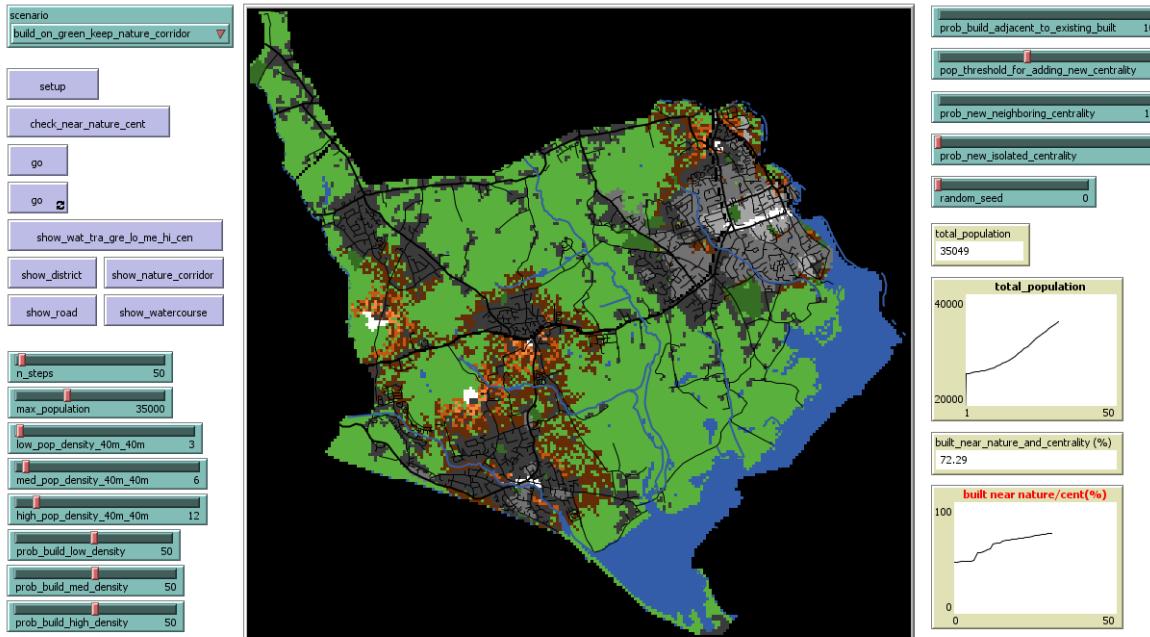


Lecture 3:

Isobenefit Urbanism Morphogenesis: Using Agent-Based Modelling (ABM) to Simulate Future Urban Growth of 15-minute Neighbourhoods



Dr Heeseo Rain Kwon

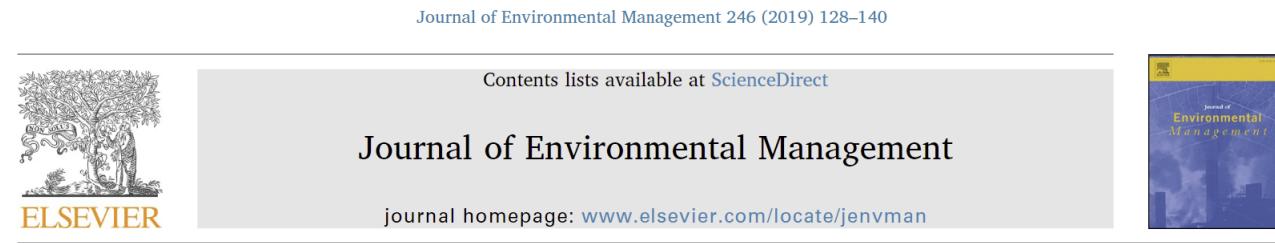
BSP Post-doctoral Research Fellow

Bartlett School of Planning, University College London

heeseo.kwon.10@ucl.ac.uk

Note: Slides are based on Kwon's postdoc research conducted at UCL in collaboration with Future Urban Growth Lab project led by Dr Tommaso Gabrieli.

What is Isobenefit Urbanism Morphogenesis?



Research article

A new type of cities for liveable futures.

Isobenefit Urbanism morphogenesis

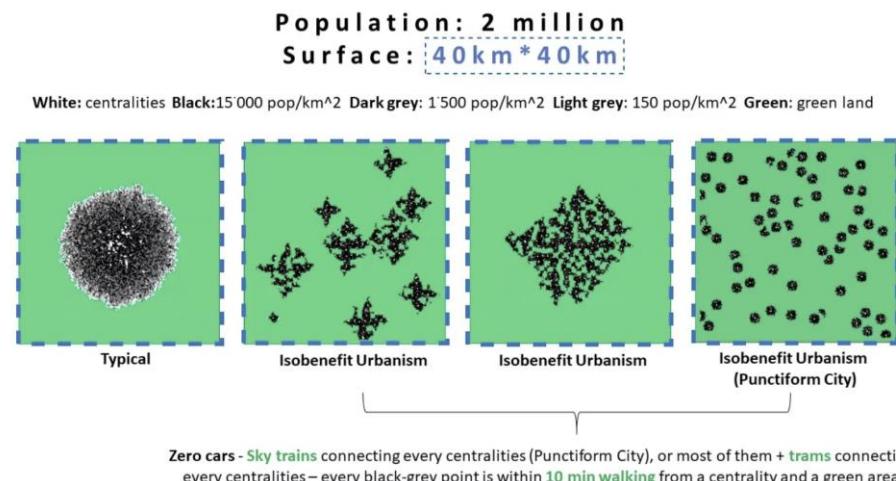
Luca D'Acci^{a,b}

^aPolitecnico di Torino, Interuniversity Department of Regional and Urban Studies and Planning, Italy

^bErasmus University Rotterdam, Erasmus School of Social and Behavioural Sciences, Netherlands

What I'm currently contributing:

- Reimplementing the Python codes on NetLogo
- Case study using real spatial data (New Forest, UK)
- Introducing new metrics that are important for the planners: e.g., housing and population target, ratio of housing that are within 1km of nature and centrality
- Seeking opportunities to extend currently CA model to a CA-ABM model by adding human decision-making element.



Source: D'Acci, 2020

We sketch the principles of *Isobenefit Urbanism*, the urban genotype, whose related phenotypes family can be called *Isotopia*:

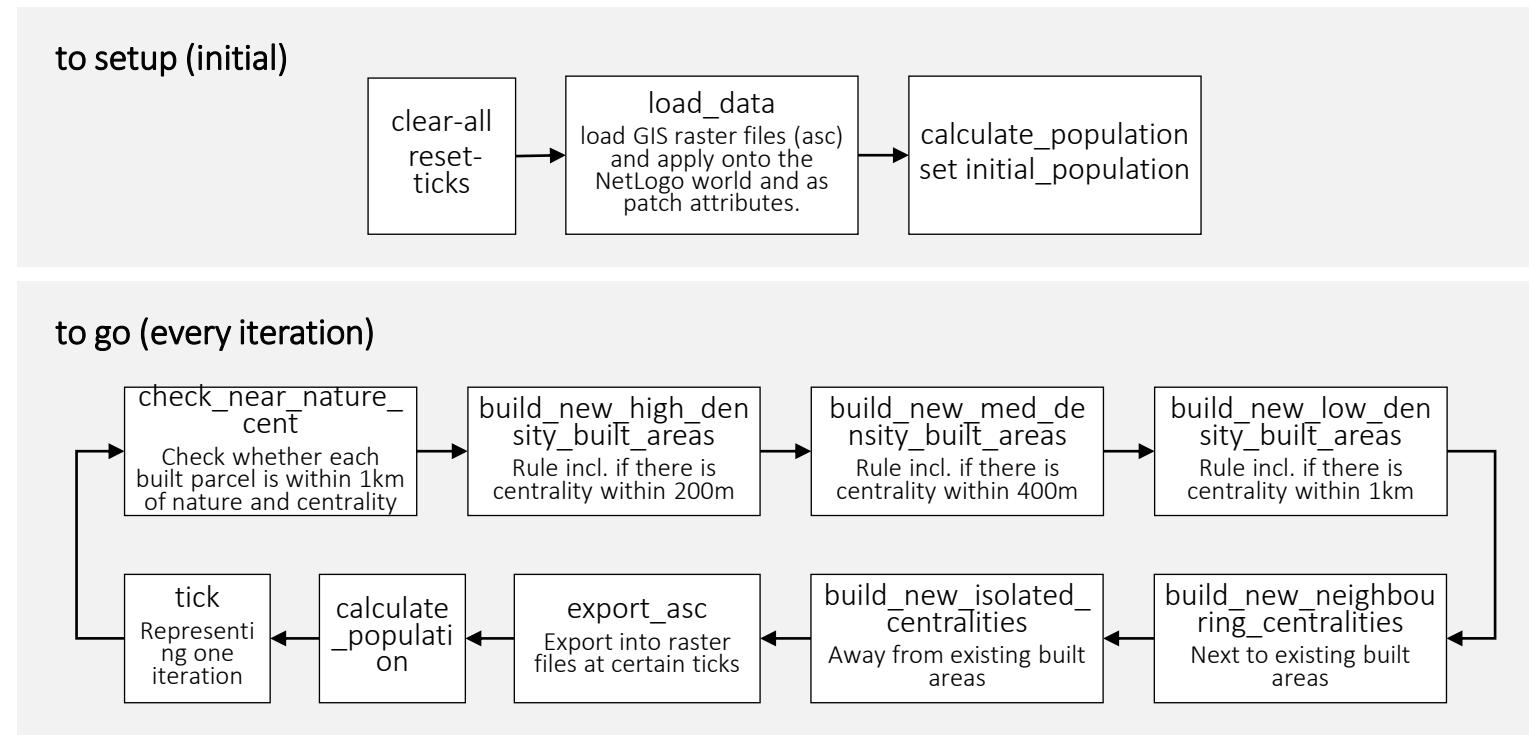
1. The amenities allocation should tend to ensure a similar accessibility and overall benefit across urban areas;
2. Each citizen should be able to reach:
 - a) the ordinary daily points within 15 min walking (T^*);
 - b) a centrality within T^* ;
 - c) a natural area within T^* ;
3. Buildings should be close to each other, in the same way natural areas (at least 1 continuous sq. km) and interconnected. Overall dense urban area population.

