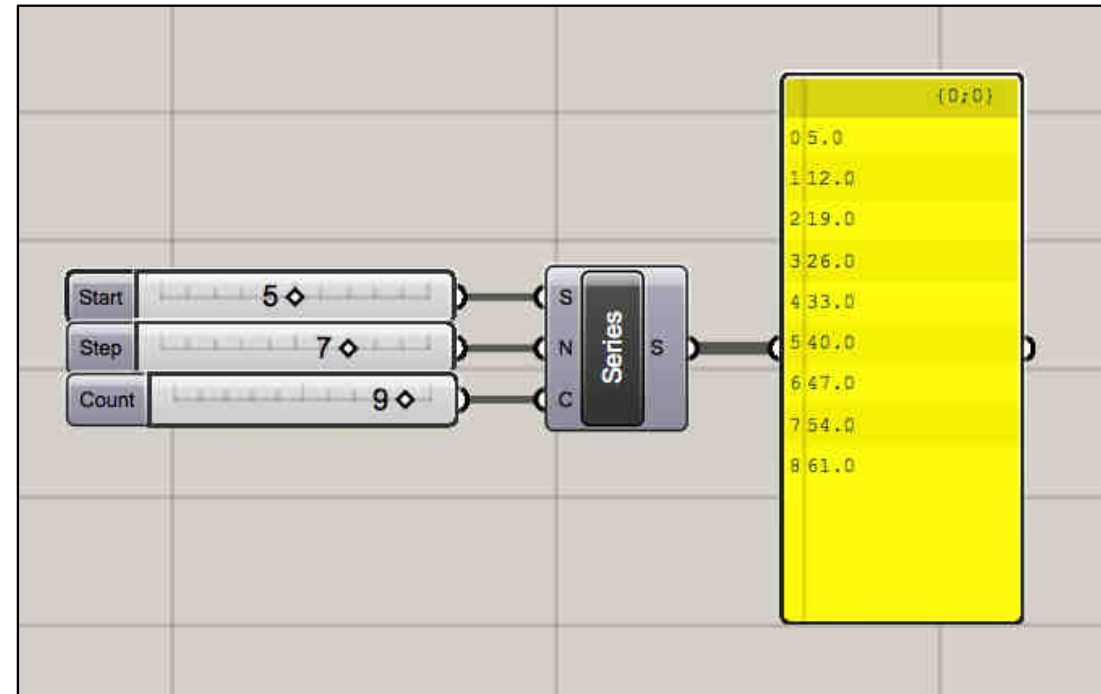


- **Background**
- Möbius
- Case Study
 - Stage 1: Geographic Mapping in QGIS
 - Stage 2: Parcel Subdivision in Möbius
 - Stage 3: Parameter Generation in QGIS
 - Stage 4: Urban Model Generation in Möbius
 - Stage 5: Spatial Analysis in QGIS
- Future Research

Background

- Support iterative design generation and performance analyses at an urban scale
- Workflows capable of integrating:
 - geographic mapping
 - parametric modelling
- Parametric modelling
 - no attribute data!
 - no explicit looping!

7303	99.13398829170	0.00000000000	C	NULL	19029000	10811002	1061811
7313	72.85598929740	0.00000000000	C	NULL	18979000	12691835	1242508
7318	-46.62501998040	0.00000000000	C	NULL	18845000	10021295	1152294
7221	77.23000402720	4.00000000000	C	Changed feature...	15925000	7630213	674739
7311	121.43550467800	0.00000000000	C	NULL	14987000	14608512	1680357
7316	88.32467565810	4.00000000000	1	Name changed. ...	14787000	4631392	778371
7248	90.40857946670	5.00000000000	C	Changed scale ra...	12797394	7000940	1489553
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7310	31.24996821970	0.00000000000	C	NULL	11893000	7734614	1372055
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7280	135.46014481500	4.00000000000	C	Changed feature...	11294000	2592413	963078
7306	116.38828568400	0.00000000000	C	NULL	11105000	7480601	903323
7274	120.98221718200	0.00000000000	C	NULL	11100000	3077575	238128
7302	376.1552282590	0.00000000000	C	NULL	10452000	10452000	1058538



- Background
- **QGIS - Möbius**
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Möbius

- A parametric modeller in the browser
- Can import and export GIS data (GeoJson, Shp)
- Supports:
 - attribute data
 - iterative loops
- <http://files.design-automation.net/mobius-dev/mobius.html>

