

Johannes Weber, Caroline Koszowski, Regine Gerike

“Friedrich List” Faculty of Transport and Traffic Sciences

Chair of Integrated Transport Planning and Traffic Engineering (IVST)

Comparing walkability of two neighborhoods in the City of Berlin

A GIS-based study on urban and transport structure

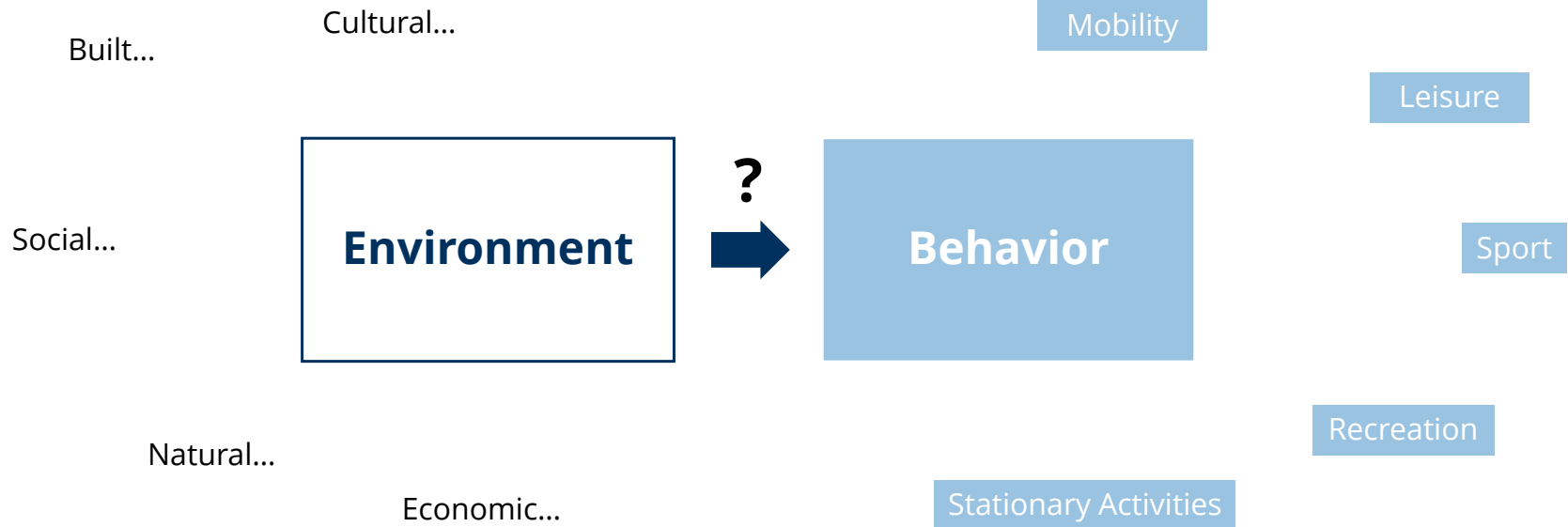
Session 02: Planning for active transportation

Urban Transitions 2022 // Sitges, 8 November 2022

Agenda

1. Introduction
2. Study Areas
3. GIS-Based Analysis Approach
4. Comparative Measurements
5. Evaluating the Analysis
6. Conclusions and Outlook

How to quantify walkability?



Elements of Walkability

(by Fitzsimons D'Arcy 2013)

Neighborhood



Transport System



Urban Design

- Density
- Connectivity and Permeability
- Land Use

- Sense of Place
- Safety
- Comfort
- Interest
- Legibility, Wayfinding and Feasibility

Neighborhood (*objective*)