Source: D'Acci, 2019

Running simulation

Demonstrate

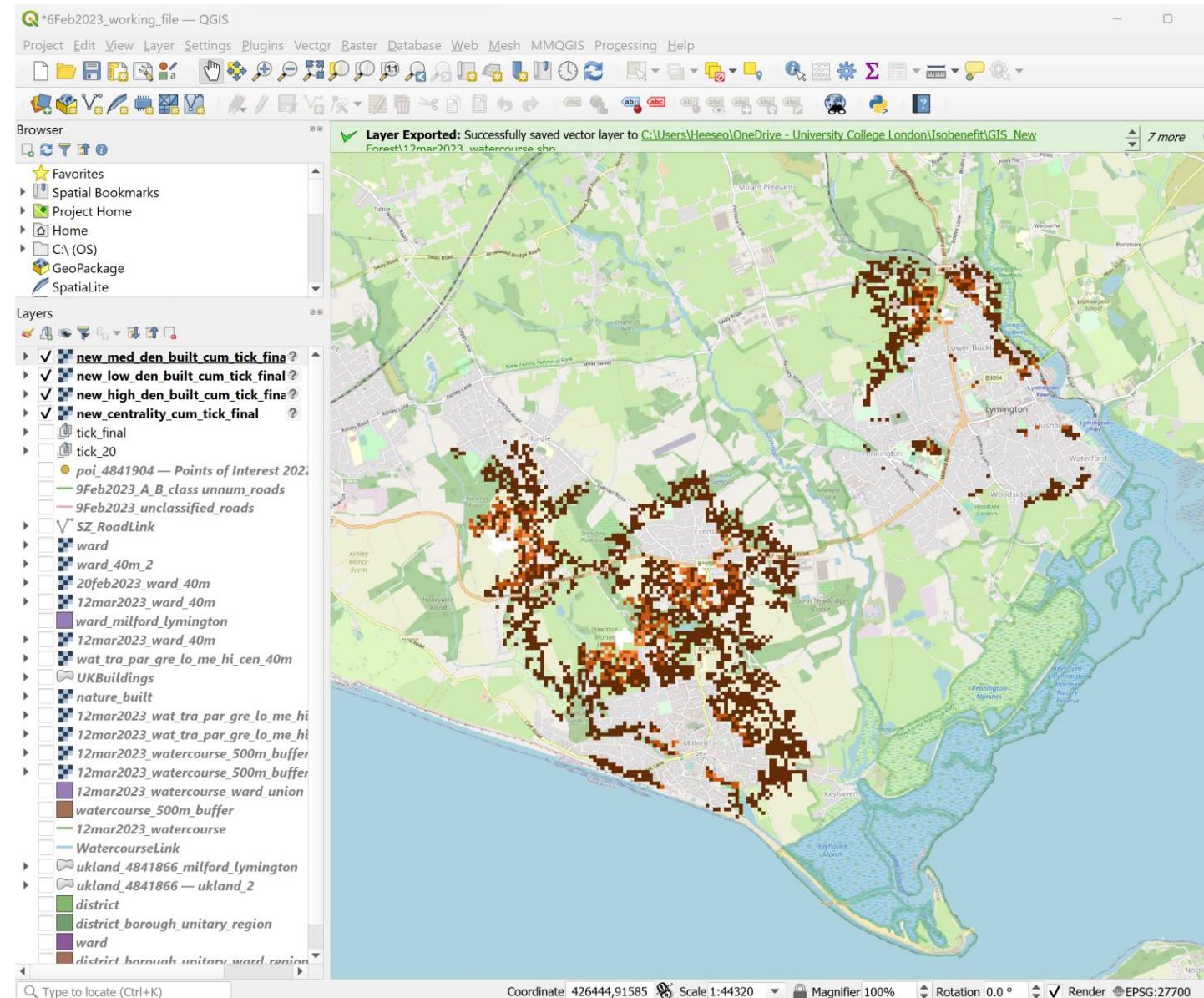
Future Urban Growth of 15-minute Neighbourhoods: Model Structure



What a simulation result can look like



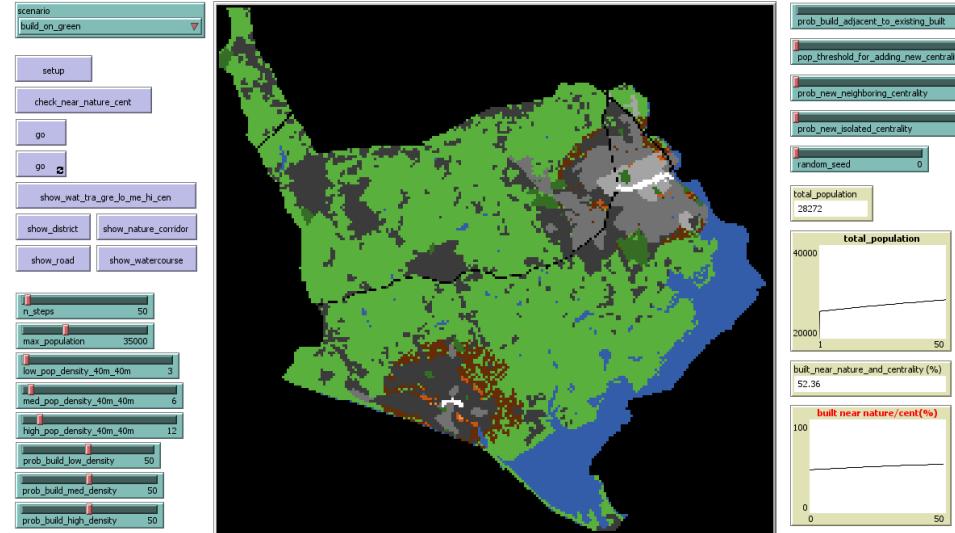
Exporting Outputs



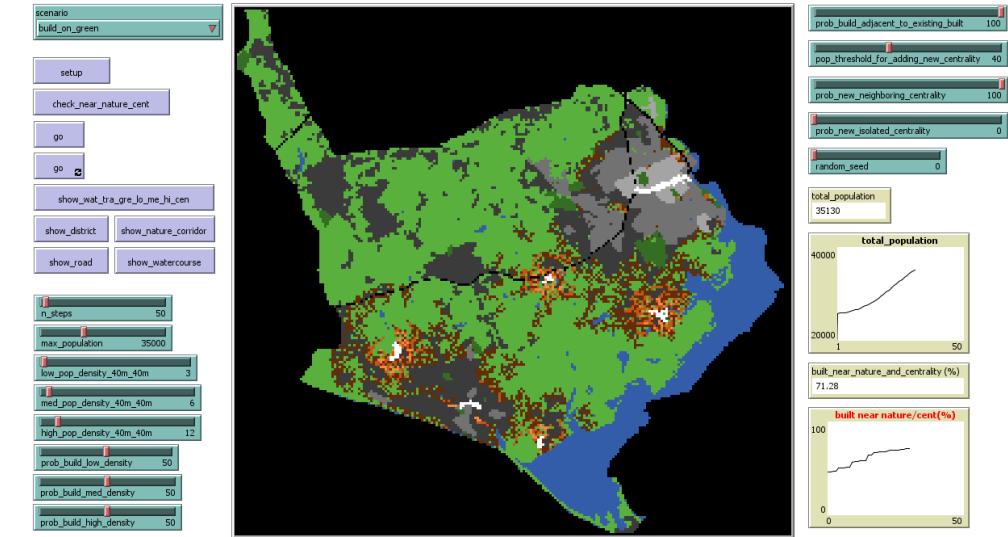
Use of parameters and scenarios and how it affects the simulation outcome

New centrality

Without new centrality (0%). Did not achieve population target.