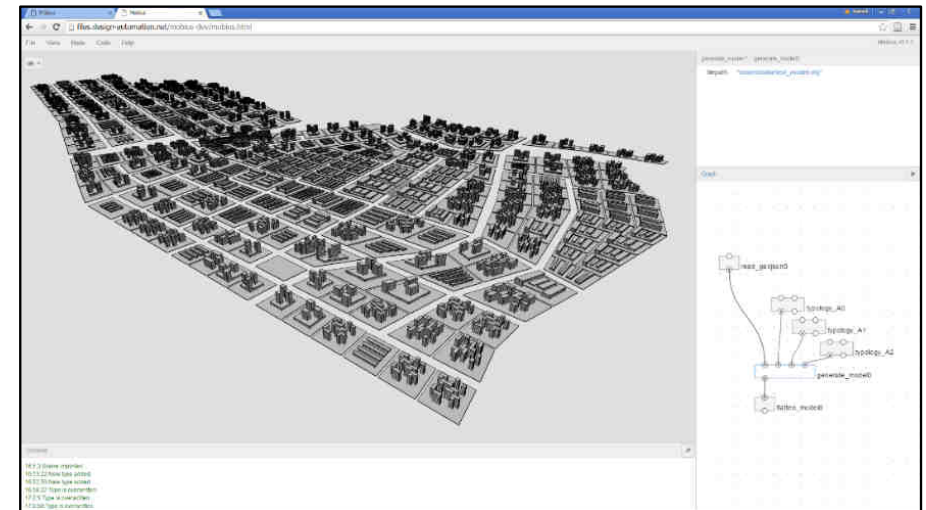
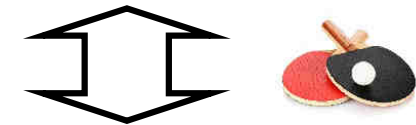
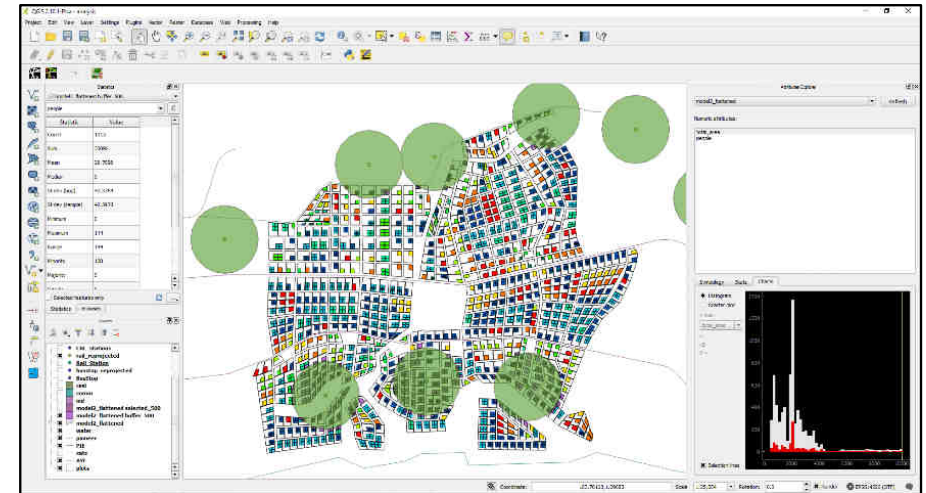
The image displays the Möbius web application interface. At the top, a 3D perspective view of a city model is shown, with buildings and streets rendered in a grey and white color scheme. Below this, a table displays GIS data with columns for 'id', 'belongs to', 'Parcel ID', 'Plot ID', 'Floors', and 'Coverage'. The table contains 18 rows of data. To the right of the table, a visual programming interface (VPL) is shown, featuring a flowchart with nodes for 'read_geojson0', 'typology_A0', 'typology_A1', 'typology', 'generate_model0', and 'flatten_model0'. A code editor window is open at the bottom right, showing JavaScript code for processing the data and generating the model.

id	belongs to	Parcel ID	Plot ID	Floors	Coverage
0	[0,0]	2	0	15	4
1	[0,1]	2	1	52	5
2	[0,2]	2	2	10	6
3	[0,3]	2	3	3	6
4	[0,4]	2	4	10	6
5	[0,5]	2	5	10	6
6	[0,6]	3	0	9	6
7	[0,7]	3	1	3	6
8	[0,8]	3	2	3	6
9	[0,9]	3	3	6	7
10	[0,10]	3	4	6	7
11	[0,11]	3	5	3	7
12	[0,12]	8	0	3	4
13	[0,13]	9	0	15	4
14	[0,14]	9	1	15	4
15	[0,14]	10	0	15	4
16	[0,14]	11	0	15	4
17	[0,17]	11	1	15	4
18	[0,18]	11	2	15	5

```
for each i in seq
  plot = all_plots[i]
  centre = obj.getCentre ( plot )
  coverage = obj.getProperty ( plot , "coverage" )
  plot_id = obj.getProperty ( plot , "plot_id" )
  parcel_id = obj.getProperty ( plot , "parcel_id" )
  floors = obj.getProperty ( plot , "floors" )
  scaled_plot = trn.scale ( plot , GLOBAL , coverage/10 , coverage/10 , 1 , true )
  _ = trn.move ( scaled_plot , centre , false )
  shiftX = plot.points[0][0] - scaled_plot.points[0][0]
  shiftY = plot.points[0][1] - scaled_plot.points[0][1]
  _ = trn.shift ( scaled_plot , GLOBAL , -shiftX + 1 , -shiftY + 1 , 0 , false )
  area = srf.area ( scaled_plot )
  if .else.
    if area > 5000
      if .else.
        if floors > 6
          building = type_1(scaled_plot) building
        else
          building = type_2(scaled_plot) building
```

