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Regional Development

State of the Map 2022
Florence, Italy

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Automated derivation of public urban green spaces via activity-related barriers using OpenStreetMap.

Theodor Rieche

About

Theodor Rieche

- cartographer & spatial scientist
- research associate at IOER, research area “Spatial Information and Modelling” (since December 2021)
- currently working in project GOAT 3.0 (Geo Open Accessibility Tool)
- interests: Open Source&Open Data, OSM, Spatial AI, Citizen Science …

Master thesis

Hochschule für Technik und Wirtschaft Dresden University of Applied Sciences

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- supervisors
  - Prof. Dr.-Ing. **Martina Müller** (University of Applied Sciences Dresden / HTW)
  - Dr.-Ing. **Robert Hecht** (Leibniz Institute of Ecological Urban and Regional Development Dresden / IOER)

Project „MeinGruen – Information and navigation to urban green spaces“

- Research project (2018-2021)
- Funded by BMVI (mFUND)
- Public urban green spaces
- „meinGrün“-App
- Filter by criteria or acitivity possible
- Pilot cities Dresden and Heidelberg
- Polygon base to store features

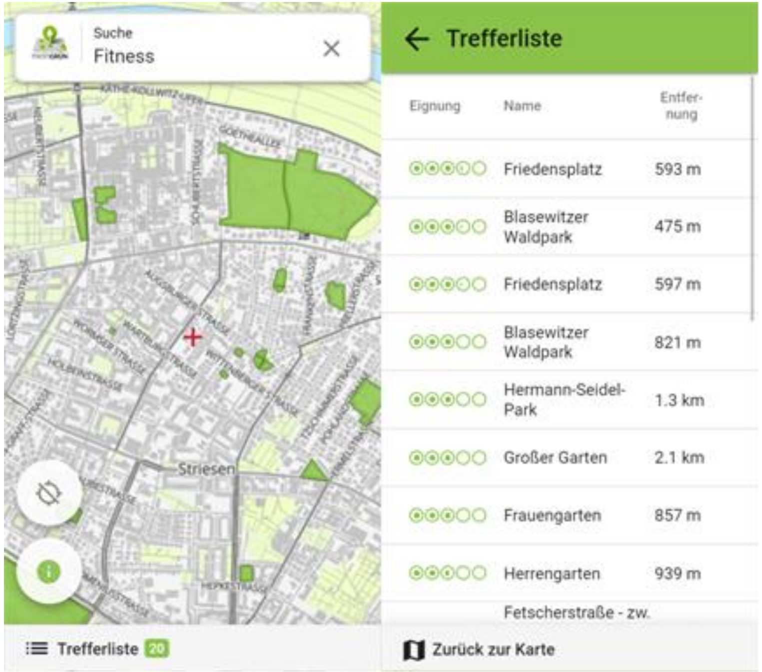

Fig. 1: Screenshot „meinGrün“-App [1]

[1] https://meingruen.ioer.info/

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Motivation

- Incomplete data of urban green spaces in official data
- Green spaces are missing (are more than parks)
- Different data sources → different data licenses → only OSM possible?
- Consideration of the reality of life / perception of the users of green spaces?
- Test of models to predict greenness or publicly accessibility?

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Research questions

- How well is OpenStreetMap data suited for deriving publicly accessible green spaces in urban areas?
- Which land use transitions or key-value (object type) mapped in OpenStreetMap have which probability of being a barrier?

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Study area

Pilot city Dresden (Germany) + 5 km buffer

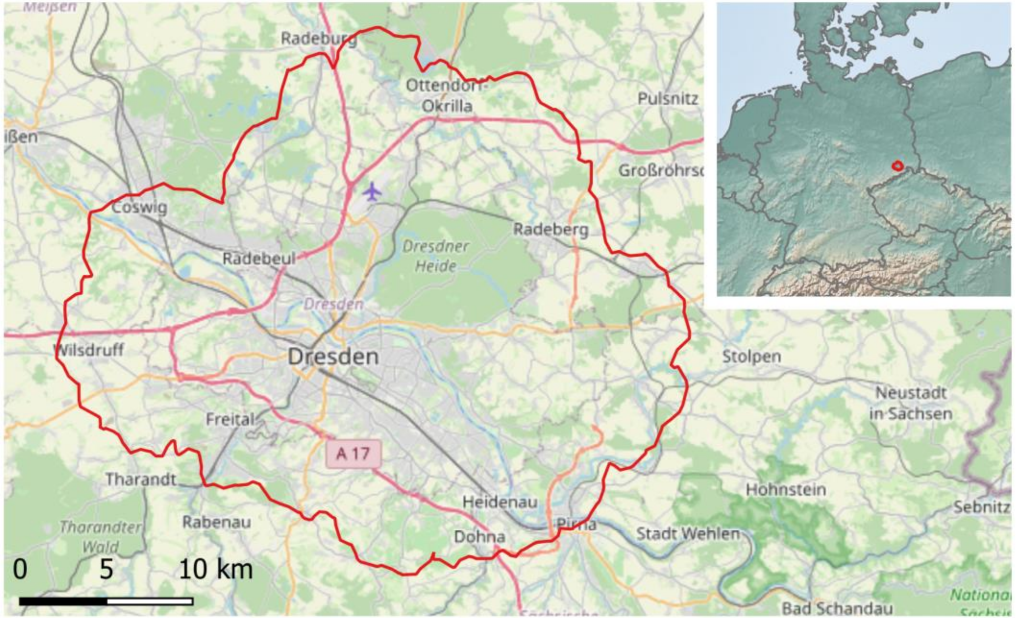

Fig. 2: Study area Dresden, Germany [2]

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Data sources

- OpenStreetMap
  - Streets, railroads, waterways, barriers, land use, …
- official cadastral data (ALKIS) → having field “TN” / land use
- cadastral parcels owned by the city of Dresden
  - Requested in the city council of the city of Dresden

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Definition of an activity-related barrier

- Physical barriers such as walls, fences, hedges (barrier=*)
- Action space of doing an activity → delimited by barriers
- Activities divided into „stationary“ or „in motion“
- Roads, railroads, waterways → are always barriers
- Trails or change of land use → uncertain knowledge of being a barrier

Ergo

- To simplify the model → reduction to stationary activities
- Conceptual framework extends OSM definition of barrier

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Definition of a activity-related barrier

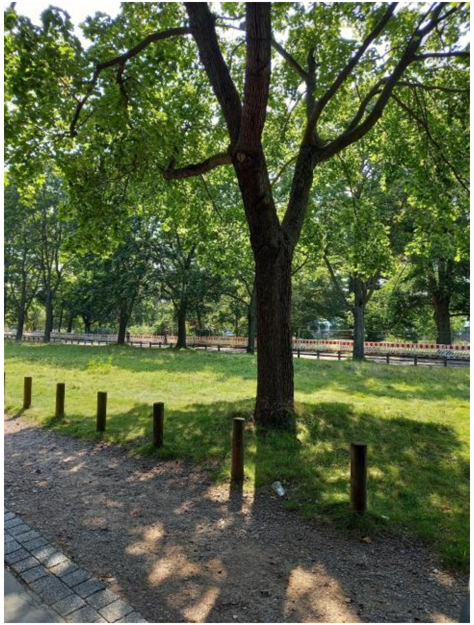

Fig. 3/4: Examples for barriers (flowerbeds, bollards)