With new centrality (100%): four new centralities

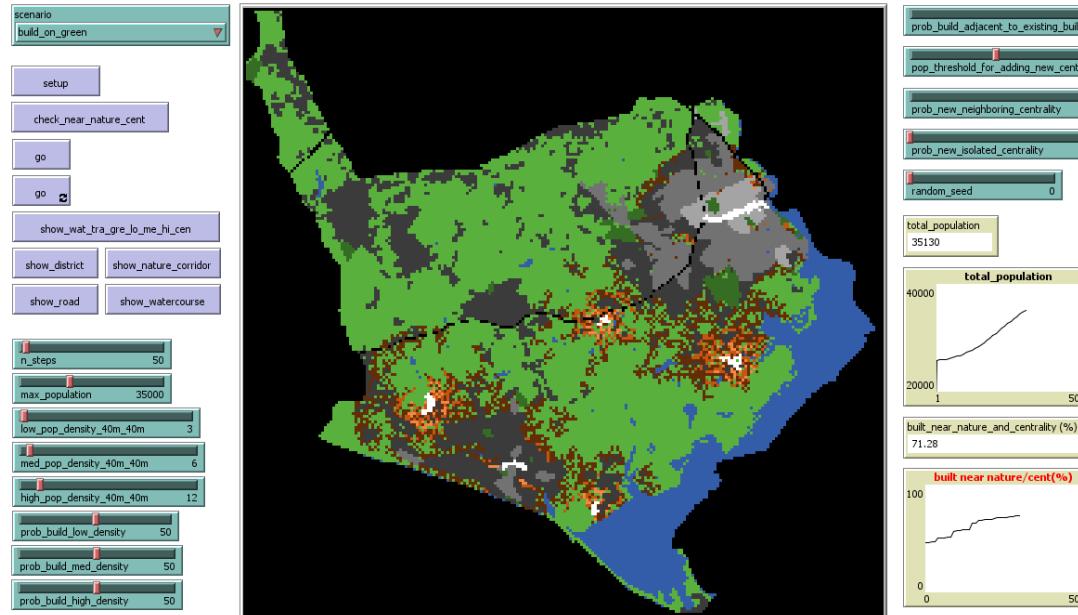


With new centrality (50%): two new centralities. Did not achieve population target.

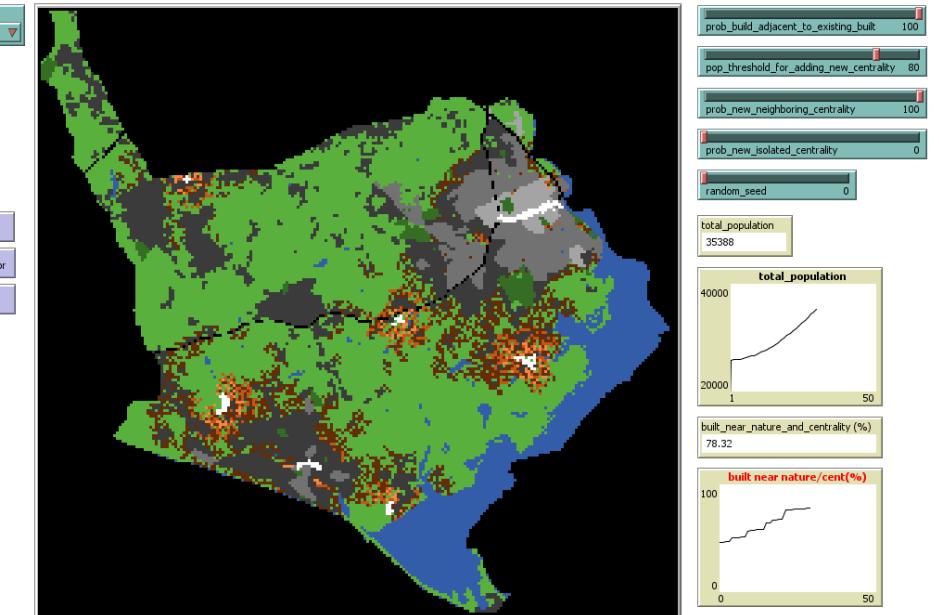
Copyright @ 2023 Heeseo Rain Kwon

New centrality

Population threshold at 40%

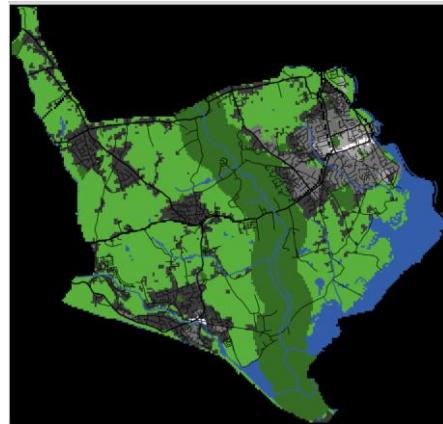


Population threshold at 80%

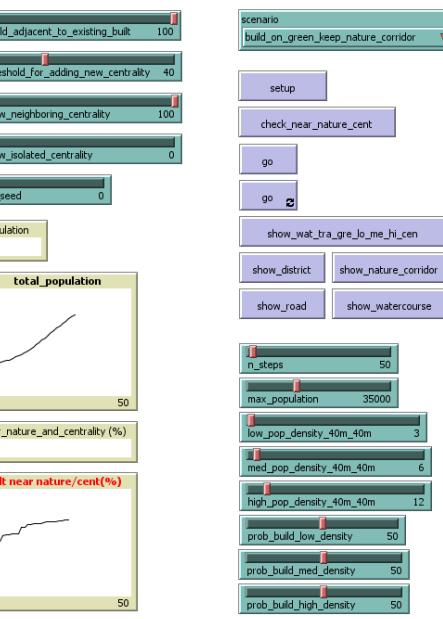


- At higher population threshold, new centrality gets added until later on, making the new population more spread out.
- Better for getting more population near nature & centrality but potentially more costly (making use of the centralities less in terms of how many population they can accommodate)