QGIS - Möbius

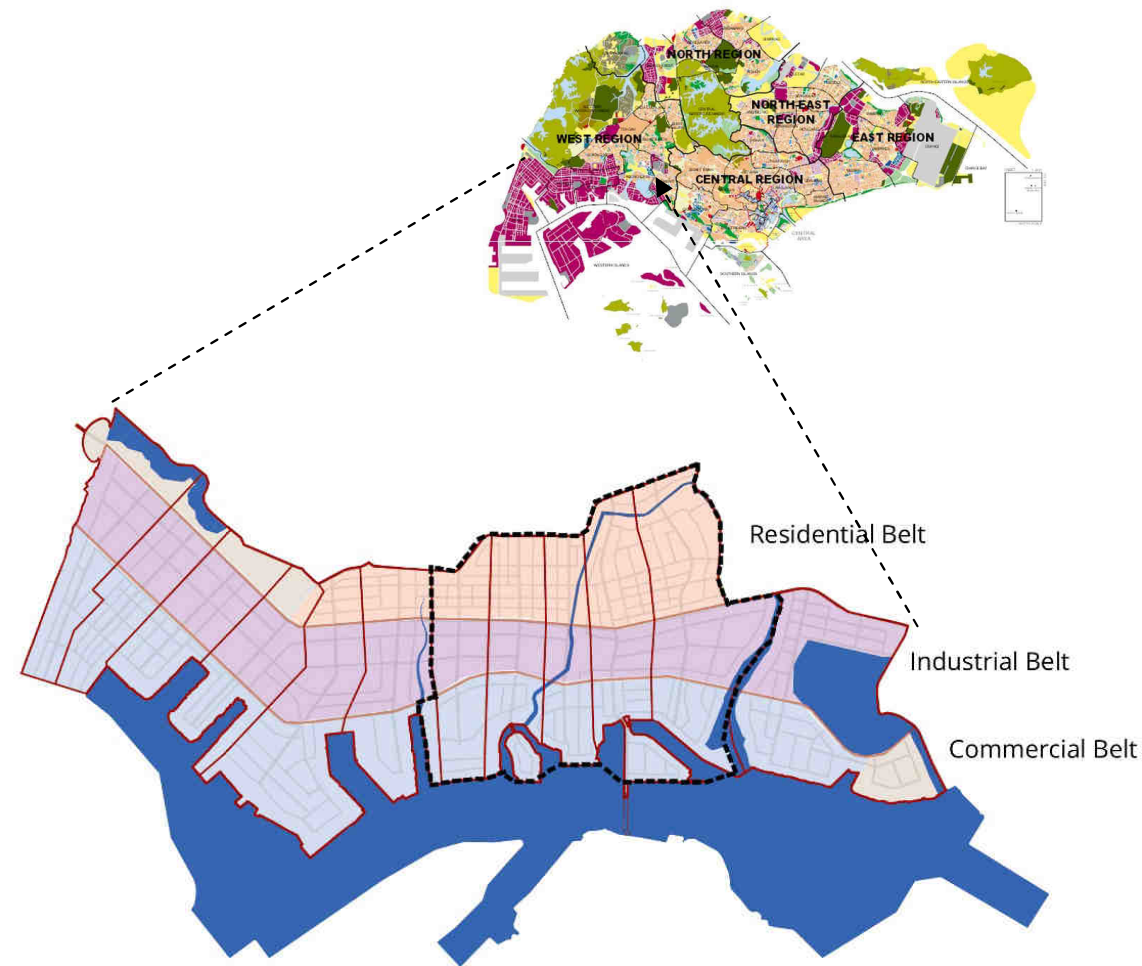
- A workflow that supports iterative generation and evaluation of large-scale urban models
- Alternates between QGIS and Möbius



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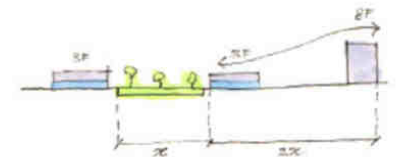
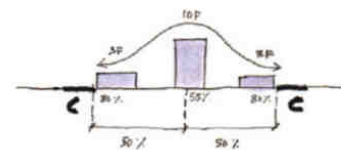
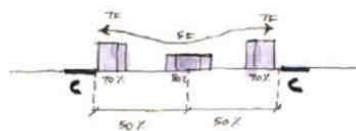
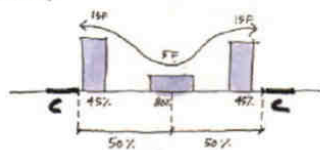
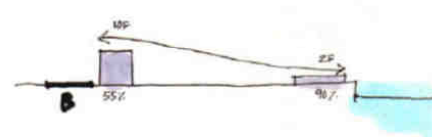
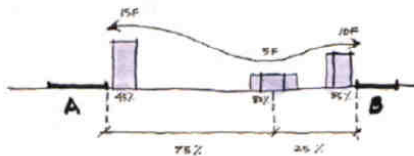
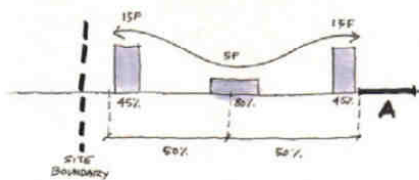
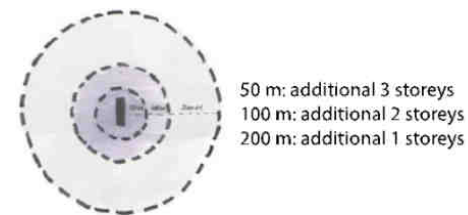
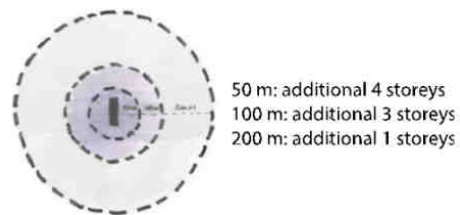
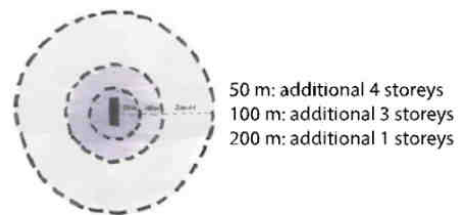
Case Study: 2050, 1 Million

- 5000 ha industrial area in the west of Singapore
- Green lungs, attractive housing and vibrant urbanity for one million people
- The case study focuses on one student project, called Ecotopia
 - Andrea Meinarti Rachmat
 - Tay Hui Ping Serene
 - Delon Leonard
 - Wu Xing Peng
 - Loh Sze Sian