Methodology

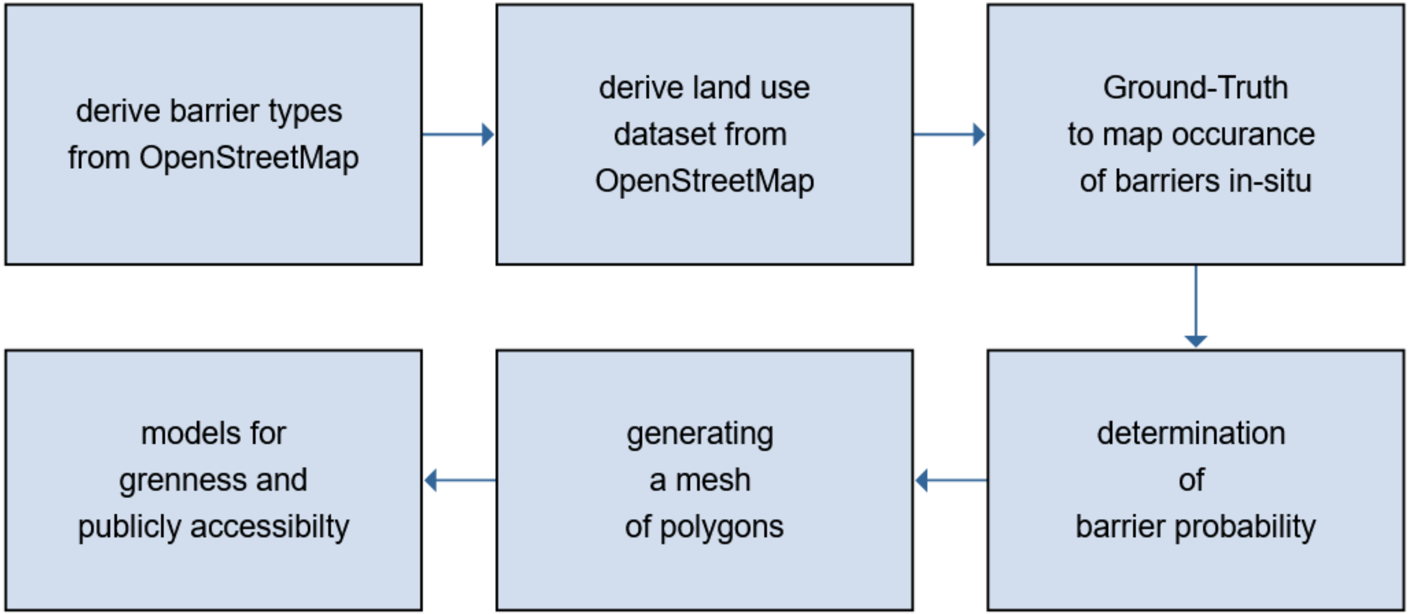

Fig. 5: conceptual framework

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Technical implementation

- Ubuntu 20.04 LTS
- dev environment based on Docker container
- Each container having specific installed packages
- PostgreSQL/ PostGIS-database
- SQL, PL/pgSQL, Python, Jupyter Notebook
- Open Source approach

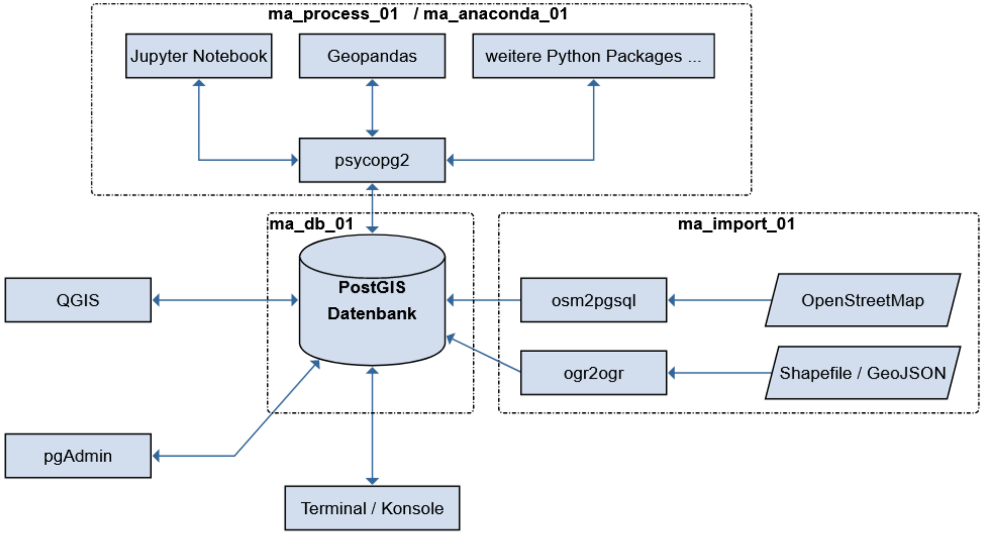

Fig. 6: Technical implementation

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Derivation of barrier types from OpenStreetMap

- Roads
- Railroads
- Waterways
- Barriers
- Trails
- Change of land use

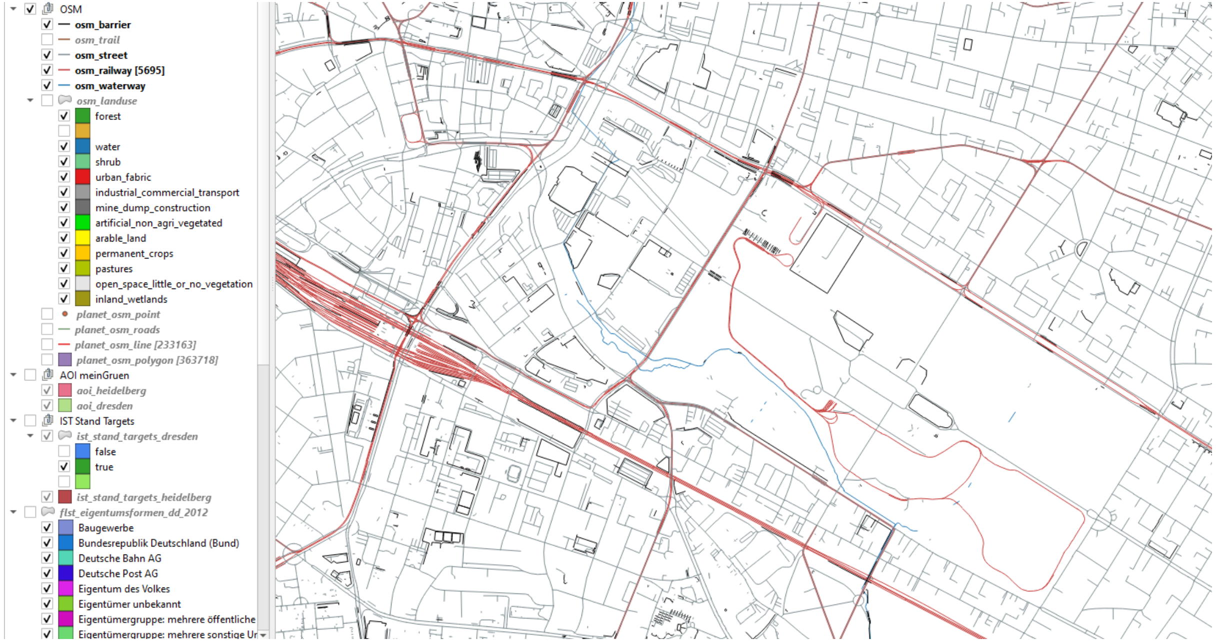

Fig. 7: derived barriers (Dresden, Germany)