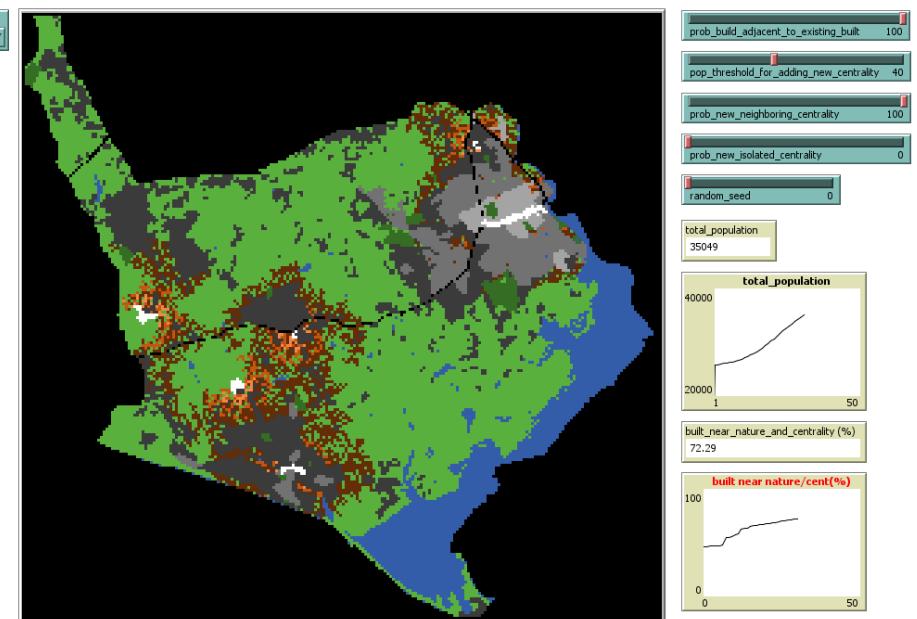
Nature corridor along the river



Without nature corridor

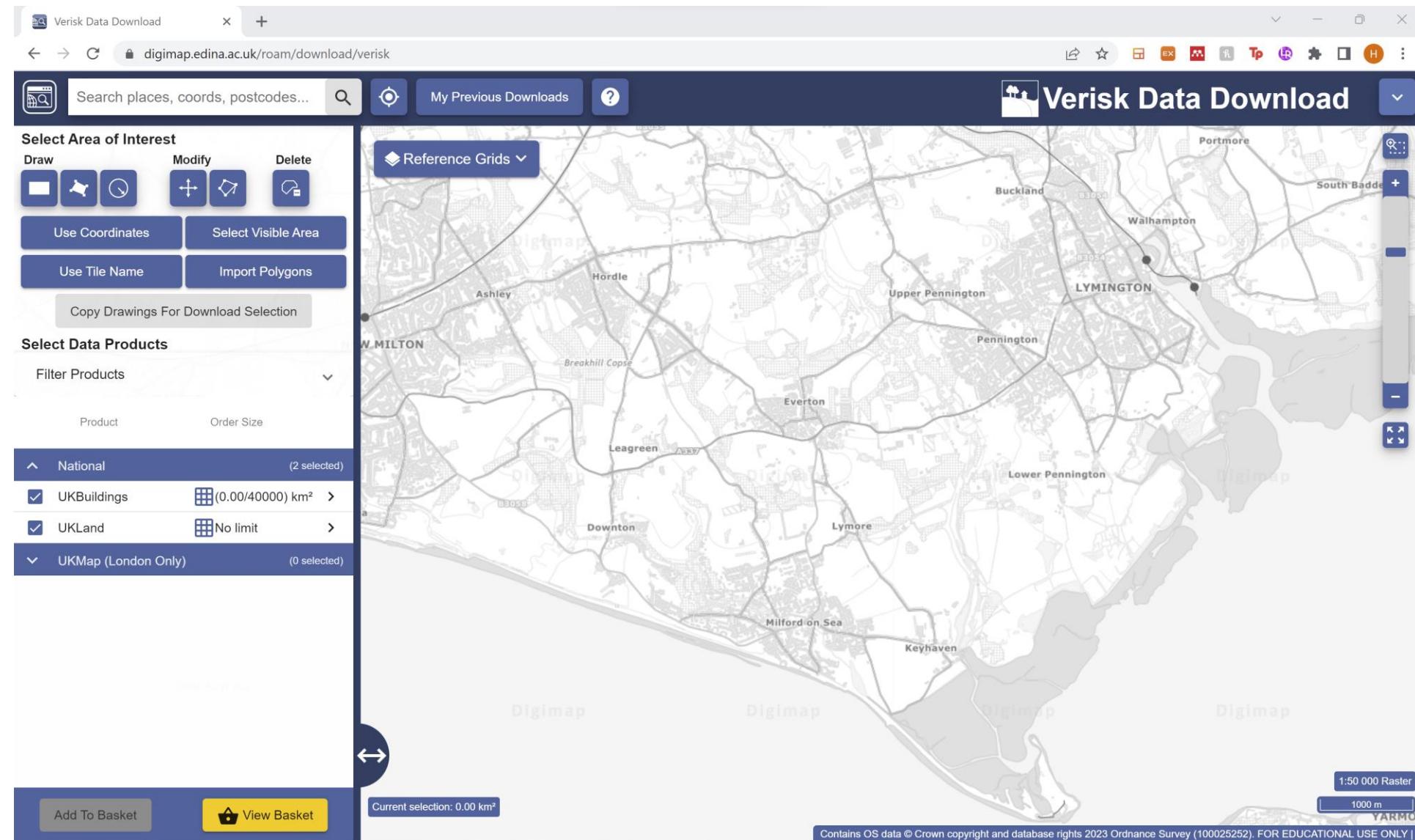


With nature corridor

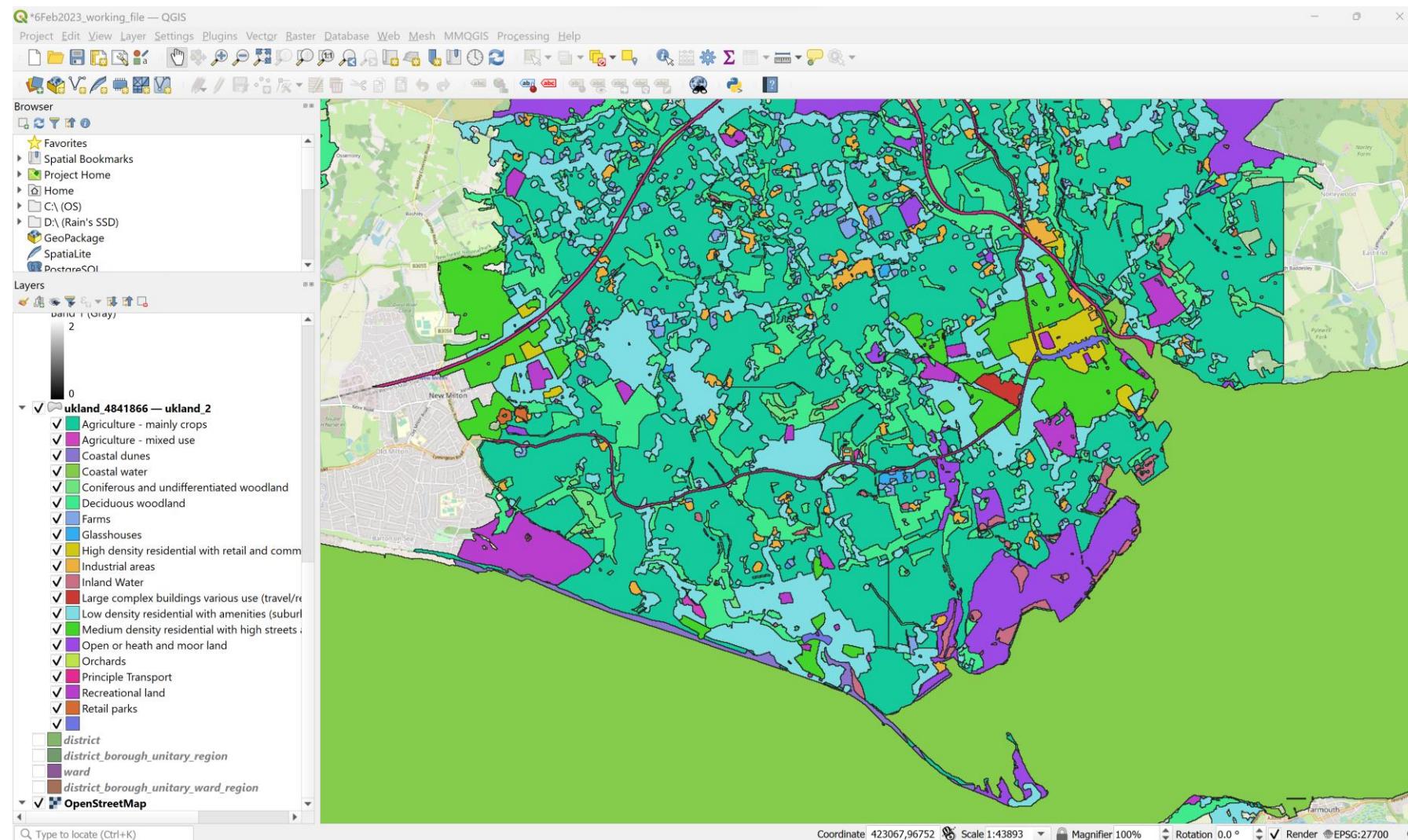


Some details on data preparation and codes

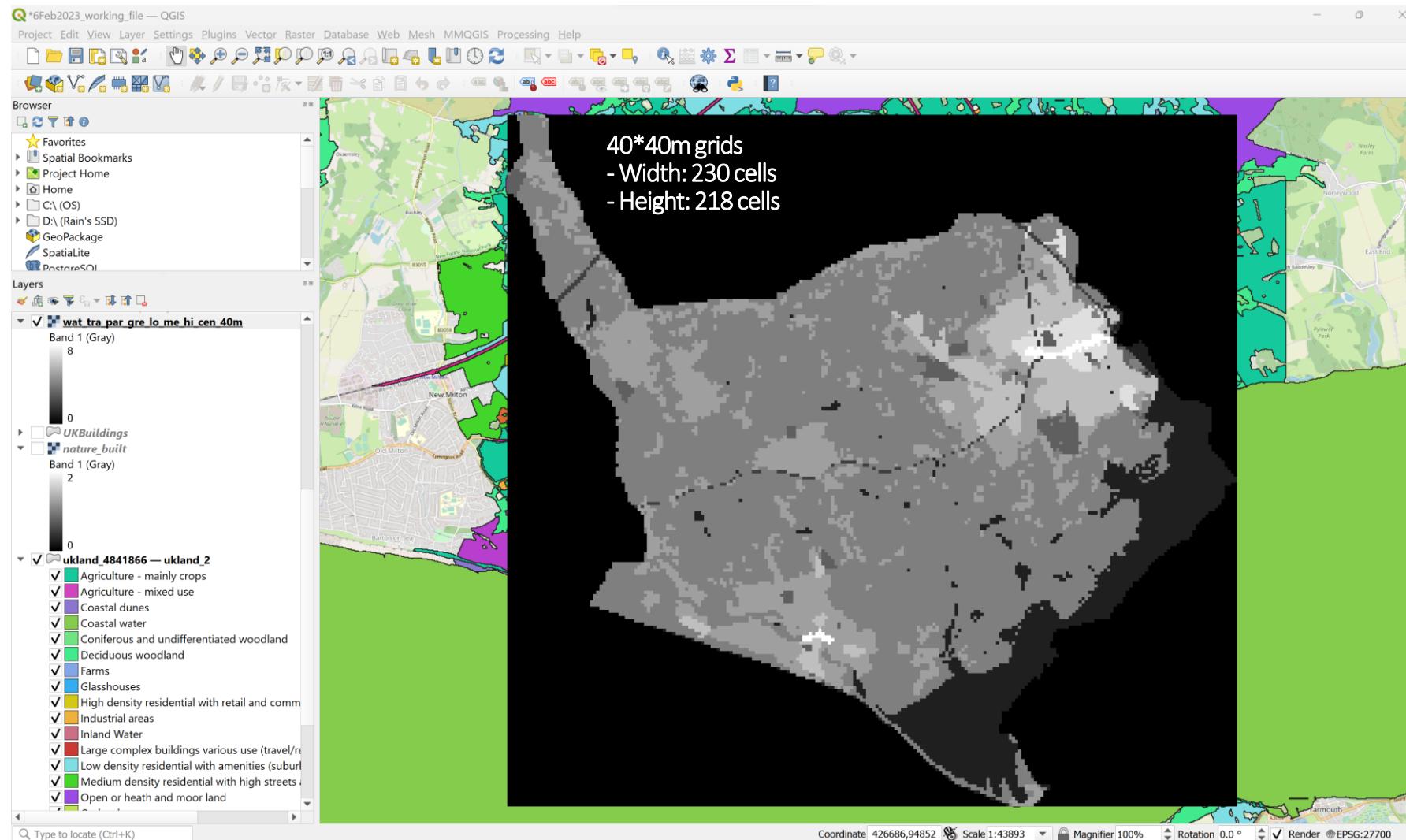
Preparing Spatial Input Data on QGIS (open-source software)



