StatEO

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A multilevel explorative approach to assess urban playground-based cultural ecosystem services supply and demand

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Aim of the study: implement a Multiscale analysis of Local Urban Services

Within cities
- Identify inner cities patterns

Across cities
- Benchmark cities

Across Countries

Combine EO products and National census data for active and across scale policy support

The idea is to design a:
- Consistent
- Replicable
- Comparable **methodology**

The main **challenge** is related to: **National Census Data**, differently

- Collected
- Structured
- Distributed

Conceptual Study design

A. LUP potential Supply

- **ES potential**
- Based on **the degree of naturalness** and available **space to play**

→ **High quality** LUPs spatial distribution




B. LUP demand

- **ES demand**
- Specific population profile

C. LUP ES Flow

- **ES Flow**
- Accessibility is a Proxy of potential actual use

→ **Relative** possibility to use the service

D. Demand analysis

- Map **Met-unmet** demand

E. ES Flow determinants

- Local models used to explore spatial predictors of ES Flow **distributional equity**

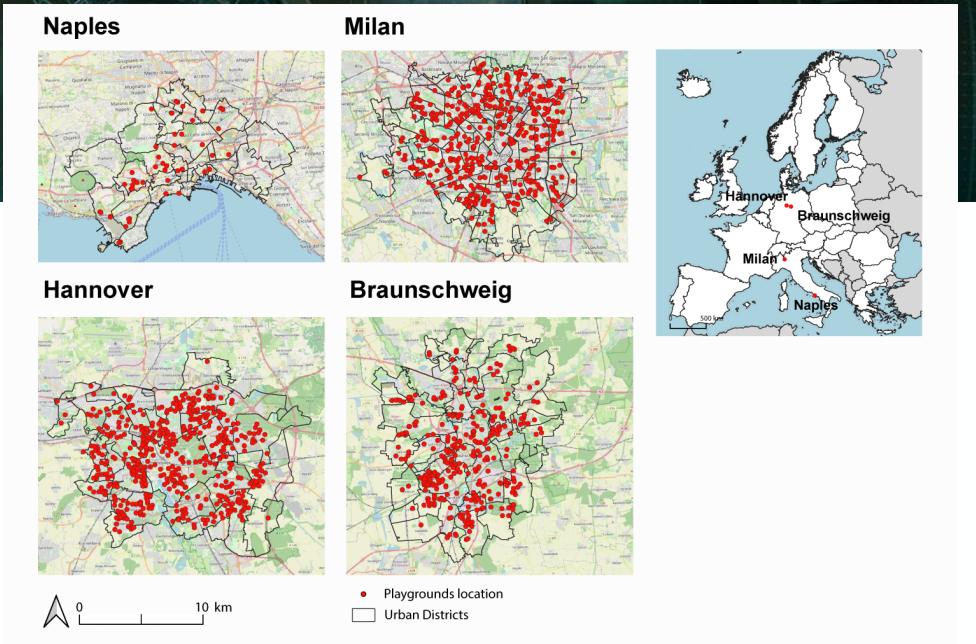
→ Elements affecting **ES Flow**

Ecosystem Services (ES) framework

Distributive Env. Justice

To recap

4 highly populated cities
- **Naples** / **Milan** in Italy
- **Hannover** / **Brunswick** in Germany



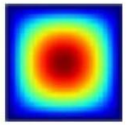
Local Urban service:
- **Local Urban Playgrounds**
- Evaluated considering the **Degree of Naturalness**

Demand:
- **0-9 years** old children

ES Flow -> Accessibility:
- Enhanced 2 Steps Floating Catchment Area method (**E2SFCA**)

Spatial covariates:
- Socio-demographic variables
- Urban morphology descriptors

Spatial analysis:
- Multiscale Geographically Weighted Regression **(MGWR)**



Key variables

- **Detailed localisation and evaluation of LUPs**
  -> Identify high quality Playgrounds