Certain and uncertain knowledge

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osm_railway	osm_trail	osm_street	osm_waterway	osm_barrier
railway='construction' railway='disused' railway='facility' railway='funicular' railway='miniature' railway='narrow_gauge' railway='platform' railway='platform_edge' railway='preserved' railway='rail' railway='tram' railway='tram_stop' railway='turntable'	highway = 'bridleway' highway = 'cycleway' highway = 'footway' highway = 'no' highway = 'path' highway = 'track'	highway = 'construction' highway = 'living_street' highway = 'motorway' highway = 'motorway_link' highway = 'pedestrian' highway = 'platform' highway = 'primary' highway = 'primary_link' highway = 'raceway' highway = 'residential' highway = 'road' highway = 'secondary' highway = 'secondary_link' highway = 'service' highway = 'steps' highway = 'tertiary' highway = 'tertiary_link' highway = 'trunk' highway = 'trunk_link' highway = 'unclassified'	waterway = 'canal' waterway = 'dam' waterway = 'ditch' waterway = 'drain' waterway = 'fish_pass' waterway = 'river' waterway = 'stream'	barrier=* (all values are relevant)
Remove bridges and tunnels. highway=elevator, only if no closed line (to avoid indoor elevators)	Remove bridges and tunnels. highway=steps, check adjazent highway-key	Remove bridges and tunnels. highway=steps, check adjazent highway-key	Remove bridges and tunnels. also tunnel=culvert	Applied to osm „polygons" and „lines". Also convert „poylgons" to „lines".

Fig. 8: derivation of barriers from OpenStreetMap

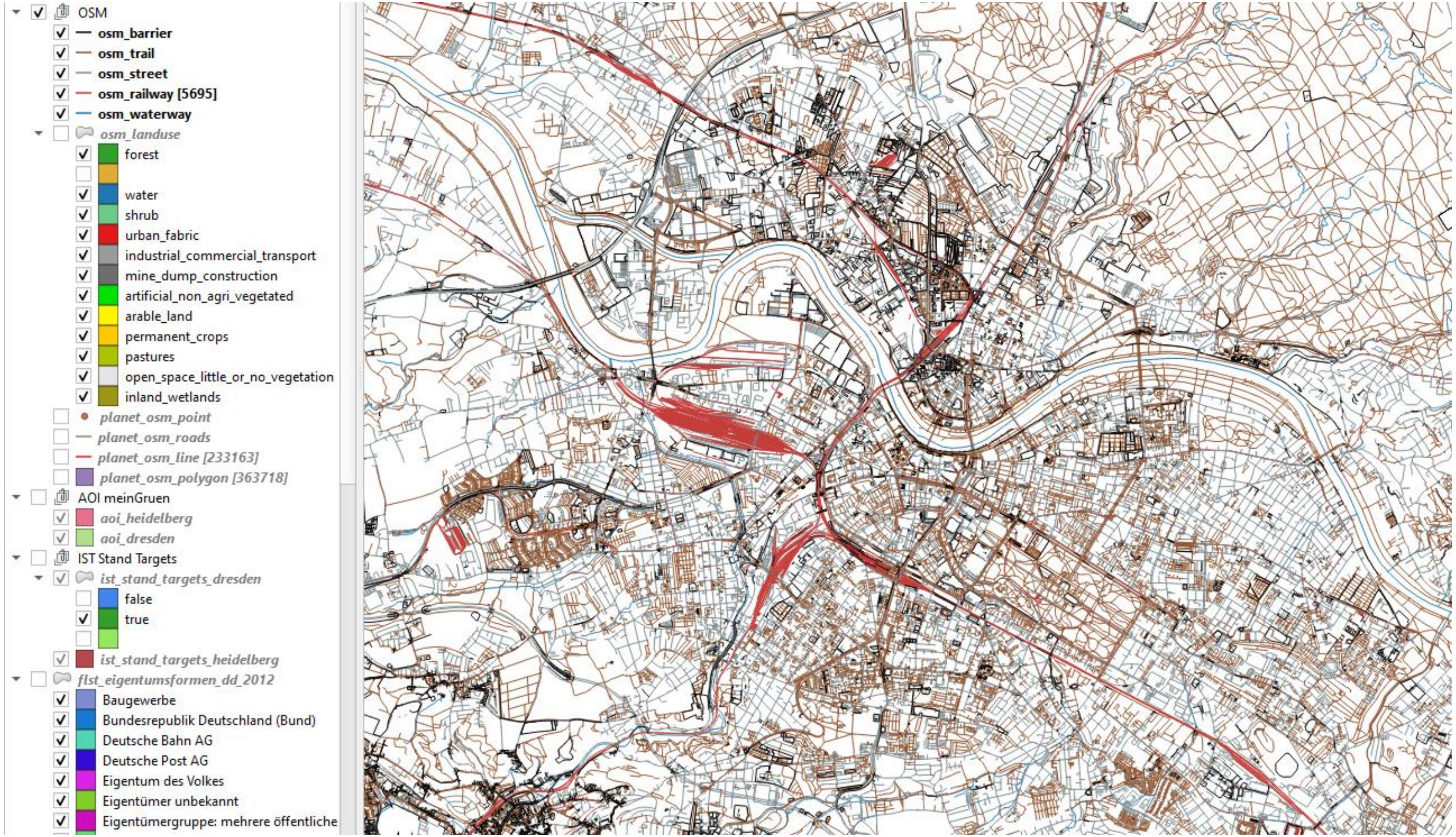
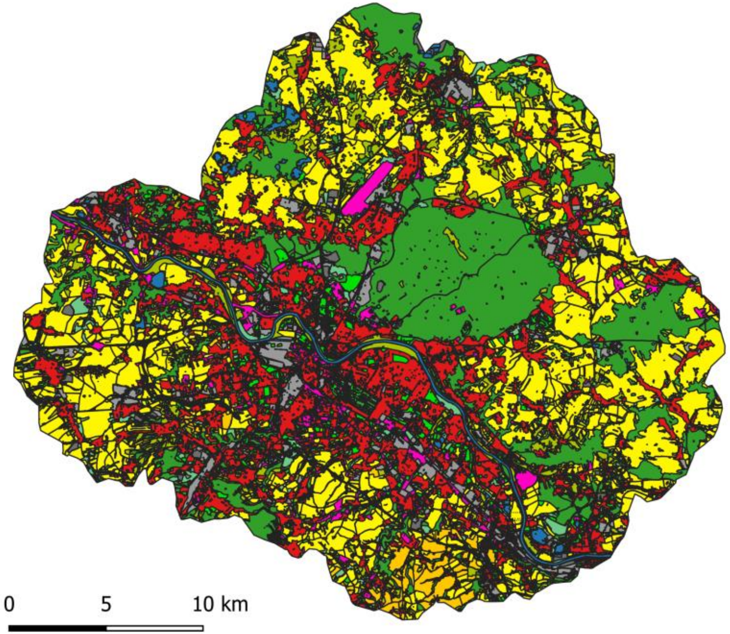