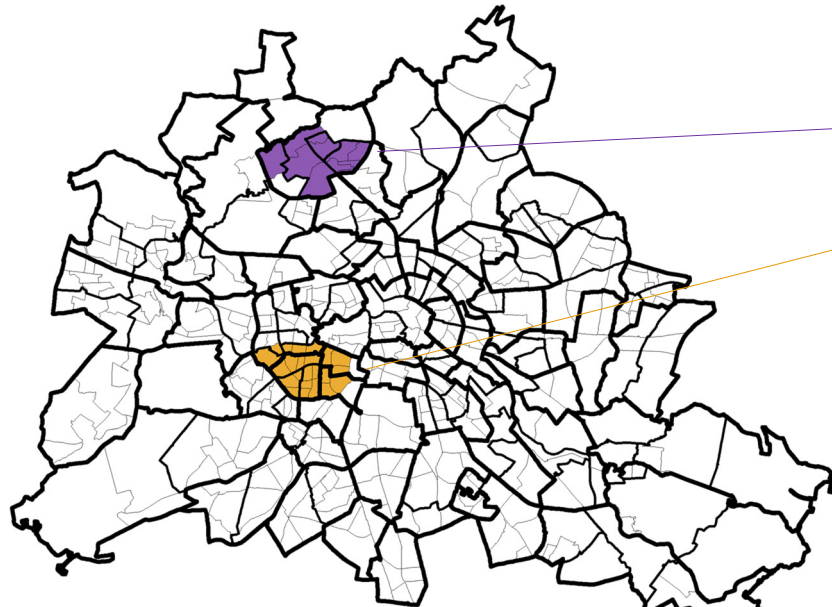
Streetscape (*individually perceived*)

Image: SenSW Berlin / DOP20RGB 2017 (DL-DE/BY-2-0)

Image: Weber

Study Areas

Part of the Living Environment Area (LEA) Hierarchy



Wittenau - Märkisches Viertel

Total Area: 1.379 ha

Schöneberg - Wilmerdorf

Total Area: 1.261 ha

Demarcation by:

- Uniform building and social structures
- Arterial roads and natural barriers
- Population
- Block margins

0 5.000 10.000 20.000
Meters

Prognosis Area
District Region
Planning Areas



Study Areas

Building Patterns

Schöneberg - Wilmersdorf



Wittenau – Märkisches Viertel



0 500 1.000 2.000
Meters



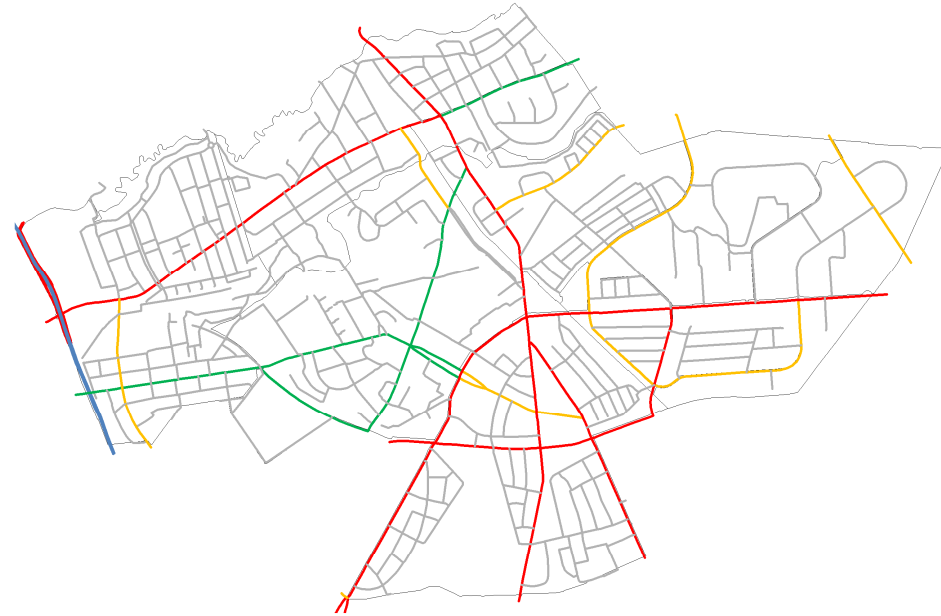
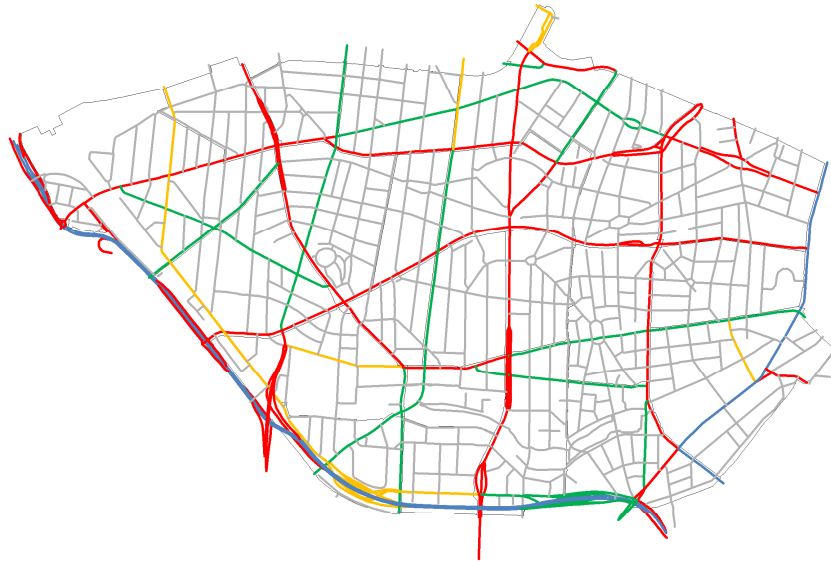
Study Areas