Case Study

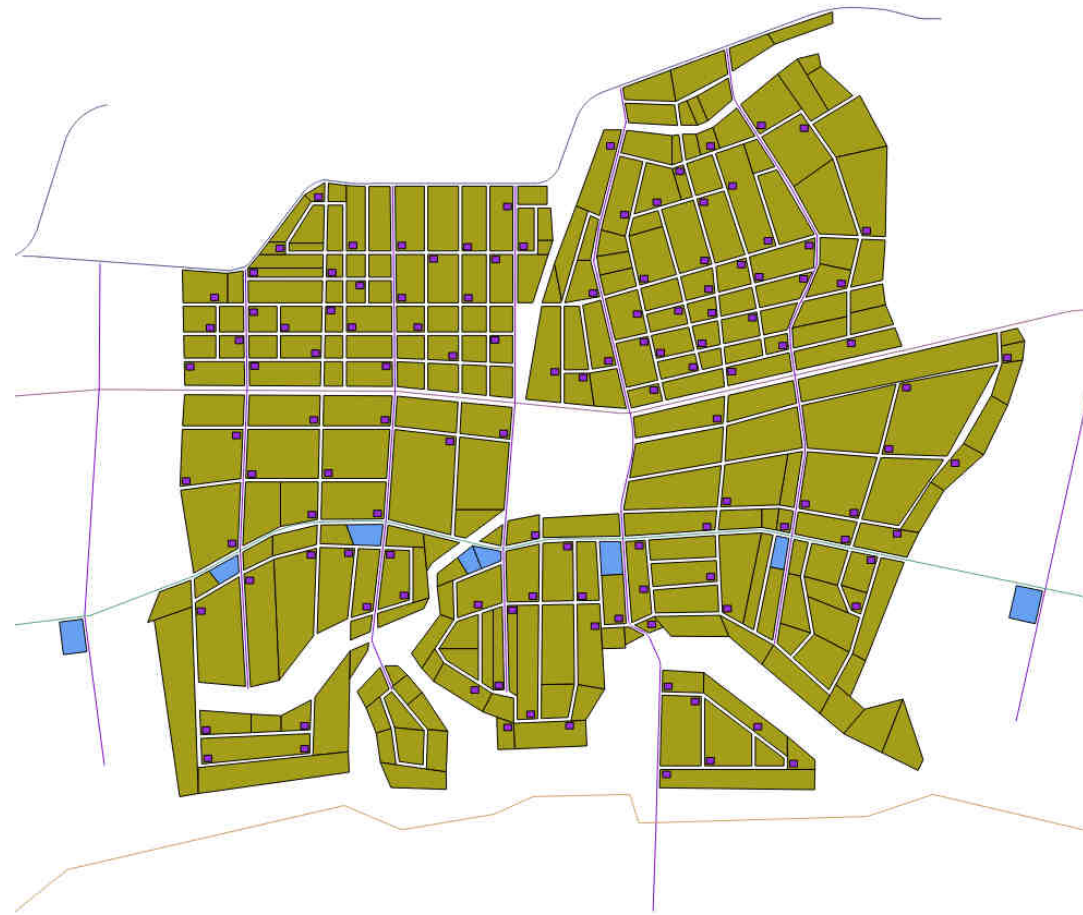
- Students developed a set of rules that defined urban parameters based on the proximity to various elements in the design



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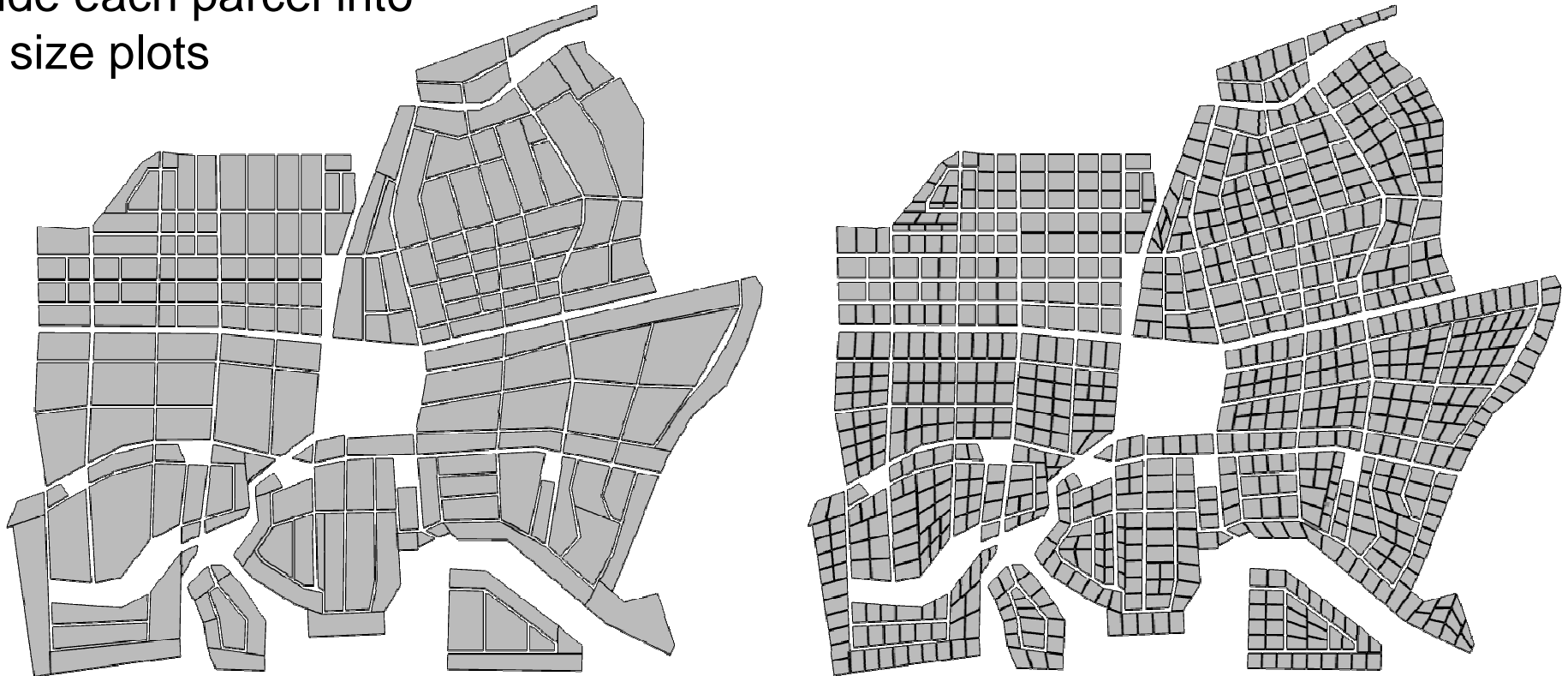
Stage 1: Geographic Mapping in QGIS

- QGIS is used to create a map of the site area using existing GIS data
- Map includes key features required for the rules
 - Coast line
 - Roads
 - Parks