Fig. 9: Screenshot QGIS showing derived barriers

Derivation of land use layer (without overlaps and holes)

- To extract land use changes as lines; also using a residual class



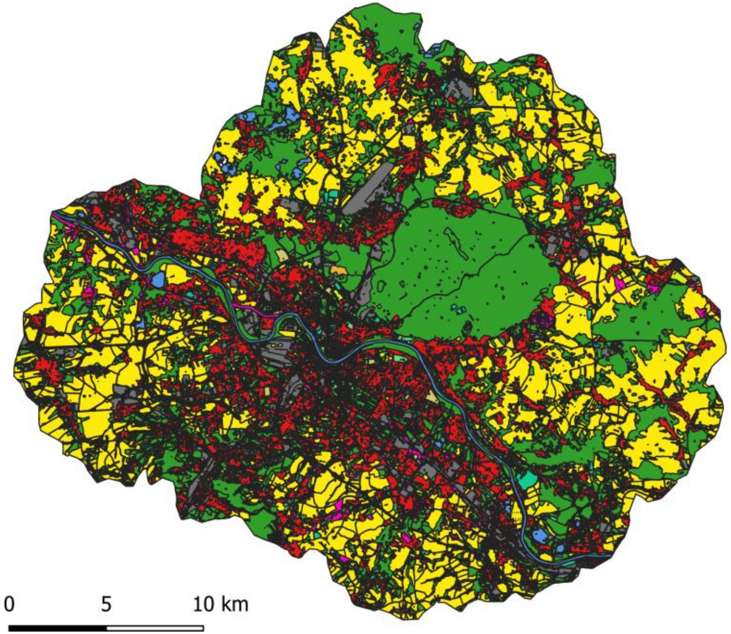


Fig. 10/11: option A (GIScience / osmlanduse.org) and option B (IOER Monitor)

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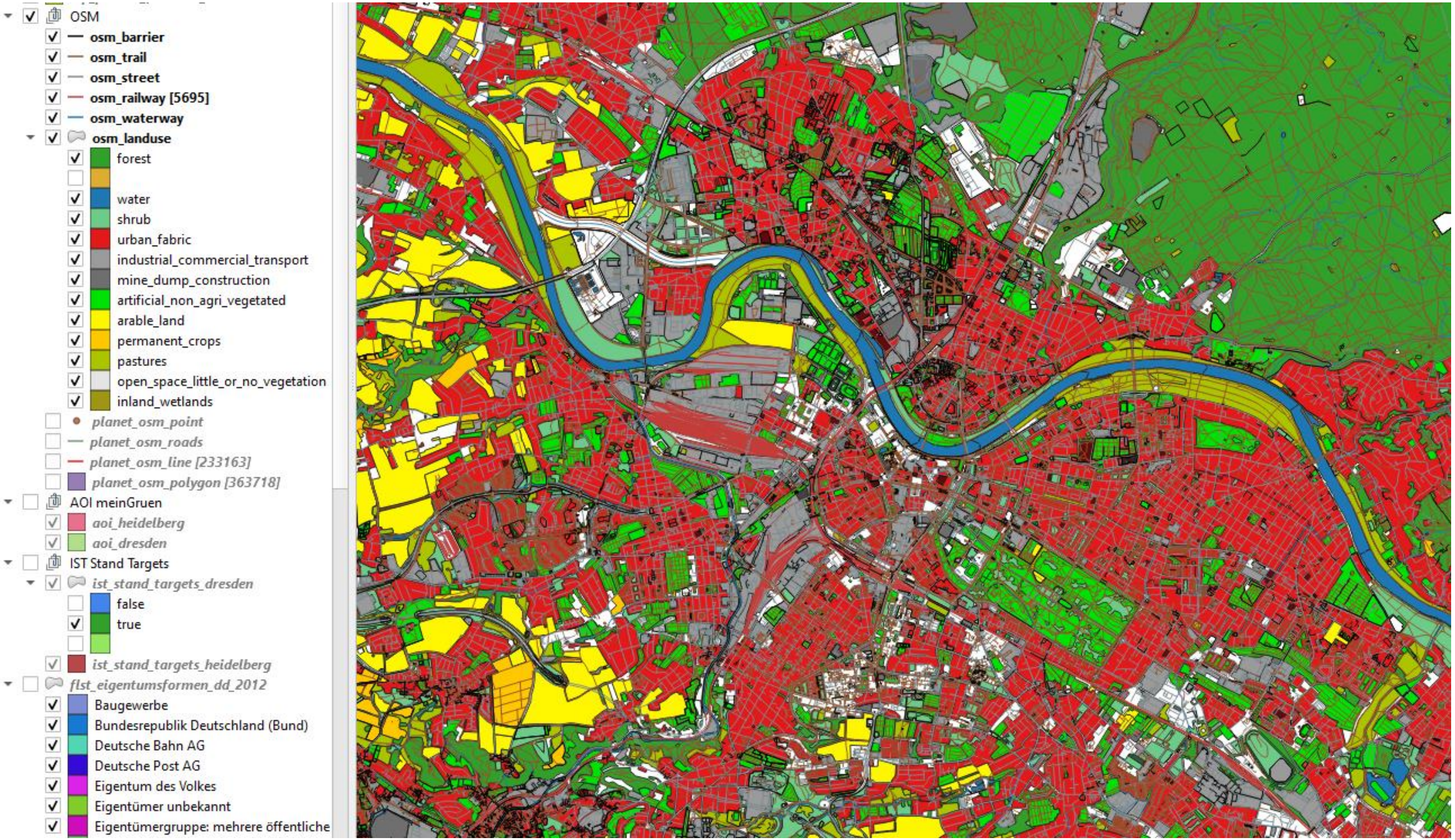
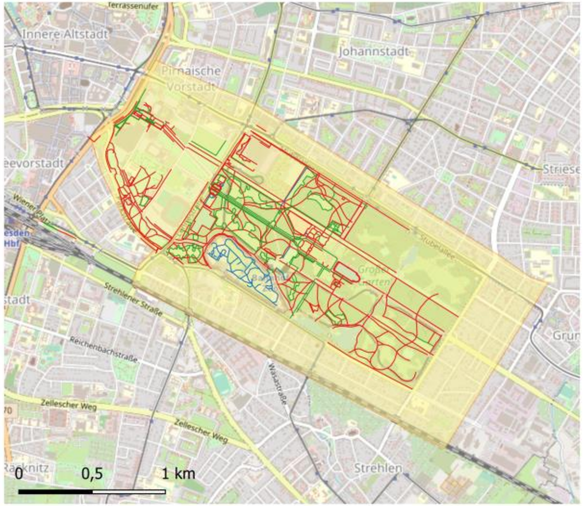