OpenStreetMap

Method to evaluate the **degree of Naturalness**

Sentinel-2

High Resolution 1m Global Canopy Height Maps

- **Detailed urban data -> to describe urban morphology**

EMC-BUILT

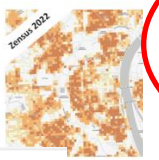
PROGRAMME OF THE EUROPEAN UNION · opernicus · Emergency Management Service

GHSL - Global Human Settlement Layer

Open and free data and tools for assessing the human presence on the planet

- **Detailed National Census data -> to localise the demand and derive socio-demographic indicators**
- **find fit to purpose units for the small-scale analysis**

zensus2022



LGLN OpenGeoData. NI

zensus ATLAS

Istat | Istituto Nazionale di Statistica

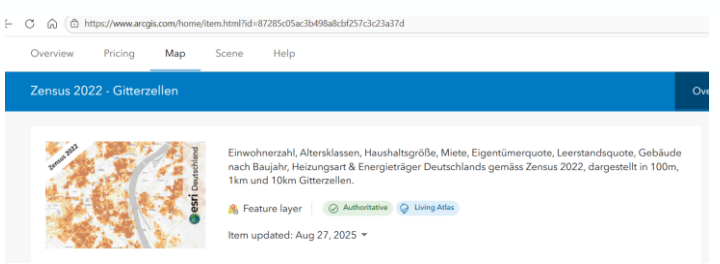
The census data challenge

	Italy	Germany
Format/structure	• **Spatial census blocks** • Tabular data	• **Grids** (100 m; 1 km; 10 km) • Tabular data
Distribution	• National web site (open portal)	• National web site (open portal) & ArcGIS web
Additional issues	• Data distributed by regions • **Blocks irregular**, size based on population density (tiny blocks in highly populated areas)	• Additional socio-dem. Indicators available in **separate sections** of the web site • District boundaries different (by states)

Banche dati censuarie

Censimenti Popolazione e Abitazioni

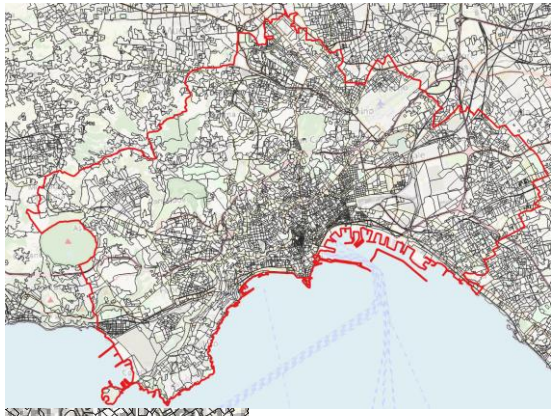
E2SFCA	MGWR
• -> need to localize demand	• Sensitive to number and distribution of locations to calibrate the model



The solution

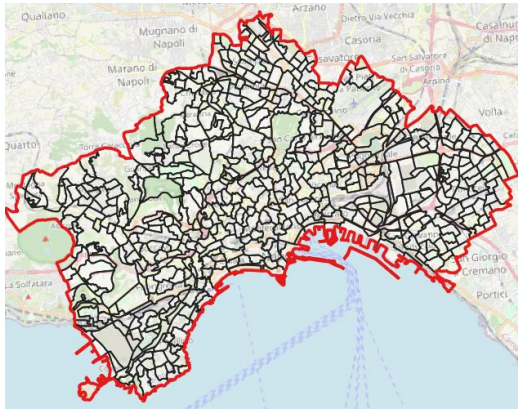
	Italy	Germany
Objective	**Merge tiny populated census** blocks	Create aggregations of populated cells
method	• Merge - ROOK contiguity (4 directions) algorithm • Size threshold to be defined	• Clump (4 directions) algorithm • Fragmented using the cadastral sectors
Number blocks	• E.g. NA From 5726 to 568	• E.g. HA 794 clumped polygons