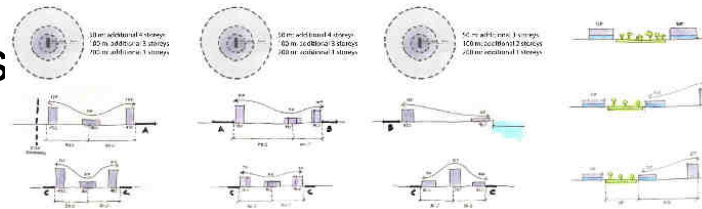
Stage 2: Parcel Subdivision in Möbius

- Möbius is used to recursively subdivide each parcel into similar size plots

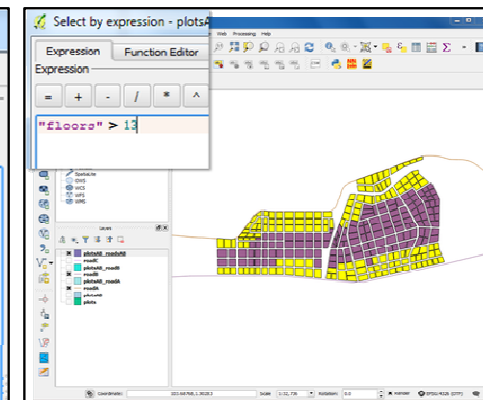
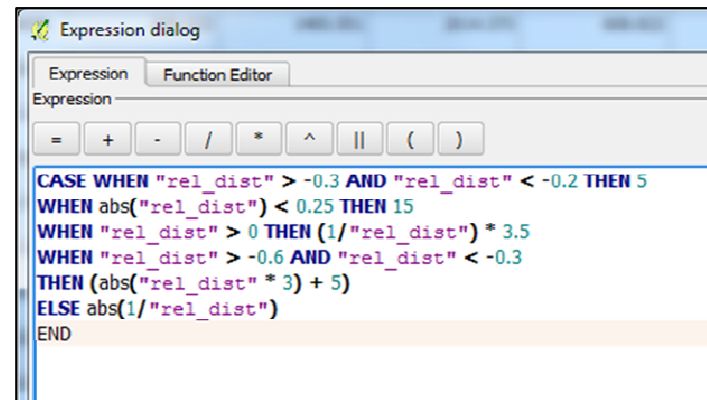


Stage 3: Parameter Generation in QGIS

- QGIS is used to create attributes that capture the spatial rules.



- proximity functions
- custom formulas

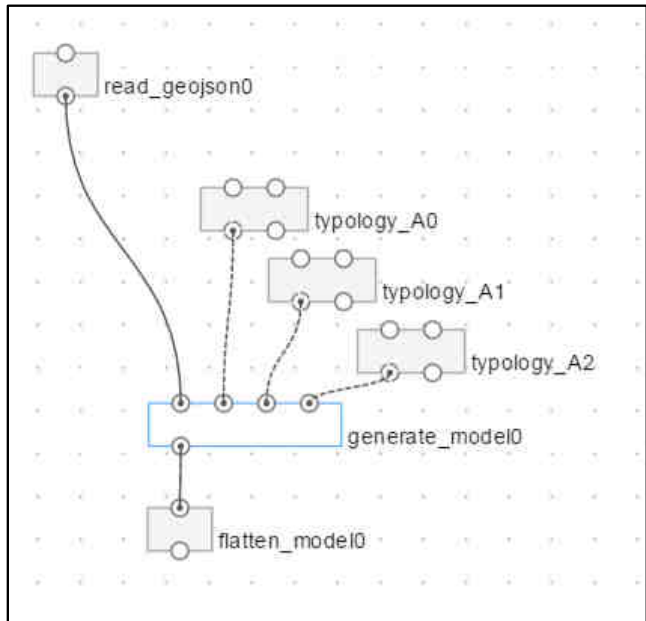


Attribute table - plots_with_attributes OGRGeoJSON Polygon - Features total: 321, filtered: 321, selected: 0

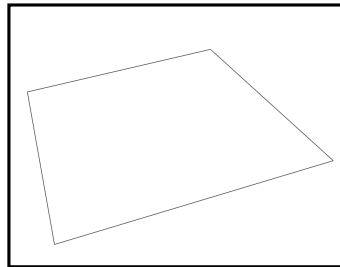
	catc_dist	park3_id	park3_dist	pionr_id	pionr_dist	water_id	water_dist	park2_id	park2_dist	PWtotal	PW	PWfloors	Cfloors	PWCfloors	floors	PWcverage	Ccverage	coverage
0	10	212.779521	257	16.506849	11	1129.668557	0	314.670453	8	1007.910151	1444.339	0.218	10	10	10	8.552	5.5	7.026
1	10	260.970644	256	34.933137	11	1135.297334	0	314.861798	9	1003.103273	1450.159	0.217	10	10	10	8.555	5.5	7.028
2	10	343.755014	255	0	11	1149.928561	0	317.134933	9	965.108865	1467.063	0.216	10	10	3	8.559	5.5	7.03
3	10	442.111932	255	0	8	1170.492188	0	319.408111	9	940.15403	1489.9	0.214	10	10	3	8.567	5.5	7.034
4	9	257.242161	41	443.279773	12	1289.013254	0	432.05063	8	1114.015949	1721.064	0.251	10	10	10	8.426	5.5	6.963
5	9	373.165405	13	455.814453	12	1397.842523	0	349.613919	8	1212.359893	1747.456	0.2	10	10	10	8.62	5.5	7.06
6	9	161.165093	41	266.679338	13	843.640252	0	718.16506	7	692.341452	1561.805	0.46	10	8	9	7.632	6.125	6.879

Stage 4: Urban Model Generation in Möbius

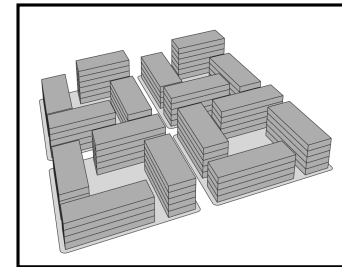
- Möbius is used to generate urban models using a library of parametric urban typologies.