Function Levels (Directives for Integrated Network Design)

Schöneberg - Wilmersdorf

Wittenau – Märkisches Viertel

Data: SenSW Berlin / LOR Vektordaten (CC BY 3.0 DE)
SenUVK Berlin / Detailnetz Berlin (DL-DE/BY-2-0)



I – Large scale
II – National

III – Regional
IV – Local connectors

V – Small scale / Not categorized



GIS-Based Analysis Approach

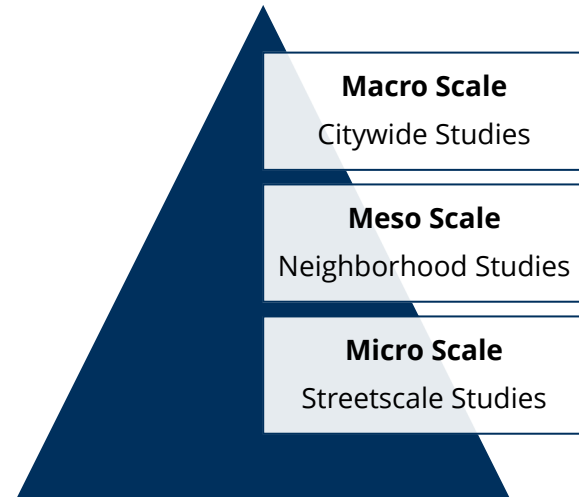
Measurement and Scale

Measurement of Walkability

| Walkability Measurement | Direct Method | Indirect Method |
|-------------------------|---------------------------|---|
| Objective Measurement | Direct field observations | Evaluation of secondary data using geographic informational system (GIS) techniques |
| Subjective Measurement | Interviews or surveys | Evaluation of built environment attributes related to perceptual response |

based on Ewing et al. 2006; Rafiemanzelat et al. 2017




Scales



based on Fitzsimons D'Arcy 2013; King et al. 2002

Comparative Measurements

Selected Indicators

| | Measurement | Indicator | References | Data Sources |
|---|--------------|---|---|---|
|  | Density | Gross Population Density | Forsyth et al. 2007 | Einwohnerdichte 2016 AfS (Statistical Office of Berlin-Brandenburg) |
|  | Connectivity | City Block Structure Census Block Density | Frank et al. 2000 | Statistische Blöcke AfS (Statistical Office of Berlin-Brandenburg) Nutzungshomogene Teilblöcke ISU (Urban and Environment Information System) |
| | | Walkable Street and Pedestrian Network Intersection Density Connected Node Ratio Amenity Pedsheds | Reilly et Landis 2003 Dill 2004 Ellis et al. 2016 | Detailnetz Berlin Fußgängernetz Berlin SenUVK (Senate Department for the Environment, Transport and Climate Protection) Infrastruktureinrichtungen OSM (OpenStreetMap) |
|  | Land Use Mix | Entropy Index | Frank et al. 2005 Leslie et al. 2007 | Tatsächliche Nutzung ALKIS Berlin (Official Cadastral Information System) |