Fig. 12: Screenshot QGIS showing land use

Ground-Truth in-situ mapping

Only for trails and land use changes

- Goal: generate knowledge about being a barrier by type
- QField-App with prepared forms, Barrier: „yes“, „no“, „nodata“



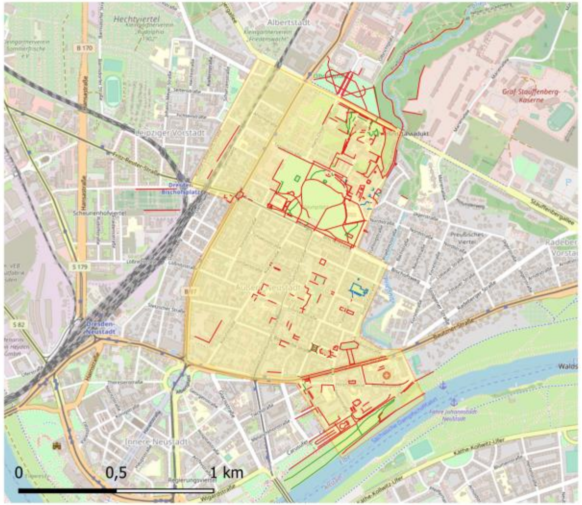


Fig. 13/14: mapped barriers (city park area and new town area in Dresden)

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Ground-Truth in-situ mapping

Mapped objects:

area	trails		land use changes	
	number	∑ length	number	∑ length
city park	297	64.682,28 m	1.145	41.429,90 m
new town	96	12.802,35 m	548	19.718,66 m
miscellaneous	15	4.816,81 m	27	3.057,84 m
sum	408	82.301,44 m	1.720	64.206,40 m

Fig. 15: mapped line segments

- Barrier probabilities were calculated for each type of trail or land use change
- Weighted by length

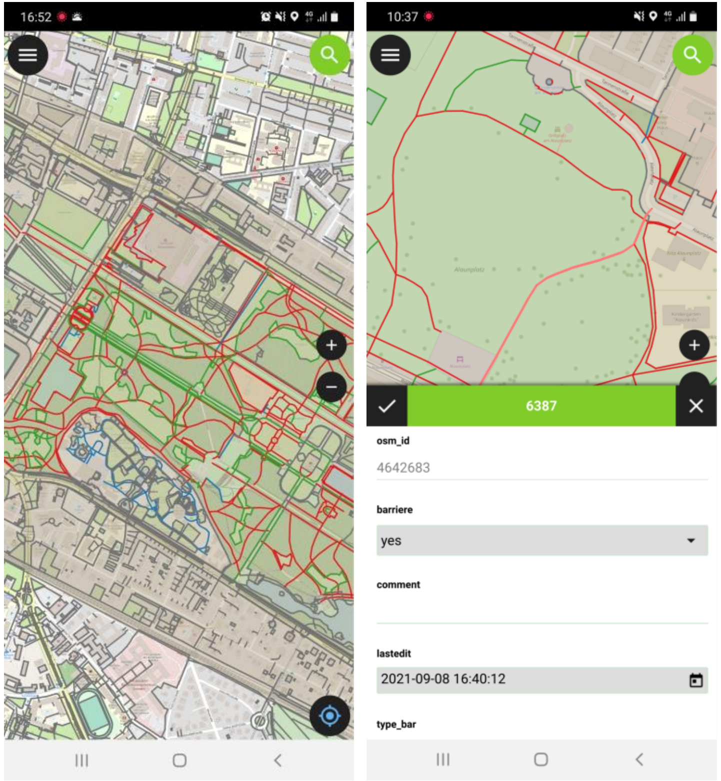

Fig. 16: screenshots QField app

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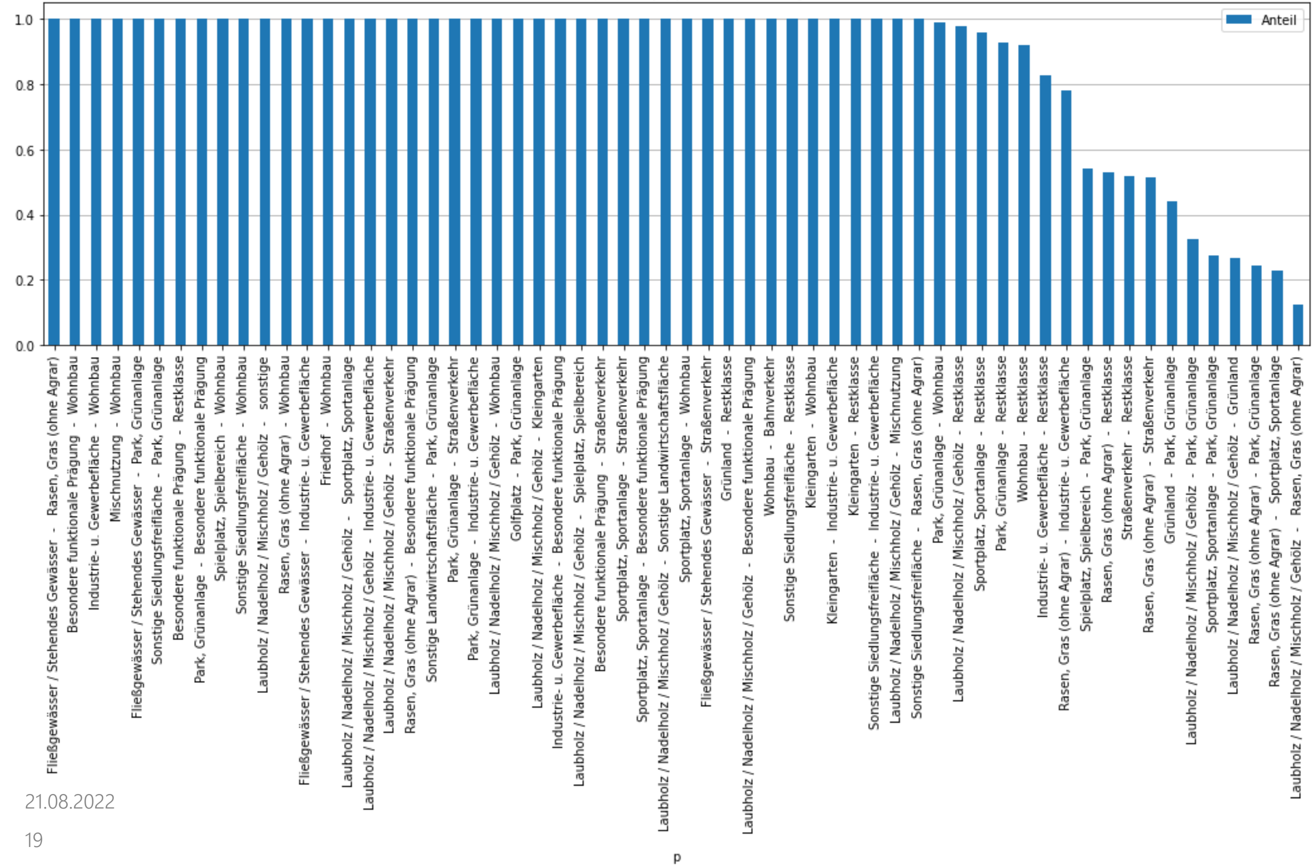
Results of barrier probabilities

barrier probability by land use change



barrier probability by trail type

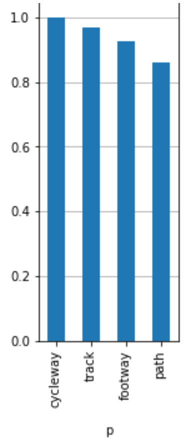


Fig. 17/18: barrier prob. for land use change and trail typ

(Unfortunately only with german labels)