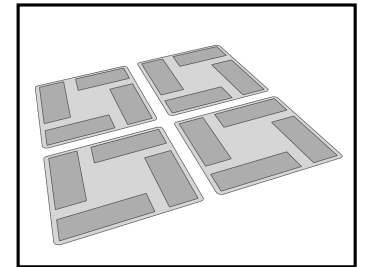
2D



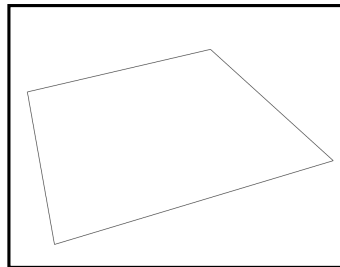
3D



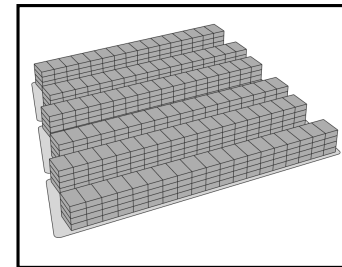
2D



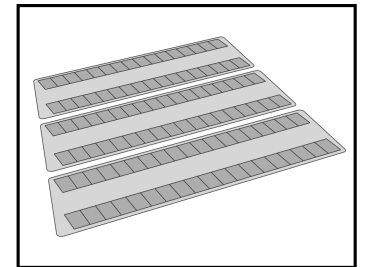
2D



3D



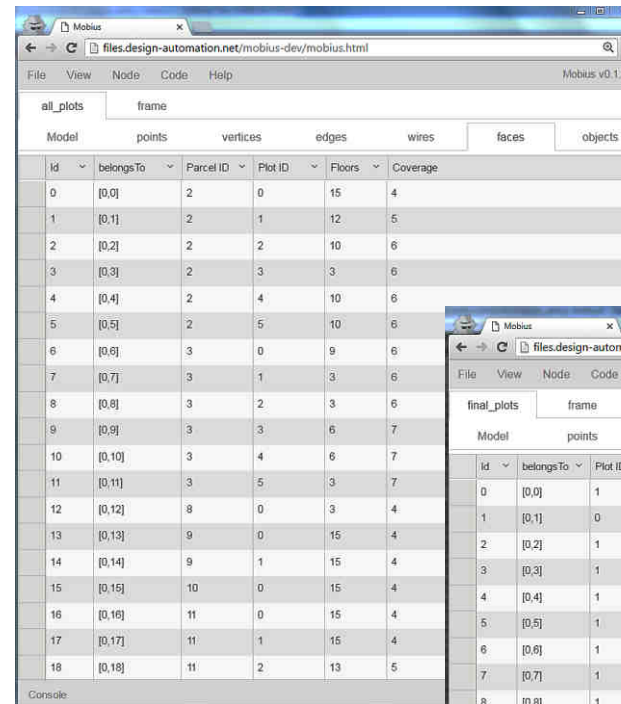
2D



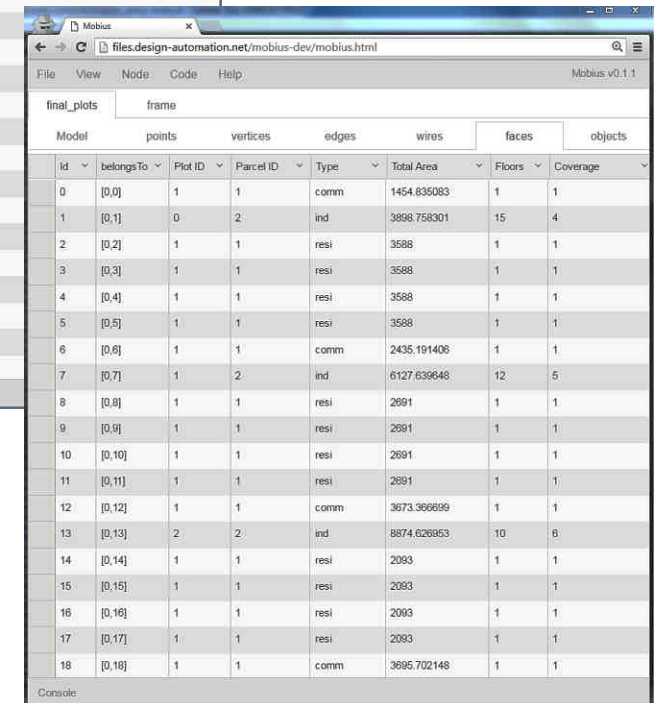
Stage 4: Urban Model Generation in Möbius

- Floor areas are saved as attributes attached to a 2D polygon.