Preparing Spatial Input Data on QGIS



Preparing Spatial Input Data on QGIS



Load data

```

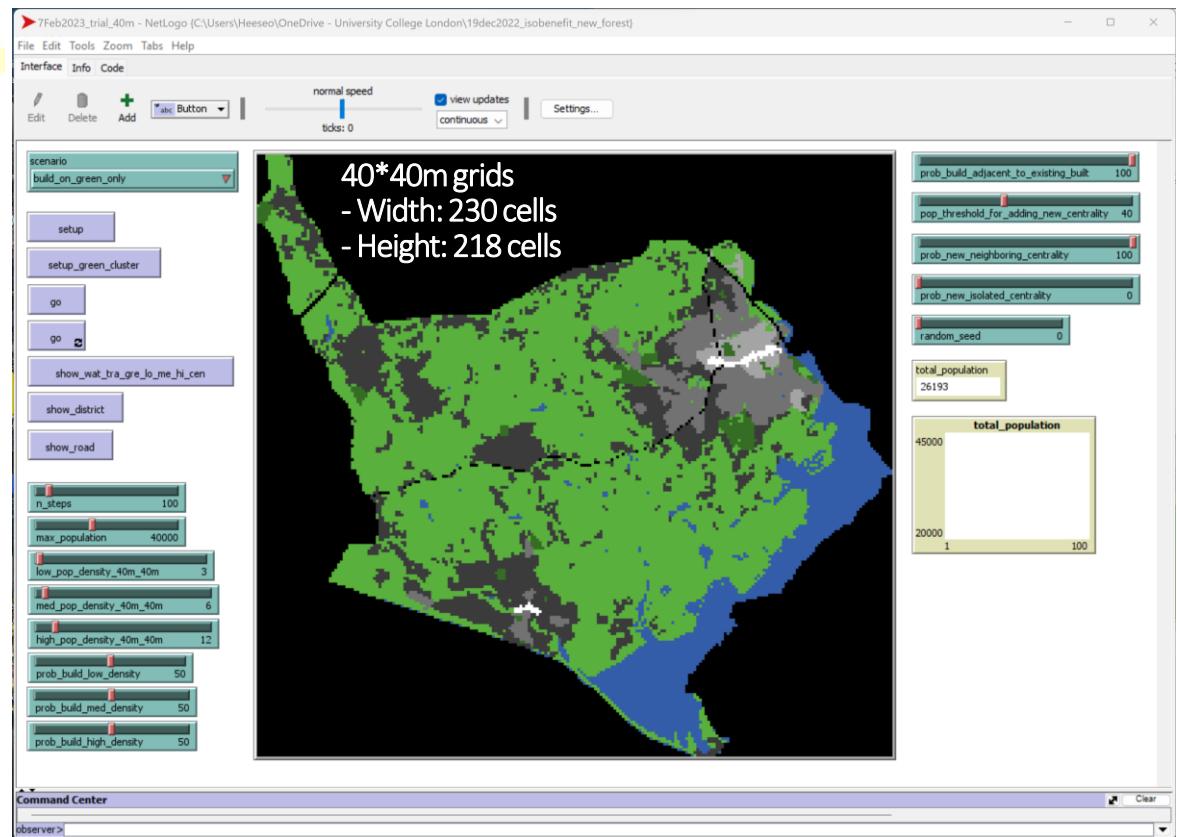
to load_data
  set ward_dataset gis:load-dataset "data/ward_40m.asc"
  set wat_tra_par_gre_lo_me_hi_cen_dataset gis:load-dataset "data/wat_tra_par_gre_lo_me_hi_cen_40m.asc"
  set nature_corridor_dataset gis:load-dataset "data/nature_corridor.asc"
  set large_road_dataset gis:load-dataset "data/large_roads.shp"
  set small_road_dataset gis:load-dataset "data/small_roads.shp"
  set watercourse_dataset gis:load-dataset "data/watercourse.shp"
; ;;;;;;;;;;;;;;;;;;;
; Applying each of the loaded raster maps onto the world and as patch values
; ;;;;;;;;;;;;;;;;;;;
gis:set-world-envelope gis:envelope-of ward_dataset
gis:apply-raster ward_dataset ward
gis:apply-raster wat_tra_par_gre_lo_me_hi_cen_dataset wat_tra_par_gre_lo_me_hi_cen
gis:apply-raster nature_corridor_dataset nature_corridor
end

to calculate_population
  set total_population count patches with [low_den_built = 1] * low_pop_density_40m_40m
  + count patches with [med_den_built = 1] * med_pop_density_40m_40m
  + count patches with [high_den_built = 1] * high_pop_density_40m_40m
end

; ##### show raster maps #####
; #####
to show_district
  ask patches [if ward = 1 [set pcolor 1]]
  ask patches [if ward = 2 [set pcolor 2]]
  ask patches [if ward = 3 [set pcolor 3]]
  ask patches [if ward = 4 [set pcolor 4]]
  ask patches [if ward = 5 [set pcolor 5]]
end

to show_nature_corridor
  ask patches [if nature_corridor = 1 [set pcolor 53]]
end

to setup_wat_tra_gre_lo_me_hi_cen
  ask patches [if wat_tra_par_gre_lo_me_hi_cen = 1 [set pcolor blue set water_bodies 1]]
  ask patches [if wat_tra_par_gre_lo_me_hi_cen = 2 [set pcolor black set prin_transp 1]]
  ask patches [if wat_tra_par_gre_lo_me_hi_cen = 3 [set pcolor 53 set park 1]] ;; dark green
  ask patches [if wat_tra_par_gre_lo_me_hi_cen = 4 [set pcolor green set green_area 1]]
  ask patches [if wat_tra_par_gre_lo_me_hi_cen = 5 [set pcolor 2 set low_den_built 1]] ;; light grey
  ask patches [if wat_tra_par_gre_lo_me_hi_cen = 6 [set pcolor 4 set med_den_built 1]] ;; medium grey
  ask patches [if wat_tra_par_gre_lo_me_hi_cen = 7 [set pcolor 6 set high_den_built 1]] ;; dark grey
  ask patches [if wat_tra_par_gre_lo_me_hi_cen = 8 [set pcolor white set centrality 1 set existing_centrality 1]]
end
  
```



Coding Urban Growth Rules

```

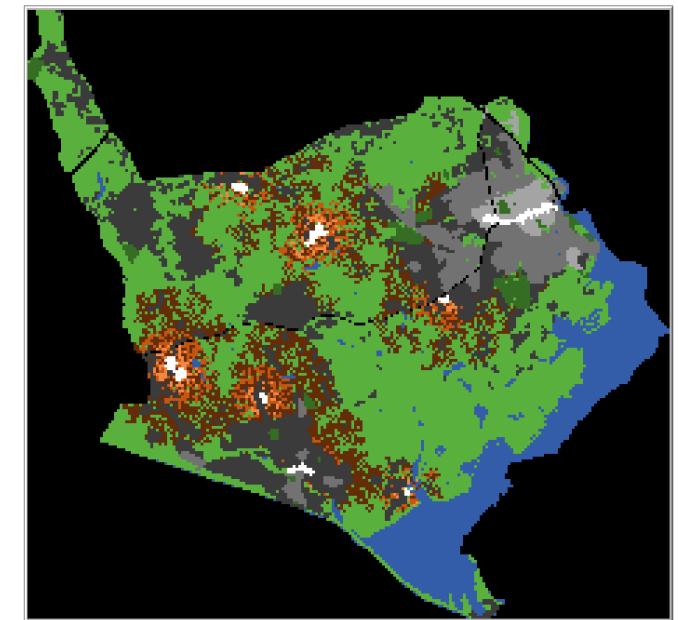
to build_on_green_only

; Build new high density built areas
ask n-of 1000 patches with [green_area = 1] ;; ask 1,000 randomly chosen green patches
[if any? neighbors with [low_den_built = 1 or med_den_built = 1 or high_den_built = 1 or centrality = 1] ;; if any of the neighbouring 8 cells are currently built or centrality.
  and any? patches with [centrality = 1] in-radius 25 and any? patches with [green_cluster = 1] in-radius 25 ;; and if there is centrality and green cluster within 1km.
  and random-float 100 < prob_build_adjacent_to_existing_built ;; roll a dice and generate a random number between 0 and 100.
  ;; If it is smaller than the "prob_build_adjacent_to_existing_built". If "prob_build_adjacent_to_existing_built" = 100, the probability is 100%.
[if random-float 100 < prob_build_high_density and any? patches with [centrality = 1] in-radius 5
  ;; again, roll a dice. If "prob_build_high_density"=50, the probability of passing this step is 50%. Also if there is centrality within 200m.
  [set high_den_built 1 set new_high_den_built 1 set new_high_den_built_cum 1 set green_area 0 set pcolor 26]]
  ;; set these green patches as high density built areas and make it light orange.
  ;; set new_high_den_built to distinguish from the existing high density built areas.
  ;; set new_high_den_built_cum to keep track of the cumulative new areas to export as raster files (asc).

; Build new medium density built areas
ask n-of 1000 patches with [green_area = 1]
[if any? neighbors with [low_den_built = 1 or med_den_built = 1 or high_den_built = 1 or centrality = 1]
  and any? patches with [centrality = 1] in-radius 25 and any? patches with [green_cluster = 1] in-radius 25
  and random-float 100 < prob_build_adjacent_to_existing_built
  [if random-float 100 < prob_build_med_density and any? patches with [centrality = 1] in-radius 10 ;; within 400m.
    [set med_den_built 1 set new_med_den_built 1 set new_med_den_built_cum 1 set green_area 0 set pcolor 24]]]

; Build new low density built areas
ask n-of 1000 patches with [green_area = 1]
[if any? neighbors with [low_den_built = 1 or med_den_built = 1 or high_den_built = 1 or centrality = 1]
  and any? patches with [centrality = 1] in-radius 25 and any? patches with [green_cluster = 1] in-radius 25
  and random-float 100 < prob_build_adjacent_to_existing_built
  [if random-float 100 < prob_build_low_density and any? patches with [centrality = 1] in-radius 25 ;; within 1km.
    [set low_den_built 1 set new_low_den_built 1 set new_low_den_built_cum 1 set green_area 0 set pcolor 22]]]