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Generating a polygon mesh

- First: creating a dataset of all lines („line pool“)

Barrier type	**Additional attributes for each line**		
	„origin“ type of barrier	**„buffer“ in meter (half width of real world object)**	**„likelihood“ being a barrier, with 0 ≤ p ≤ 1**
streets	osm_street	highway = 'motorway': **5,25** highway != 'motorway': **3**	**1**
railroads	osm_railway	railway != 'tram': **3,75** railway = 'tram': **2,25**	**1**
waterways	osm_waterway	**1**	**1**
barriers	osm_barrier	**0**	**1**
trails	osm_trail	**1**	**0 … 1** (from ground-truth)
land use change	lu_change	**0**	**0 … 1** (from ground-truth)

Fig. 19: additional attributes for line segments

- Second: polygon mesh (`ST_Polygonize()`) for different thresholds of „likelihood“ → representing different action spaces of activities

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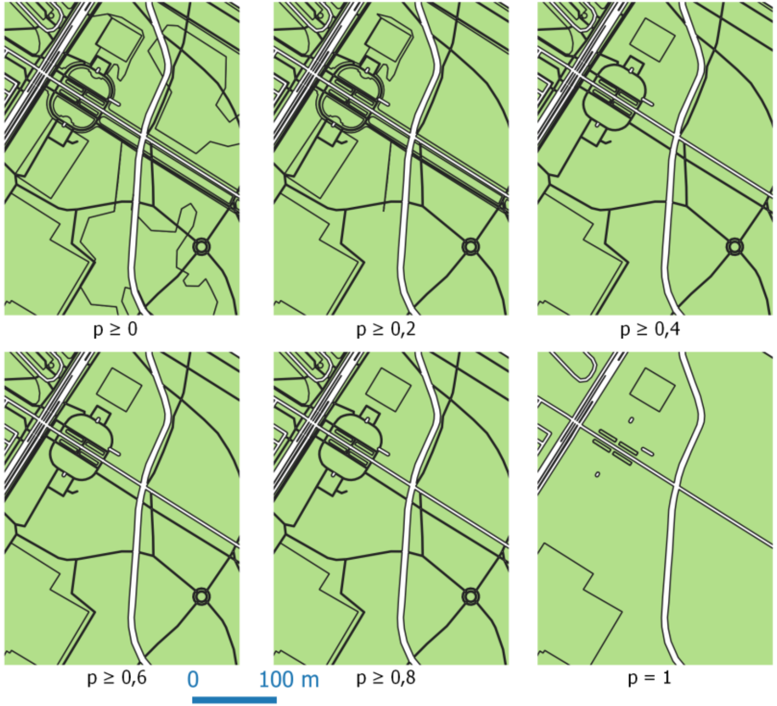
Polygon mesh

Selecting different polygons based on different intervals for barrier likelihood



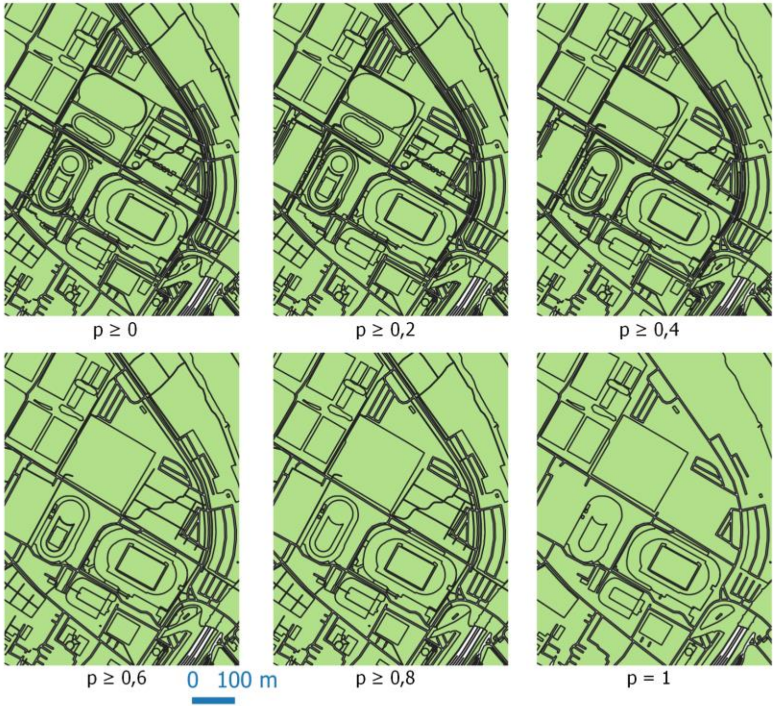


Fig. 20/21: polygon mesh in city park (left) and Ostragehege (right), Dresden

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Model to predict publicly accessibility

Input features of each polygon

- Number of benches
- Number of waste baskets
- Number of public toilets
- Number of public internet / wifi

Reference data: cadastral parcels owned by the city of Dresden (17840 polygons)

Assumption: cadastral parcels owned by the city of Dresden will be publicly accessible

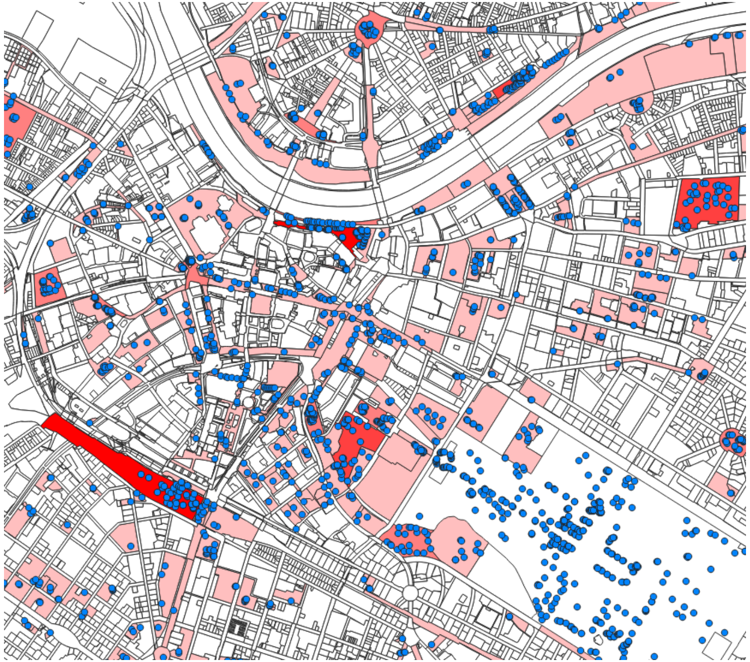

Fig. 22: relation polygons to benches

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Logistic Regression

- Target
  - 0: not publicly accessible
  - 1: puclicly accessible
- Counts *(in BBox)*
  - Total: 27126
  - 0: 26732
  - 1: 430