- *residential area*
- *commercial area*
- *industrial area*

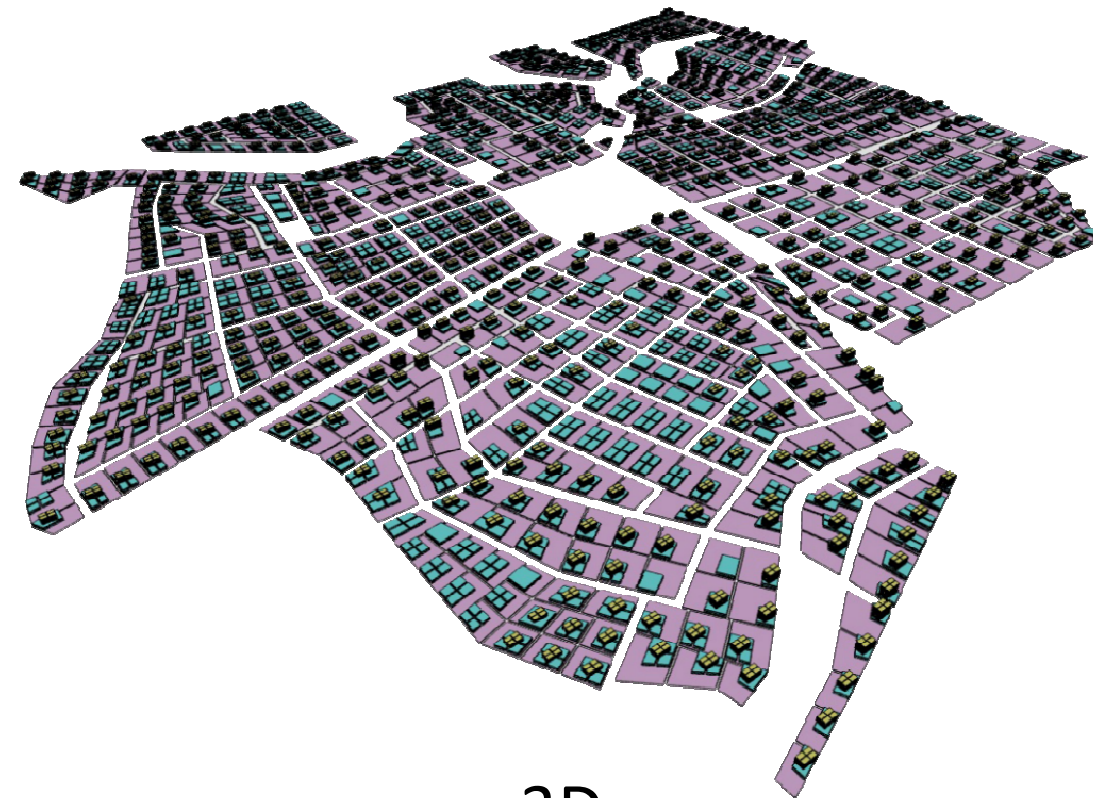


id	belongsTo	Parcel ID	Plot ID	Floors	Coverage
0	[0,0]	2	0	15	4
1	[0,1]	2	1	12	5
2	[0,2]	2	2	10	6
3	[0,3]	2	3	3	6
4	[0,4]	2	4	10	6
5	[0,5]	2	5	10	6
6	[0,6]	3	0	9	6
7	[0,7]	3	1	3	6
8	[0,8]	3	2	3	6
9	[0,9]	3	3	6	7
10	[0,10]	3	4	6	7
11	[0,11]	3	5	3	7
12	[0,12]	8	0	3	4
13	[0,13]	9	0	15	4
14	[0,14]	9	1	15	4
15	[0,15]	10	0	15	4
16	[0,16]	11	0	15	4
17	[0,17]	11	1	15	4
18	[0,18]	11	2	13	5



id	belongsTo	Plot ID	Parcel ID	Type	Total Area	Floors	Coverage
0	[0,0]	1	1	comm	1454.836083	1	1
1	[0,1]	0	2	ind	3898.758301	15	4
2	[0,2]	1	1	resi	3588	1	1
3	[0,3]	1	1	resi	3588	1	1
4	[0,4]	1	1	resi	3588	1	1
5	[0,5]	1	1	resi	3588	1	1
6	[0,6]	1	1	comm	2435.191406	1	1
7	[0,7]	1	2	ind	6127.639648	12	5
8	[0,8]	1	1	resi	2891	1	1
9	[0,9]	1	1	resi	2891	1	1
10	[0,10]	1	1	resi	2891	1	1
11	[0,11]	1	1	resi	2891	1	1
12	[0,12]	1	1	comm	3673.366899	1	1
13	[0,13]	2	2	ind	8874.626953	10	6
14	[0,14]	1	1	resi	2093	1	1
15	[0,15]	1	1	resi	2093	1	1
16	[0,16]	1	1	resi	2093	1	1
17	[0,17]	1	1	resi	2093	1	1
18	[0,18]	1	1	comm	3695.702148	1	1