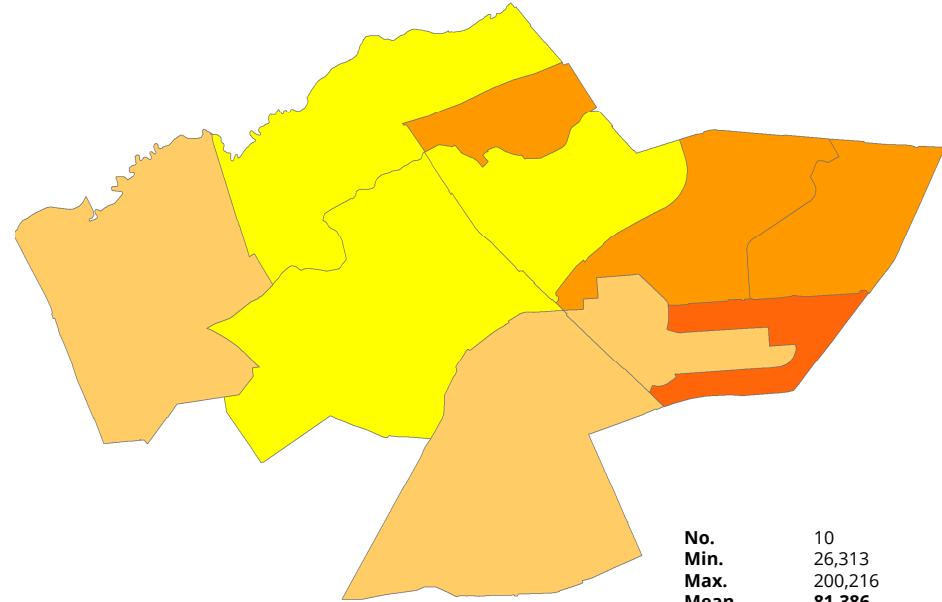
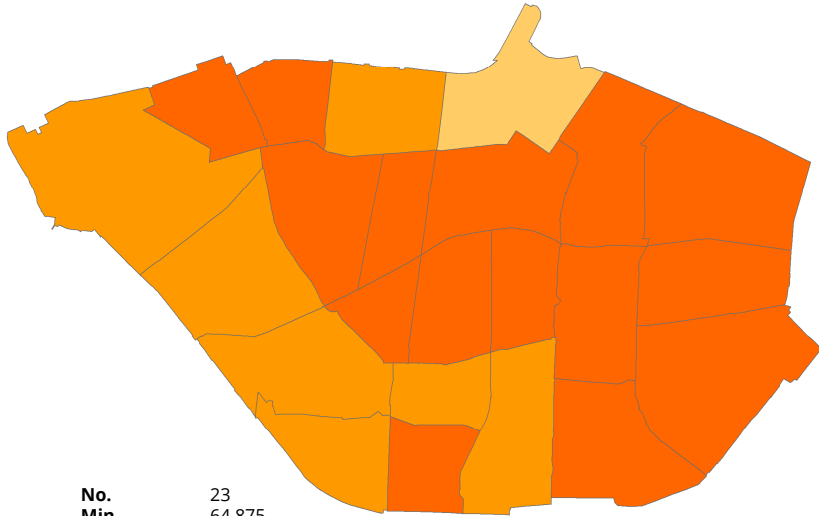
Density

Population Density per Living Environment Area (LEA)

Inhabitants
ha

Schöneberg - Wilmerdorf

Wittenau – Märkisches Viertel



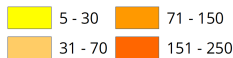
No. 23
Min. 64,875
Max. 233,870
Mean 157,364
SD 47,906

No. 10
Min. 26,313
Max. 200,216
Mean 81,386
SD 55,638

Total 151,517

City Reference 40

Total 61,880



Data: AFS Berlin-Brandenburg / EWR_LOR_31.12.2016 (CC BY 3.0 DE)
SenSW Berlin / LOR_Vektordaten (CC BY 3.0 DE)