Original data: 5726 census blocks

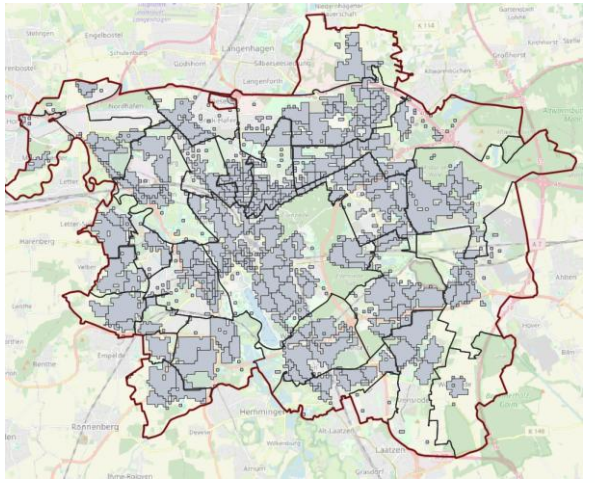


Some of them very small in size 500 to 1000 m2

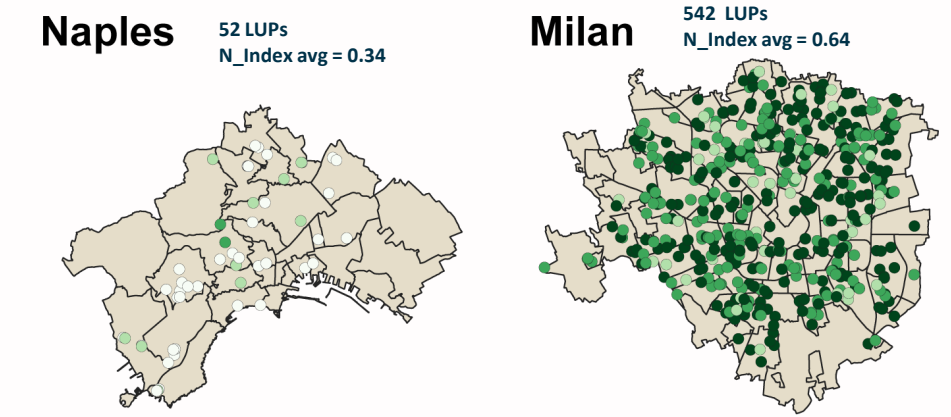
derived data: 568 aggregated populated census blocks



Hannover: 794 clumped polygons



Results: High Quality playgrounds distribution



High quality Playgrounds = characterized by enough space to play and presence of vegetation with structure diversity

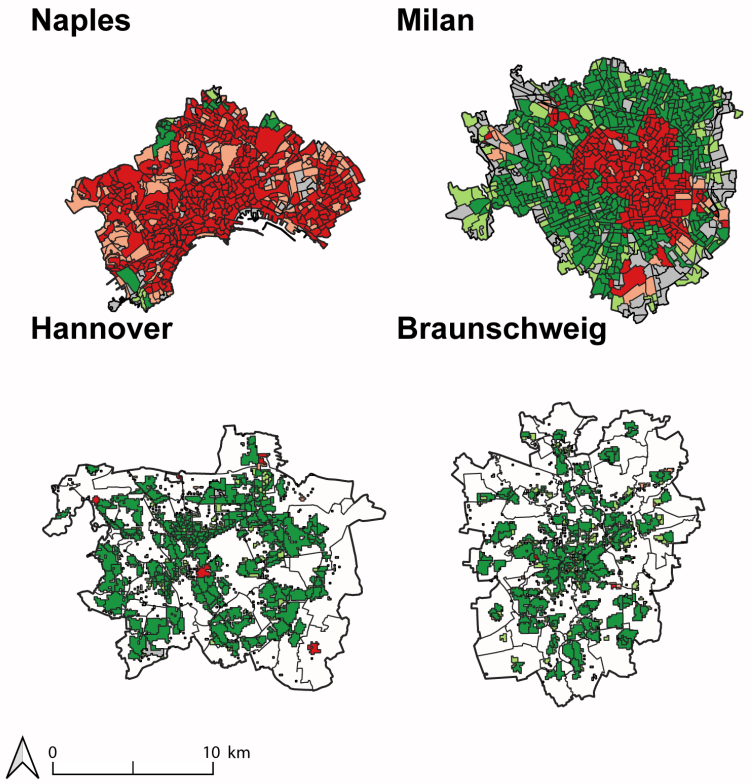
In Italian cities playgrounds are spread out more randomly, with only limited neighbourhood "clumps" in Milan.