```



Coding Urban Growth Rules

```

; Build new neighbouring centralities
if (total_population - initial_population) < (max_population - initial_population) * pop_threshold_for_adding_new_centrality / 100
; If initial_population = 26,193, max_population = 40,000 and pop_threshold = 100, new centralities can be built until the newly added population reaches 13,619.
; If pop_threshold = 50, new centralities can be built until the newly added population reaches 6,809.
; Lower the pop_threshold, the building of new centralities stops earlier and the simulation focuses on building near the already formed centralities.
; Higher the pop_threshold, the building of new centralities continues until later
; and the simulation is likely to end with some new centralities that didn't manage to have built areas formed around because the simulation stops when it reaches max_population.

[ask n-of 1 patches with [green_area = 1] ;; ask one randomly chosen green patch
 [if any? neighbors with [low_den_built = 1 or med_den_built = 1 or high_den_built = 1] ;; if any of the neighbouring 8 cells are currently built.
   and count patches with [centrality = 1] in-radius 25 = 0 and any? patches with [green_cluster = 1] in-radius 30
   ;; and if there is no centrality within 1km but there is green cluster within 1.2km. Give a little buffer because the new centrality will be bigger than one cell.
   and random-float 100 < prob_new_neighboring_centrality ;; Note: if "prob_new_neighboring_centrality"=100, the probability of passing this step is 100%.
   [set centrality 1 set new_centrality 1 set new_centrality_cum 1 set green_area 0 set pcolor white]]] ;; set this green patch as centrality.

; Build new isolated centralities
if (total_population - initial_population) < (max_population - initial_population) * pop_threshold_for_adding_new_centrality / 100
[ask n-of 1 patches with [green_area = 1] ;; ask one randomly chosen green patch
 [if count patches with [low_den_built = 1 or med_den_built = 1 or high_den_built = 1] in-radius 25 = 0 and any? patches with [green_cluster = 1] in-radius 30
   ;; if there is no built area within 1km but there is green cluster within 1.2km.
   and random-float 100 < prob_new_isolated_centrality ;; Note: if "prob_new_isolated_centrality"=0, the probability of passing this step is 0%.
   [set centrality 1 set new_centrality 1 set new_centrality_cum 1 set green_area 0 set pcolor white]]] ;; set this green patch as centrality.

ask patches with [new_centrality = 1] ;; ask the patches that became centrality.
[ask n-of 4 neighbors [if green_area = 1 [set centrality 1 set new_centrality2 1 set new_centrality_cum 1 set green_area 0 set pcolor white]]]
;; if any of the four neighbours are green, turn them into centrality. Repeat the process a couple more times to allow random shaping of the new centralities.

```

Potential Add-ons as a Behavioural Model

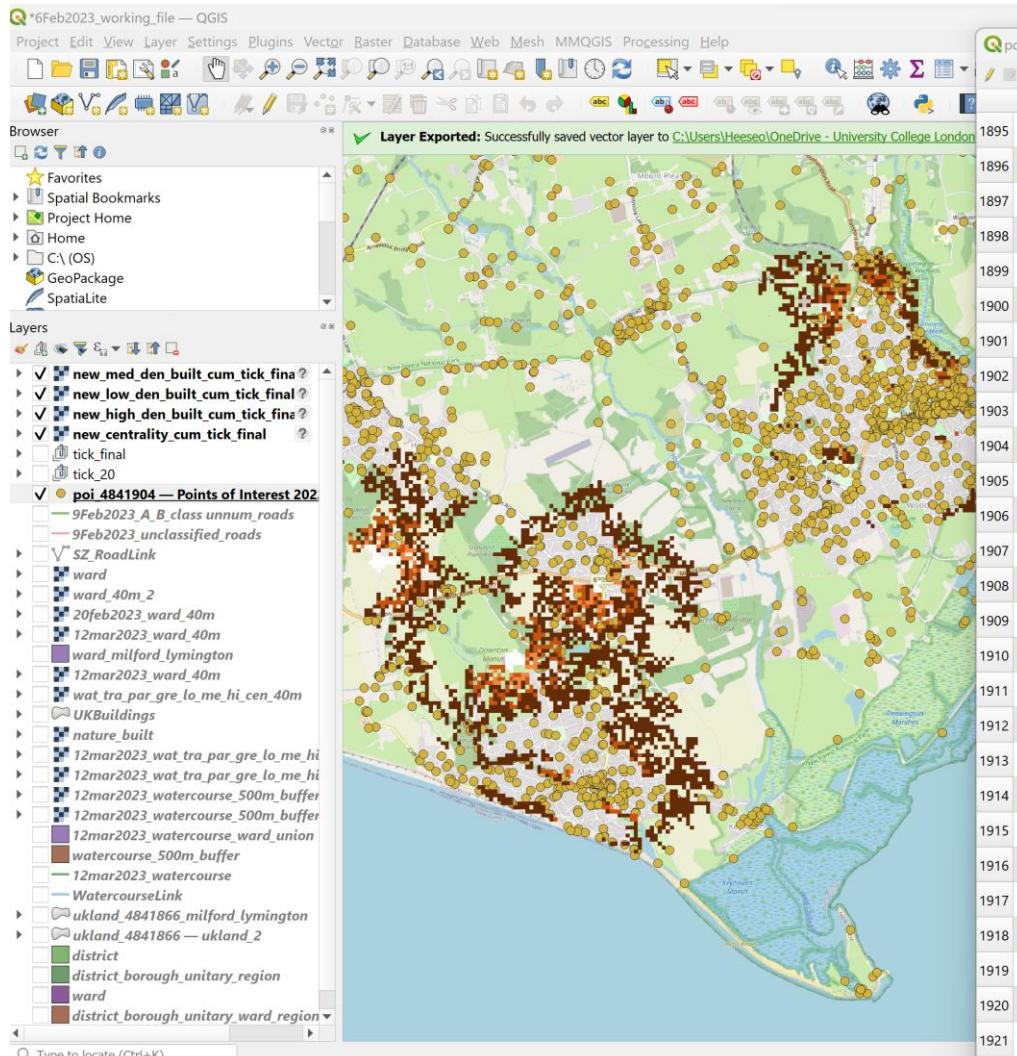
- Whose behaviour and what behaviour are urban development actors (e.g. planners) interested in to model in linkage with the Isobenefit urbanism?
- Can design/test a behavioural science approach to encouraging/discouraging certain behaviour

01 Accommodation

0003 Bed and breakfast and backpacker accommodation	0007 Self catering
0002 Camping, caravanning, mobile homes, holiday parks and centres	0008 Timeshare
0005 Hostels and refuges for the homeless	0009 Youth accommodation
0006 Hotels, motels, country houses and inns	



Example: can load data like detailed point of interest data.