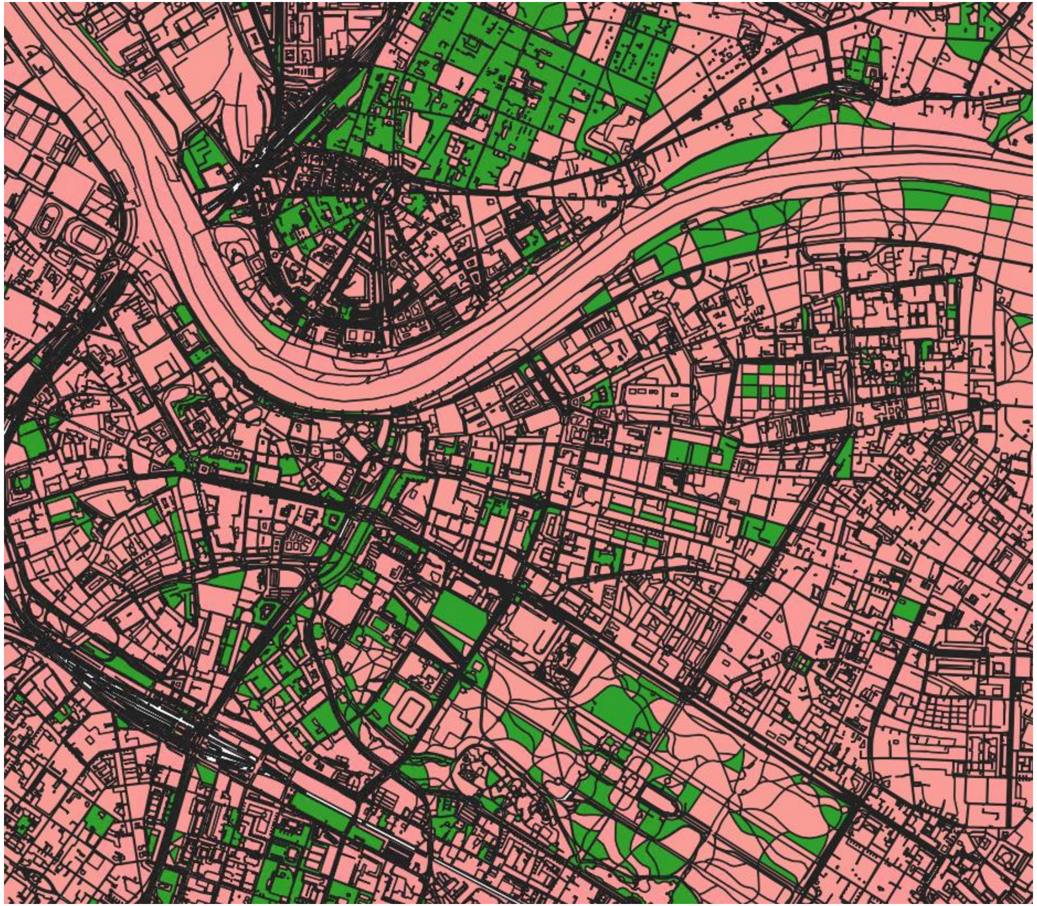

Fig. 23: result publicly accessibility

bench (in_1)	waste basket (in_4)	public toilet (in_8)	Öffentliches Internet (in_9)	Score
Logistic Regression				
X	X	X	X	0,767433
X	X	X		0,767433
X	X		X	0,767096
X		X	X	0,766424
	X	X	X	0,767321
Support Vector Classsifier (SVC)				
X	X	X	X	0,767545
X	X	X		0,767545
X	X		X	0,767321
X		X	X	0,766200
	X	X	X	0,767321
SVC with Radial Basis Function (C=1E6, gamma=1.)				
X	X	X	X	0,772197
X	X	X		0,771804
X	X		X	0,771637
X		X	X	0,770123
	X	X	X	0,769170

Fig. 24: intrinsic score

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Model to predict greenness

Input features of each polygon

- Number of benches
- Number of picnic tables
- Number of trees
- Number of waste baskets

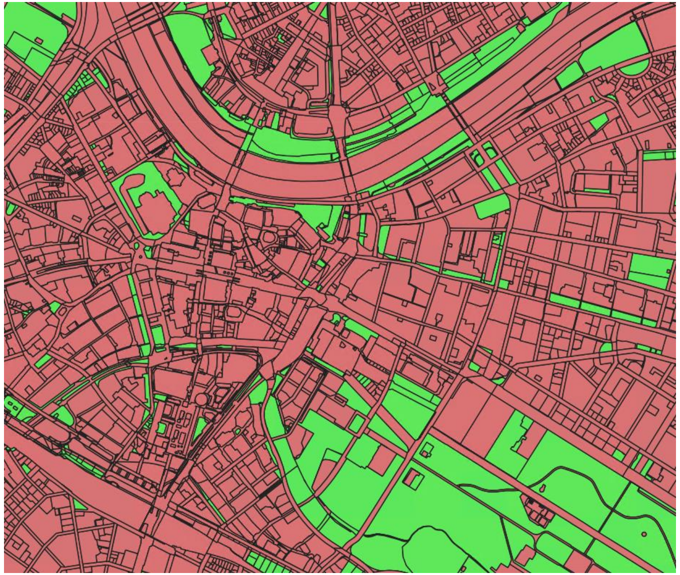

Fig. 25: reference data showing greenness

Reference data: official cadastral data (ALKIS) + land use information (22753 polygons)

Assumotion: land use type „Wald“, „Gehölz“, „Friedhof“, „Sport-, Freizeit- und Erholungsfläche“ represents greenness

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Logistic Regression

- Target
  - 0: not green
  - 1: green
- Counts *(in BBox)*
  - Total: 26472
  - 0: 26732
  - 1: 690