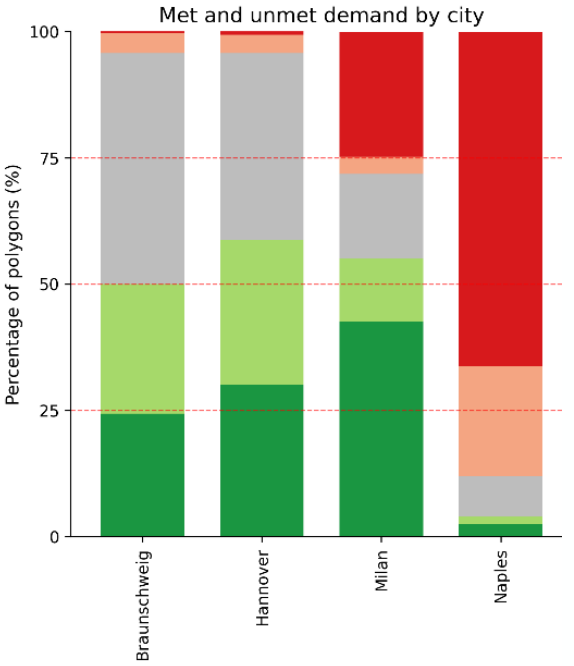
In German cities playgrounds tend to group together consistently, forming noticeable clusters

Example of Grey playgrounds

Example of Green playground

Results: High Quality playgrounds Met/Unmet demand





Answers the question:

- **Is the demand Met?**

Italian cities prevalence of un/met demand in highly populated areas (Milano shows a concentric shape) compared to **German cities**

Met - unmet demand

- Met demand but low request
- Fully met demand
- Severely unmet demand
- Unmet demand but low request
- No demand
- Urban Districts

predefined decision matrix

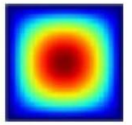
		ES Flow			
		High	Medium	Low	No service
ES Demand	High	Fully met demand		Severely un met demand	
	Medium				
	Low	Met demand but low request		Un-met demand but low request	
	No demand	No demand			

The determinants method: key steps

Dependent variable:
- ES Flow (continuous)

Spatial covariates:
- Socio-demographic variables
- Urban morphology descriptors

Spatial analysis:
- **MGWR**



Answers the question:
- What does shape ES Flow?
- Can we identify **:**
  - **Spatial drivers: drivers that vary across the space (significant MC test),**
  - **Structural drivers: drivers that act consistently across the entire city (global scale and high stability).**
  - Stability is measured : based on coefficient consistency across space. Variables with consistent signs and narrow value ranges were classified as highly stable,

Methodological steps

VIF + Pearson correlation
- Applied to avoid multicollinearity and identify common variables across the case studies

3 models tested
- Sensitivity test to evaluate model robustness/spatial structure/scale (Model 3 selected)

Monte Carlo Test
- Applied to evaluate spatial variation

Model	Role	Variables included	Purpose
1	Stable baseline	Child_dependency_ratio, green_sqm_per_capita	Tests a simple, low-collinearity **demographic–environmental** specification
2	Local sensitivity / stress test	Foreign_pop, NRD (ratio residential/non residential Buildings)	Tests whether socially and spatially structured predictors generate local heterogeneity
3	Balanced / multi-scale model	Child_dependency_ratio, green_sqm_per_capita, population density (only residential Bld)	Tests **demographic, environmental, and urban-structure effects together**

The determinants method: results

City	Model 3 R^2	
	Global	MGWR
Milan	0.38	**0.71**
Naples	0.06	**0.83**
Hannover	0.54	**0.80**
Braunschweig	0.62	**0.77**

After the evaluation of the 3 models results:

German cities show structured and robust spatial patterns, especially driven by child population