poi_4841904 — Points of Interest 2022_09 — Features Total: 2245, Filtered: 2245, Selected: 0

id	ref_no	name	pointx_class	groupname	categoryname	classname
1895	481	49865942 Britannia Thai	01020043	Accommodation...	Eating and Drink...	Restaurants
1896	482	49869221 Verveine	01020043	Accommodation...	Eating and Drink...	Restaurants
1897	648	64122048 Maison Cuisine	01020043	Accommodation...	Eating and Drink...	Restaurants
1898	720	68705426 Lanes of Lyming...	01020043	Accommodation...	Eating and Drink...	Restaurants
1899	769	91452414 Prezzo Restaura...	01020043	Accommodation...	Eating and Drink...	Restaurants
1900	864	85633222 Zaika	01020043	Accommodation...	Eating and Drink...	Restaurants
1901	897	97754478 La Perle	01020043	Accommodation...	Eating and Drink...	Restaurants
1902	967	104542454 Rivaaz	01020043	Accommodation...	Eating and Drink...	Restaurants
1903	1006	108330110 Haven Bar & Res...	01020043	Accommodation...	Eating and Drink...	Restaurants
1904	1049	118121172 Pizza Express	01020043	Accommodation...	Eating and Drink...	Restaurants
1905	1098	125652850 Rokali's Indian R...	01020043	Accommodation...	Eating and Drink...	Restaurants
1906	1266	145413306 Monsoori Heights	01020043	Accommodation...	Eating and Drink...	Restaurants
1907	1267	145413501 Ray's Italian Kitc...	01020043	Accommodation...	Eating and Drink...	Restaurants
1908	1324	158336731 Koh Thai Tapas	01020043	Accommodation...	Eating and Drink...	Restaurants
1909	1328	157760116 The Ferryman B...	01020043	Accommodation...	Eating and Drink...	Restaurants
1910	1342	156921825 The Waterford R...	01020043	Accommodation...	Eating and Drink...	Restaurants
1911	1345	158557141 Brewers Fayre	01020043	Accommodation...	Eating and Drink...	Restaurants
1912	1350	159612183 Faros Greek Rest...	01020043	Accommodation...	Eating and Drink...	Restaurants
1913	1492	165164424 The Saltern	01020043	Accommodation...	Eating and Drink...	Restaurants
1914	2131	95261704 Three Bells	01020043	Accommodation...	Eating and Drink...	Restaurants
1915	2215	168344858 The Larder	01020043	Accommodation...	Eating and Drink...	Restaurants
1916	961	103812456 New Forest Pro...	02030058	Commercial Ser...	Construction Ser...	Restoration a...
1917	1381	161954758 3Lance Develop...	02030058	Commercial Ser...	Construction Ser...	Restoration a...
1918	1392	162683752 Coombe Stables	04230321	Sport and Entert...	Outdoor Pursuits	Riding Schoo...
1919	1135	125815346 G P West	02030059	Commercial Ser...	Construction Ser...	Road Constru...
1920	517	54524139 M S Bingham Ro...	02030060	Commercial Ser...	Construction Ser...	Roofing and t...
1921	520	54527515 Browning Roofin...	02030060	Commercial Ser...	Construction Ser...	Roofing and t...

57 Public transport, stations and infrastructure

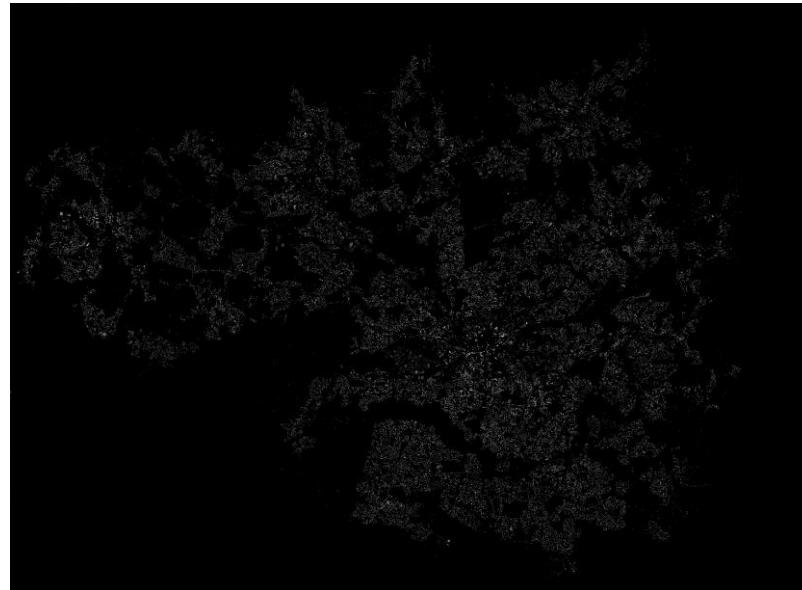
0731 Bus and coach stations, depots and companies	0758 Taxi ranks
0794 London Underground entrances	0756 Tram, metro and light railway stations and stops
0738 Railway stations, junctions and halts	0761 Underground network stations

59 Bus transport

0732 Bus stops	0759 Hall and ride zones
----------------	--------------------------

Example of Greater Manchester: can load data like building use data

Data: UKBuildings_Sep2022 (1,467,143 features). Gets updated 3 times a year since Feb 2020.
From low intensity to high intensity (will later multiply by building height)



- General commercial mixed use (25% resi)
- Residential with retail on ground floor (80% resi)
- Residential only (100% resi)

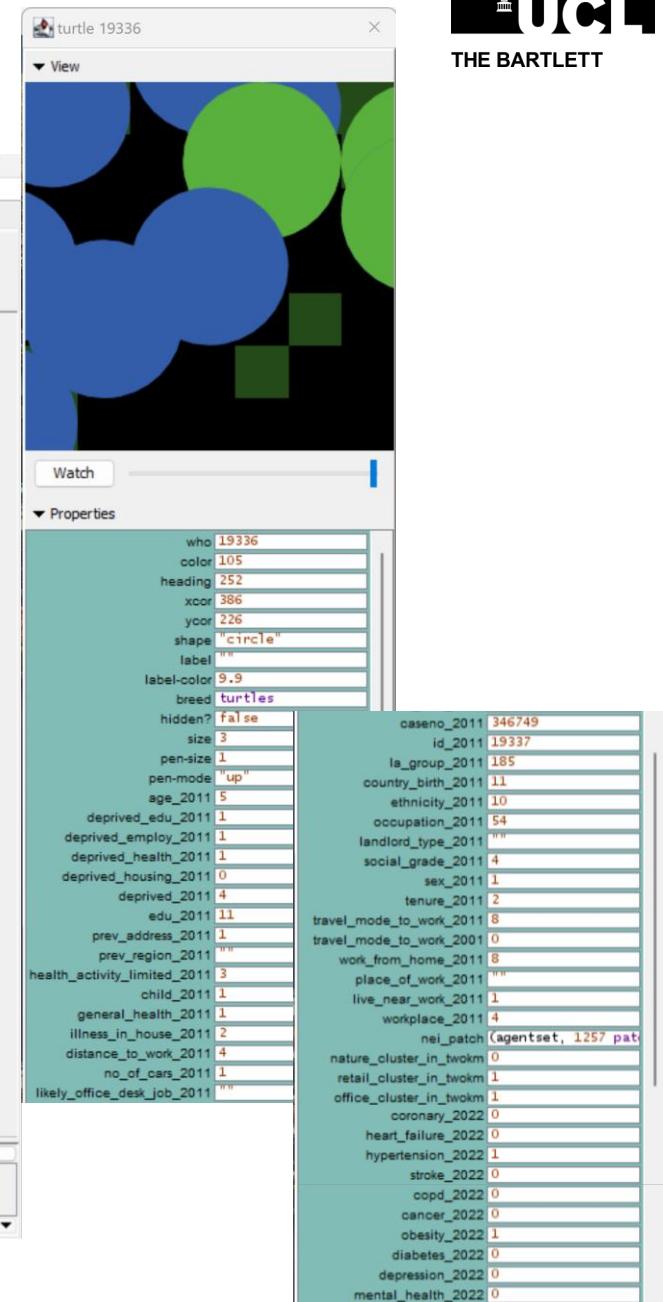
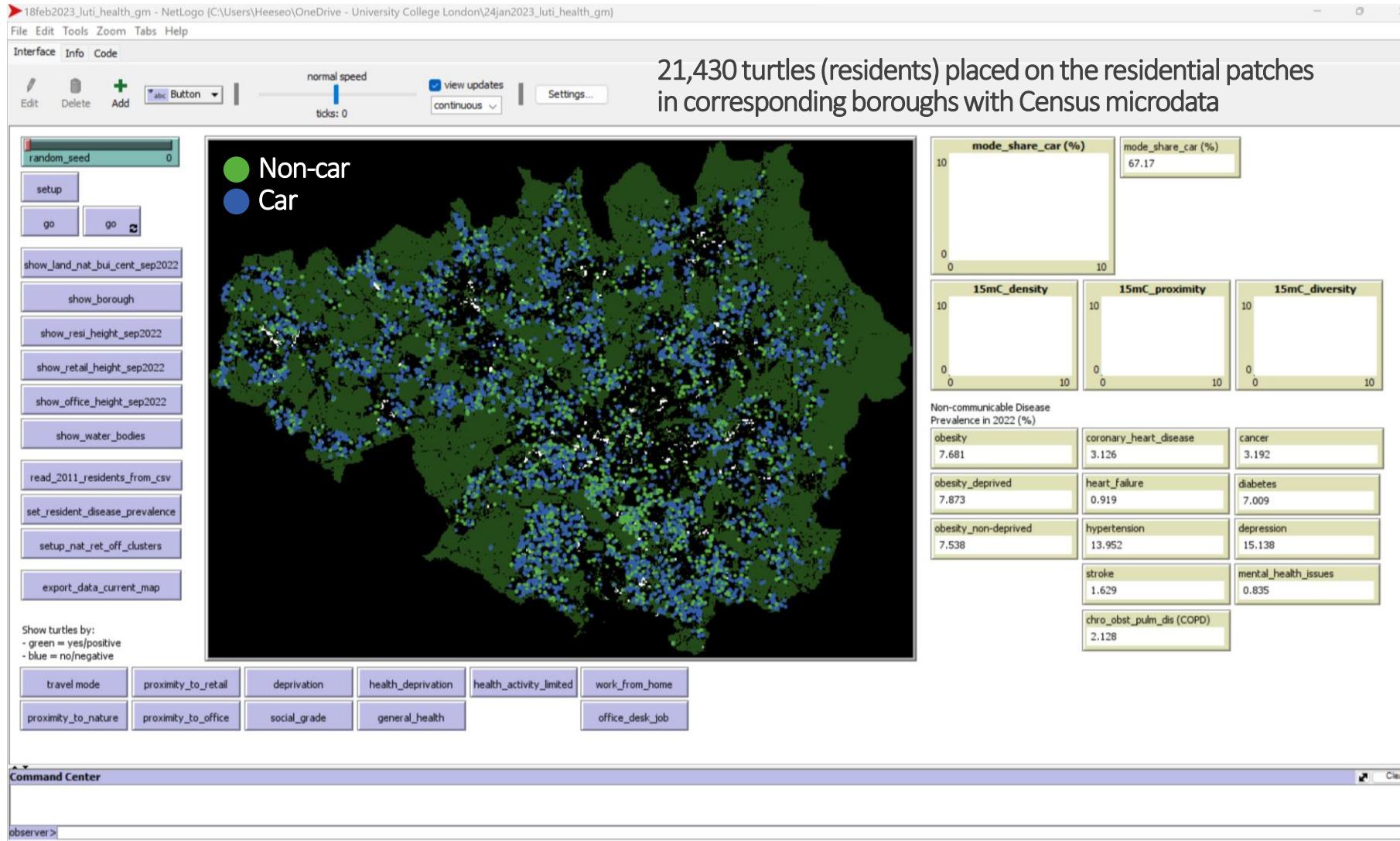