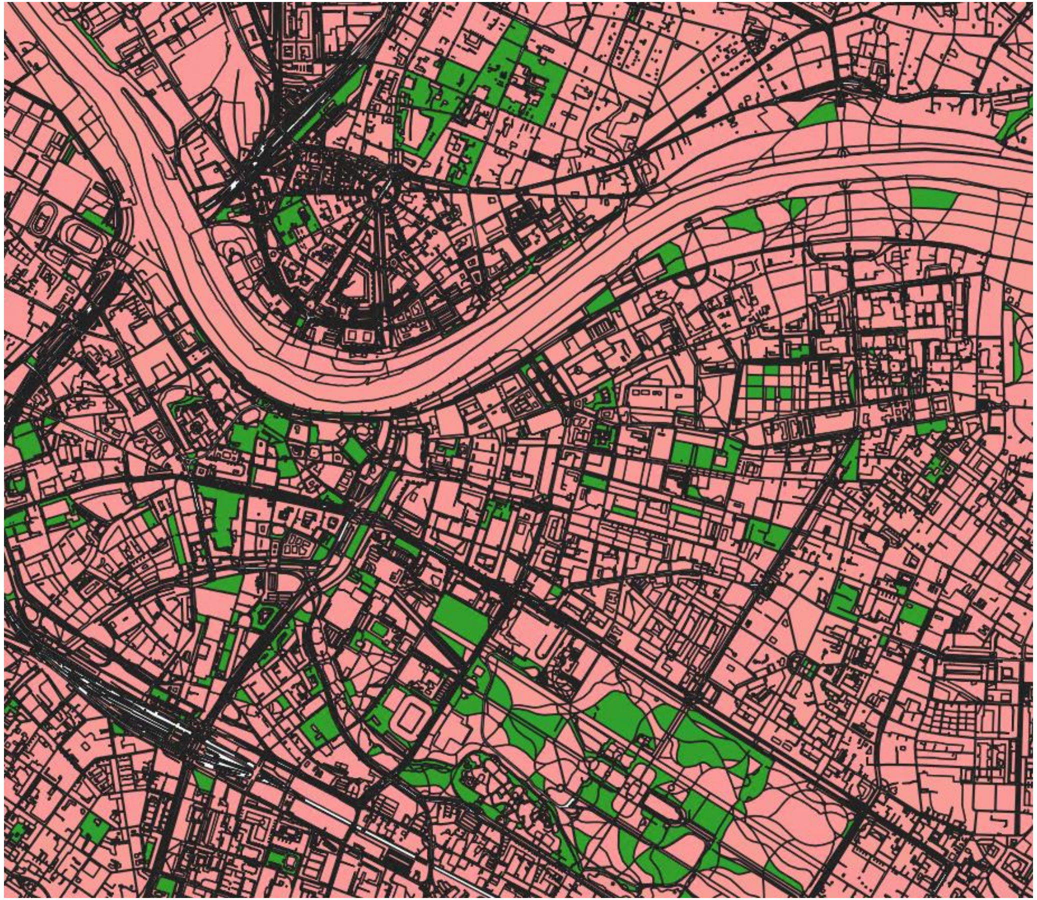

Fig. 26: result greenness

Model to predict greenness

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bench (in_1)	picnic table (in_2)	tree (in_3)	waste baskets (in_4)	Score
Logistic Regression				
X	X	X	X	0,922867
X	X	X		0,922779
X	X		X	0,922867
X		X	X	0,922867
	X	X	X	0,922691
Support Vector Classsifier (SVC) with linear Kernel and C=1				
X	X	X	X	0,926018
X	X	X		0,925432
X	X		X	0,926018
X		X	X	0,926018
	X	X	X	0,926018

Fig. 27: intrinsic score

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Conclusion and outlook

- A new approach of generating urban green spaces
- First testing show good results

Outlook

- E. g.: XGBoost, grid search for parameters, feature importance
- Generate further input features (path density, other POIs, geometry…)
- Intersect with greenness from remote sensing
- Testing in further cities, mapping more barrier probabilities

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Return to OpenStreetMap project

- Completeness analysis of barrier=* ?
- Creating an assistant layer as a help to map land use / land cover ?
- Knowledge about barrier probability and publicly accessibility could be useful to improve routing, e.g. Open Space routing (through polygons)
- …

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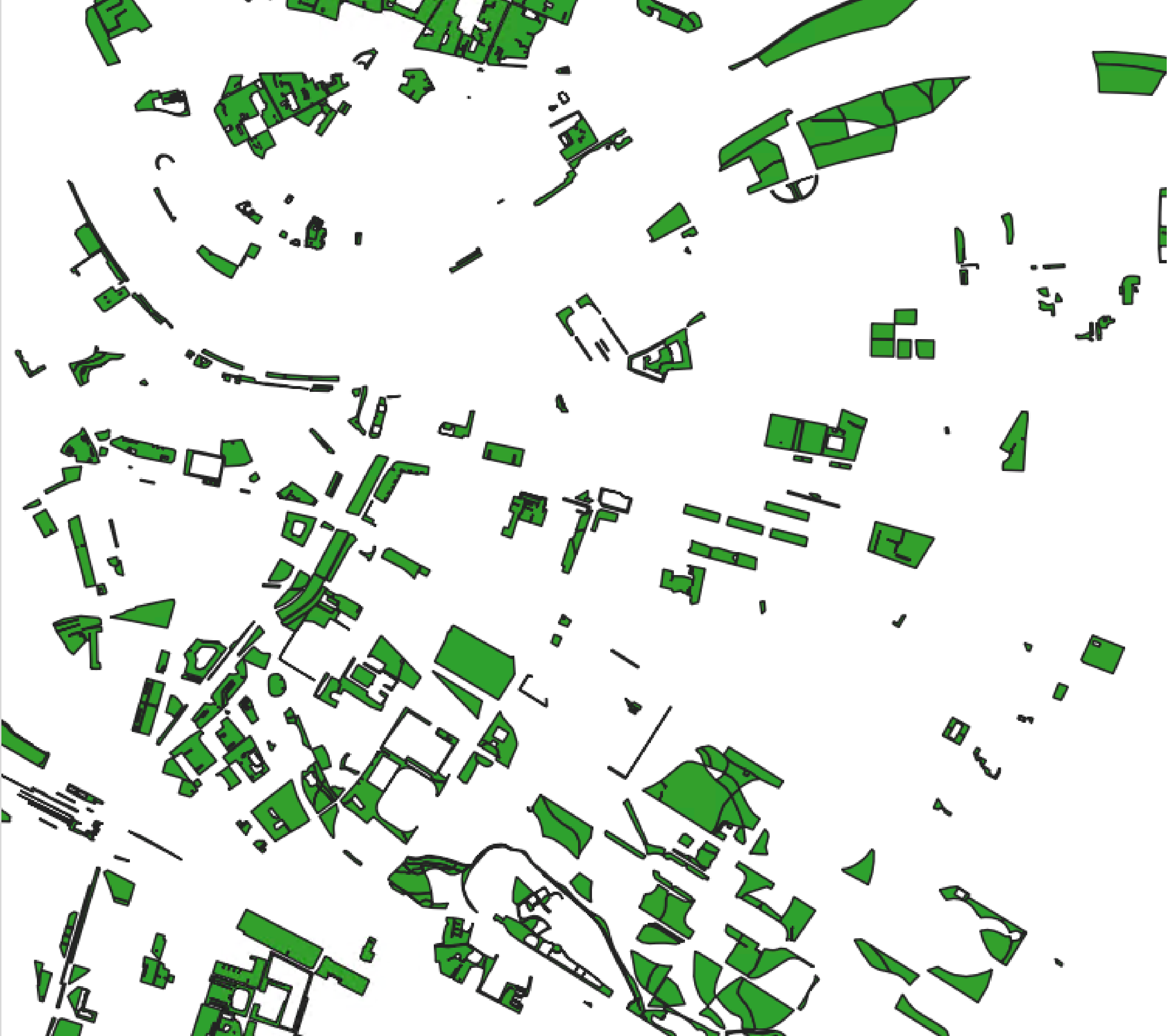

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Thank you for your attention!

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source code & master thesis:
https://github.com/traveller195/master-thesis_green_spaces_derived_from_osm