Italian cities display weak or unstable patterns with no consistent drivers

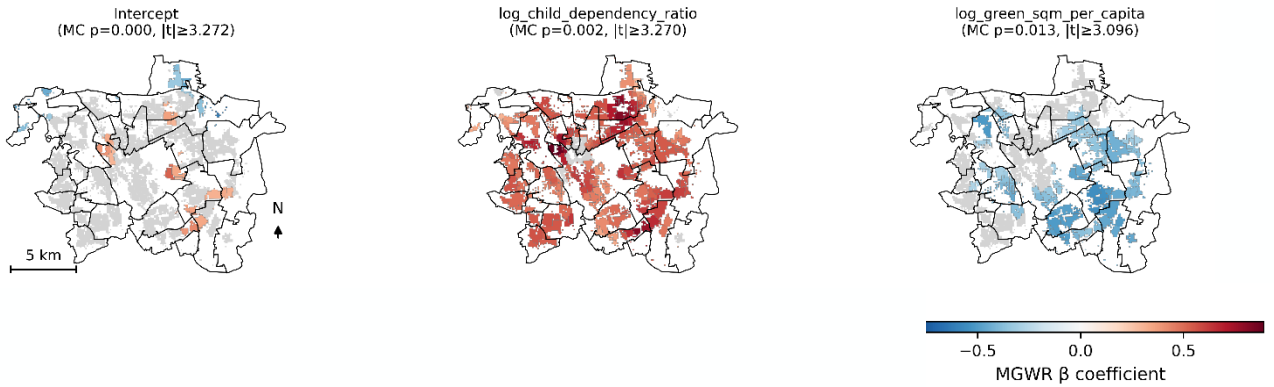
The MGWR overperformed the OLS regression -> pattern highly context related

City	Spatial Structure	Dominant Scale	Key Driver	Robustness
Milan	Weak / smooth	Regional	Child dependency	Low
Naples	Fragmented / unstable	Mixed	None consistent	Low
Hannover	Clear / local	Local	Child dependency	Moderate
Braunschweig	Structured / multi-scale	Local + Global	Child dep + pop Density	High

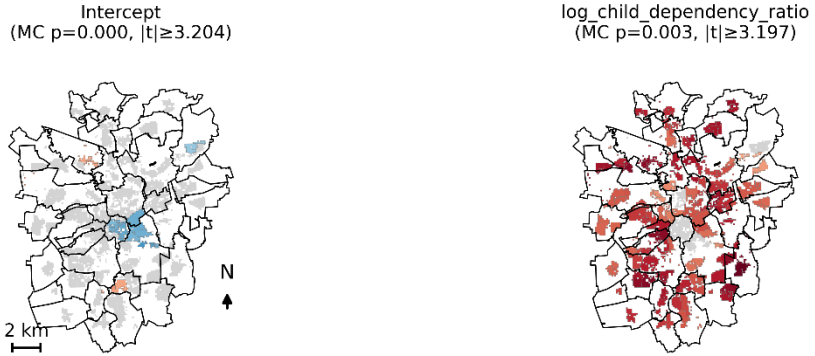
The determinants method: spatial results

Accessibility to high-naturalness playgrounds is shaped by different spatial processes across cities.

Hannover



Braunschweig



- **Hannover and Braunschweig** exhibit clear and interpretable spatial structures – complemented by locally statistically significant variables
- **Milan and Naples display** weak or inconsistent relationships, with limited statistical significance and low stability

- This suggests that **meaningful spatial heterogeneity** emerges only where accessibility is systematically **aligned** with **demographic demand and urban structure**

Conclusions

Methodology

- Consistent/comparable
- To be fully **replicable** more testing is needed

Local playgrounds

- Localisation based on **OSM**
- Evaluation based on **GEE**

Accessibility

- Additional level parametrisation

Challenge National Census Data (structure, **language**, identification….)