Stage 4: Urban Model Generation in Möbius



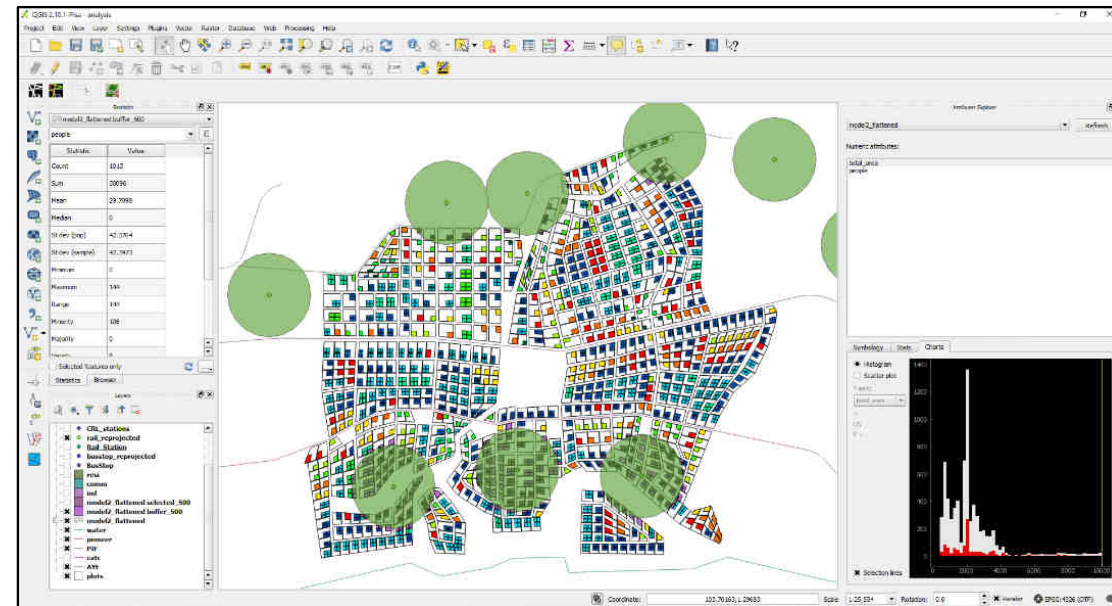
3D



2D + attributes

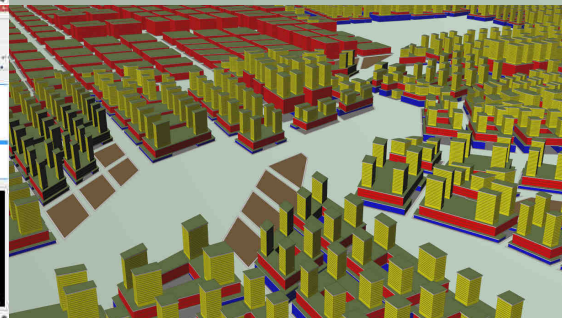
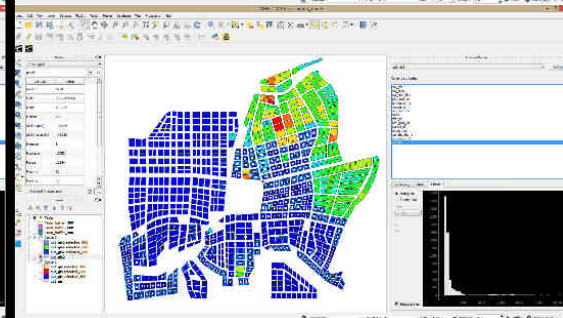
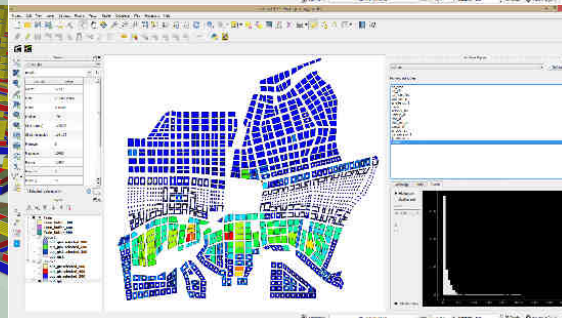
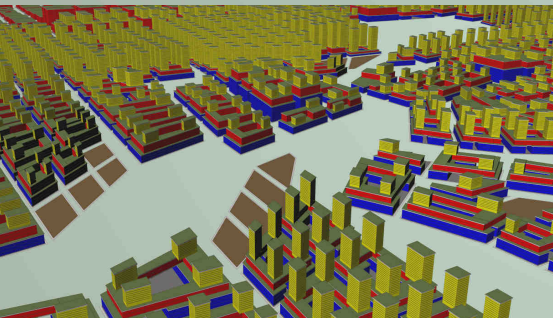
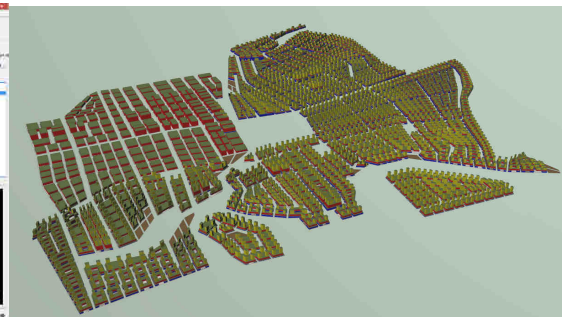
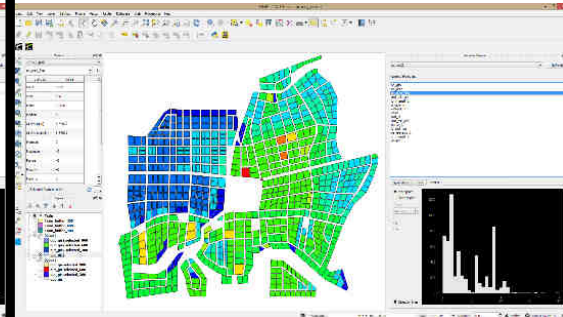
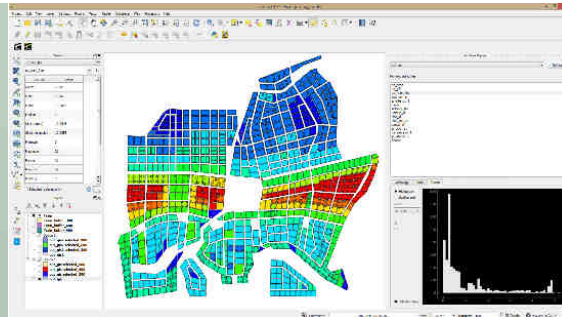
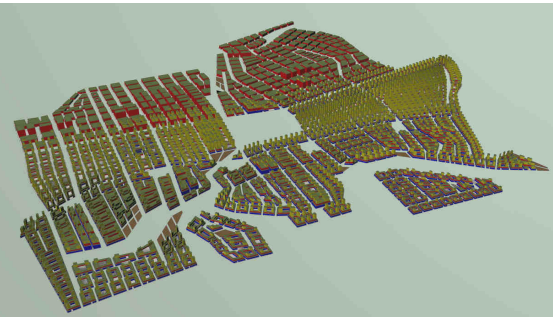
Stage 5: Spatial Analysis in QGIS

- QGIS is used to analyse the flattened map of the urban model.
- Additional attributes are created:
 - the number of people in each building
 - the percentage of people within a certain walking distance of transport nodes



Option 1

Option 2



Total (residents): 910,000
300m buffer: 1% of residents
600m buffer: 6% of residents
900m buffer: 14% of residents

Total (residents): 650,000
300m buffer: 2% of residents
600m buffer: 9% of residents
900m buffer: 20% of residents

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Future Research

- Explore the integration of a rule or grammar-based data synthesis method within the visual programming approach
- Thanks for listening!
- Collaborators
Assoc. Prof. Rudi Stouffs, NUS
- Research Assistants
Akshata Mohanty, NUS
Elvira Tan, NUS
Ruize Li, NUS
- Janssen, P., Stouffs, R., Mohanty, A., Tan, E., Li, R., 2016. Parametric Modelling with GIS, in: *Proceedings of the 33rd eCAADe Conference*. Oulu, Finland, pp. 59–68.