- General commercial mixed use (25% retail)
- Retail with office/residential above (80% retail)
- Retail only (100% retail)

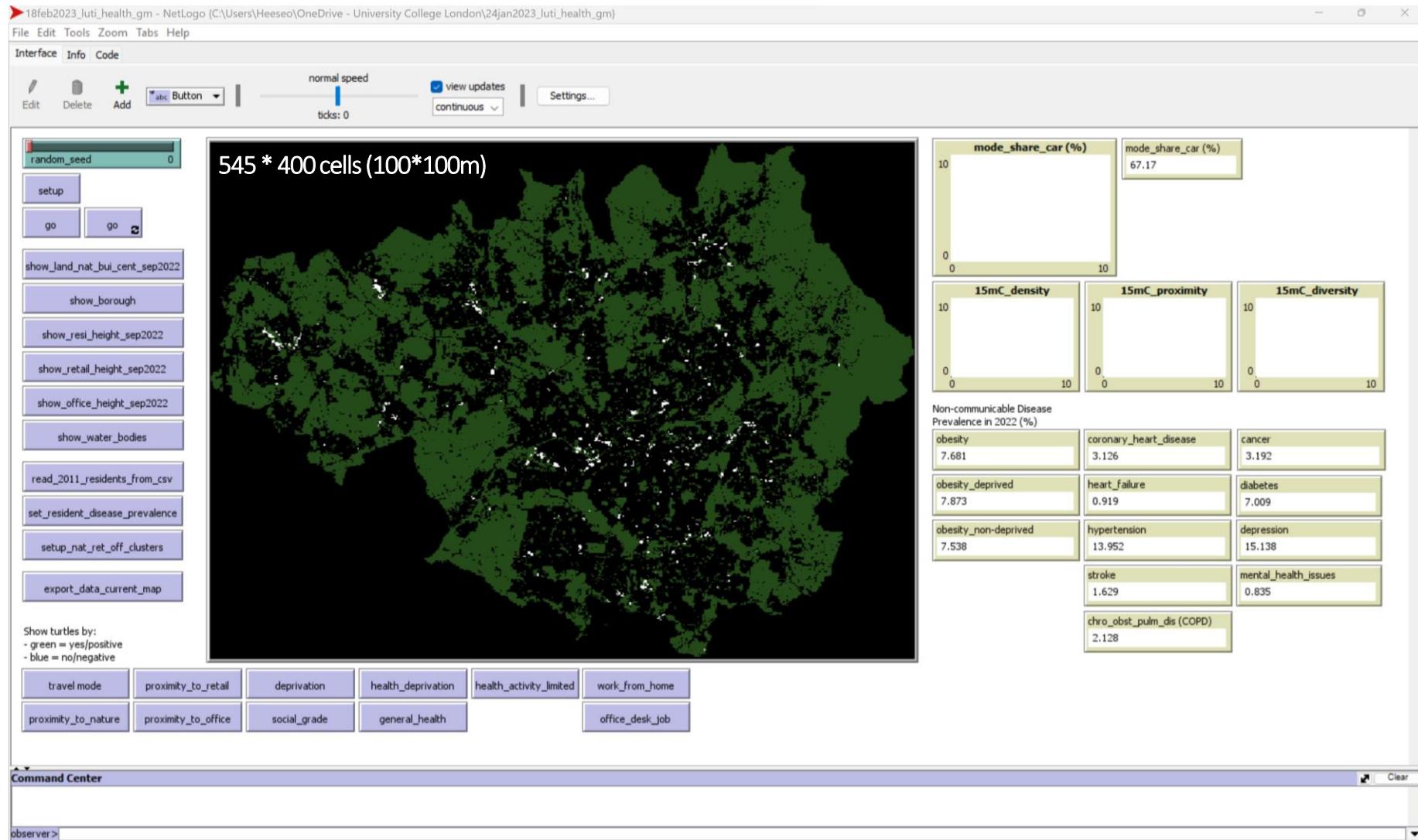


- General commercial mixed use (25% office)
- Office with retail on ground floor (80% office)
- Office only (100% retail)

Example of GM: can load data like individual-level Census microdata



Example of Greater Manchester: can load data like NHS health prevalence data

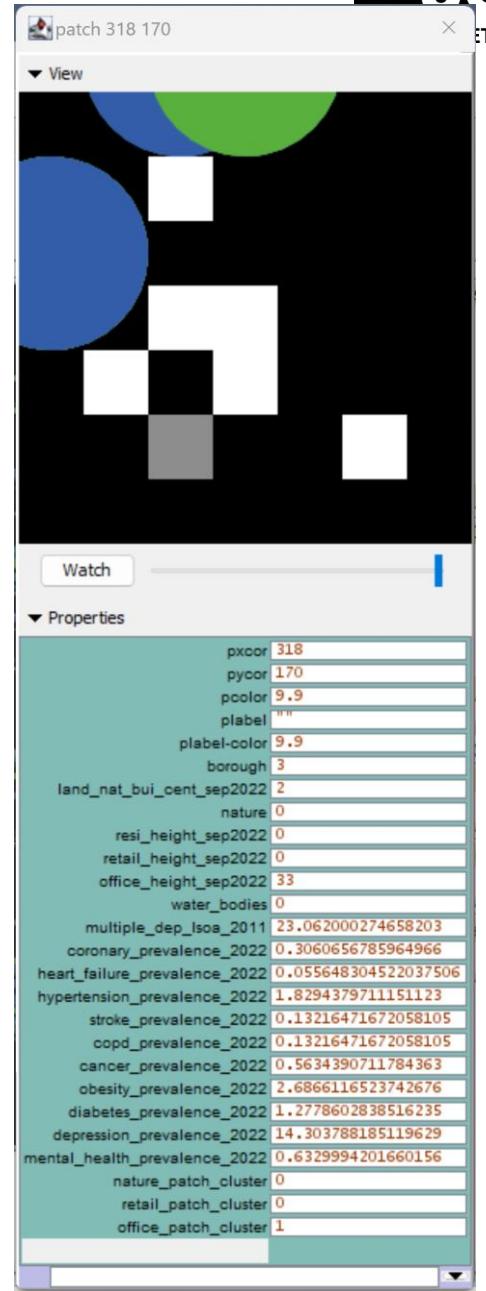


Nature

Built

Urban centre

Data: UKLand_Sep2022 (57,269 features). Gets updated once a year since Oct 2020.



Key references

D'Acci, L. (2019) 'A new type of cities for liveable futures. Isobenefit Urbanism morphogenesis', Journal of Environmental Management, 246, pp. 128–140. doi: 10.1016/j.jenvman.2019.05.129.

Moreno, C., Allam, Z., Chabaud, D., Gall, C., and Pratlong, F. (2021). Introducing the “15-Minute City”: Sustainability, Resilience and Place Identity in Future Post-Pandemic Cities. Smart Cities, 4(1):93-111.