Additional services can be evaluated

THANKS

Annika Heuser

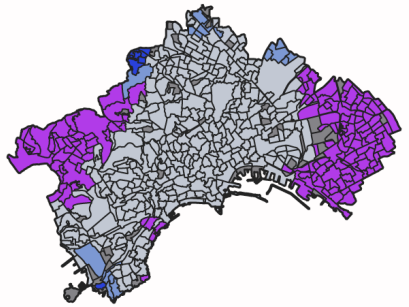
Dr. Grazia Zulian

Prof. Benjamin Burkhard

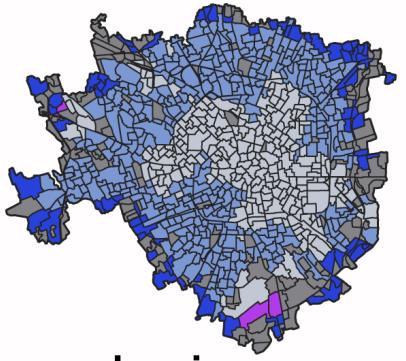
Results: High Quality playgrounds ES Flow

High quality Playgrounds ES Flow (accessibility)

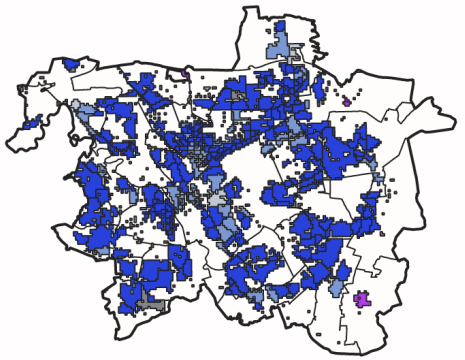
Naples



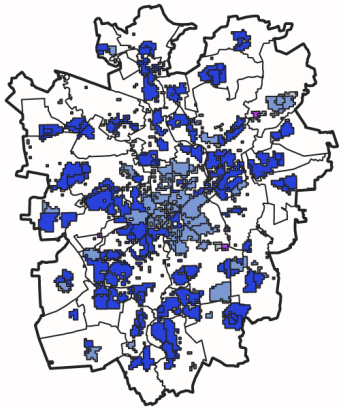
Milan

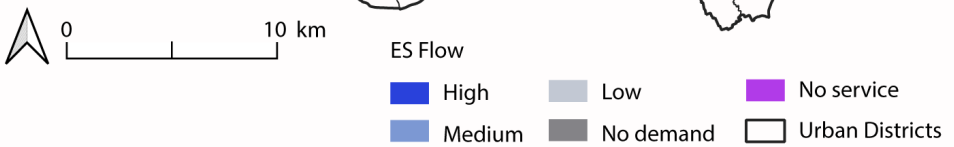


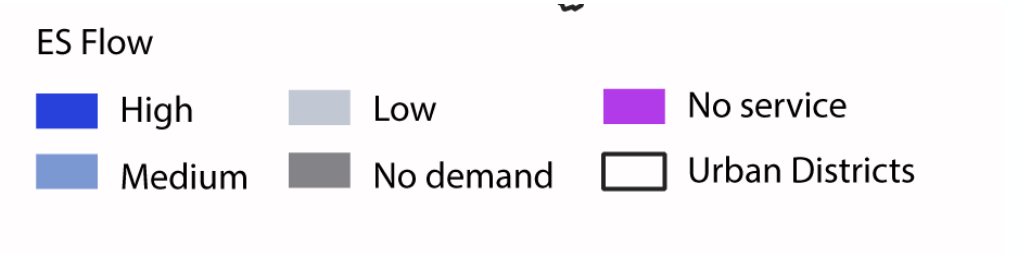
Hannover



Braunschweig

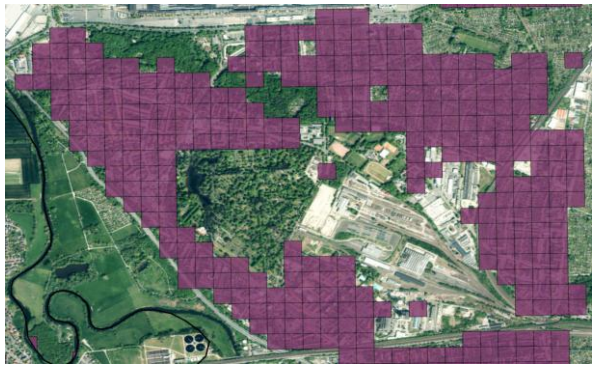




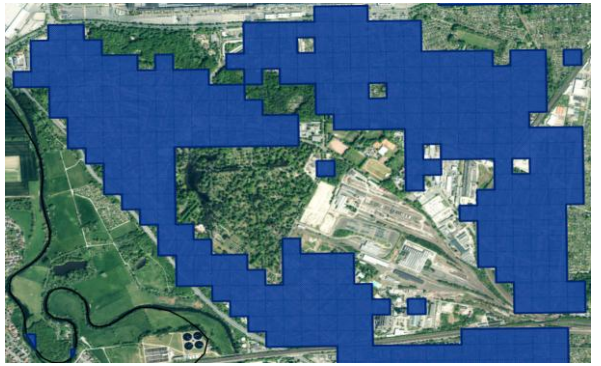


Italian cities prevalence of medium / low ES Flow compared to **German cities**

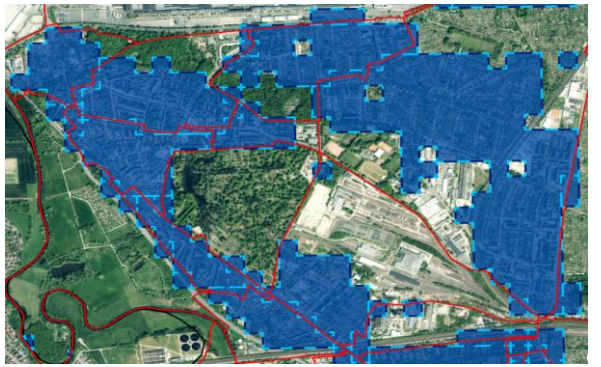
Clumping method applied to census GRIDS in Germany



100 m census grid cells

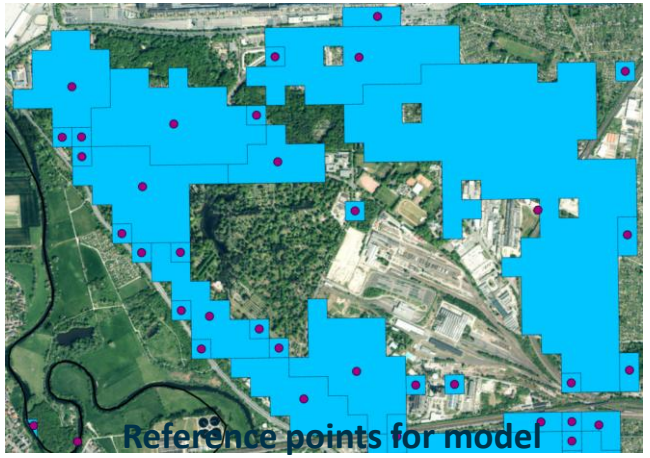


Contiguous census-cell clumps

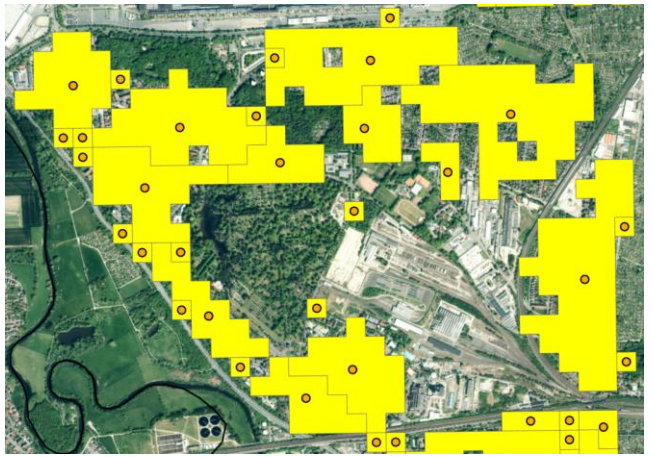


Cadastral sections and cutlines

- Population-based fragments and population-weighted centroids



Reference points for model calibration in (M)GWR, Spatial analysis units



Reference points for demand in E2SFCA

- Children-based fragments and children-weighted centroids