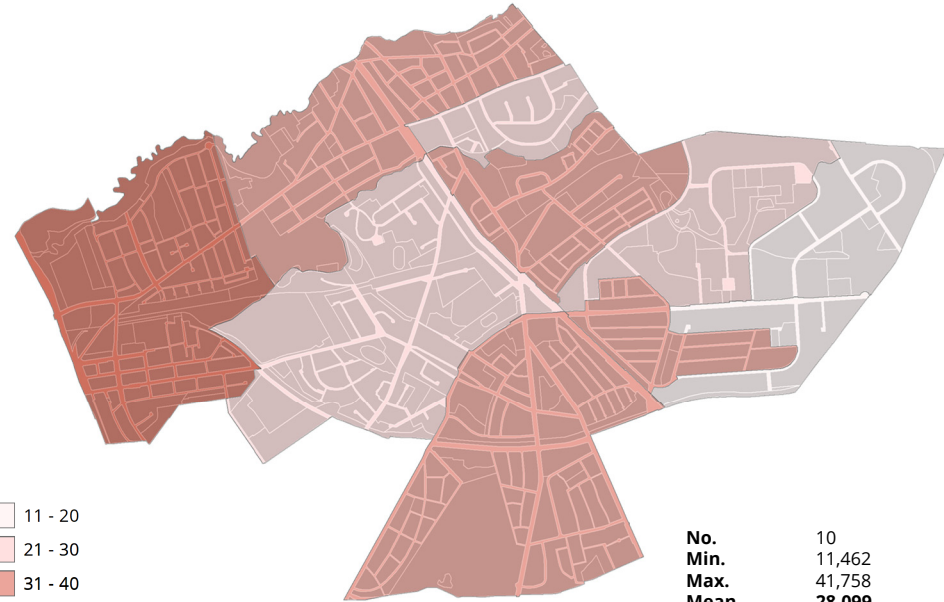
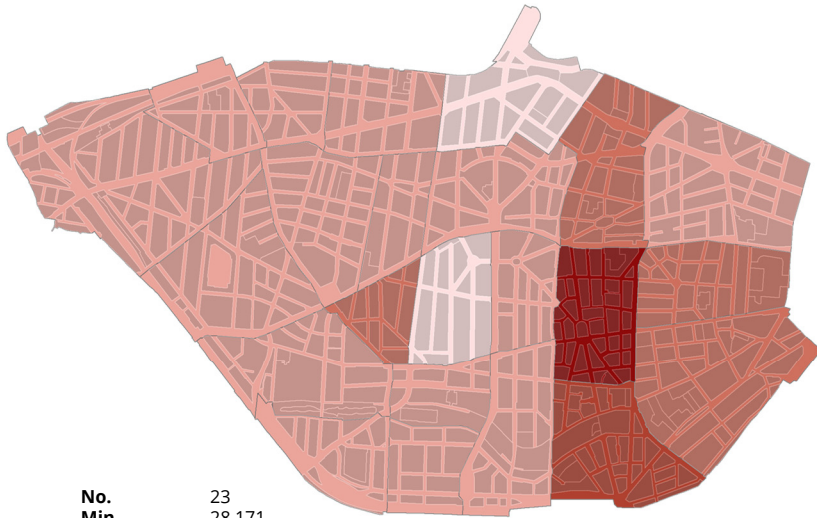
Connectivity

Census Block Density per LEA

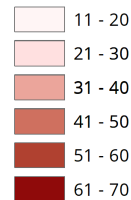
Blocks
km²

Schöneberg - Wilmersdorf

Wittenau – Märkisches Viertel



No. 23
Min. 28,171
Max. 68,758
Mean **40,448**
SD 7,948
Total 40,444



No. 10
Min. 11,462
Max. 41,758
Mean **28,099**
SD 9,623
Total 30,885

Data: SenSW Berlin / ISU5 Blockkarte (DL-DE/BY-2.0)
 SenSW Berlin / LOR Vektordaten (CC BY 3.0 DE)

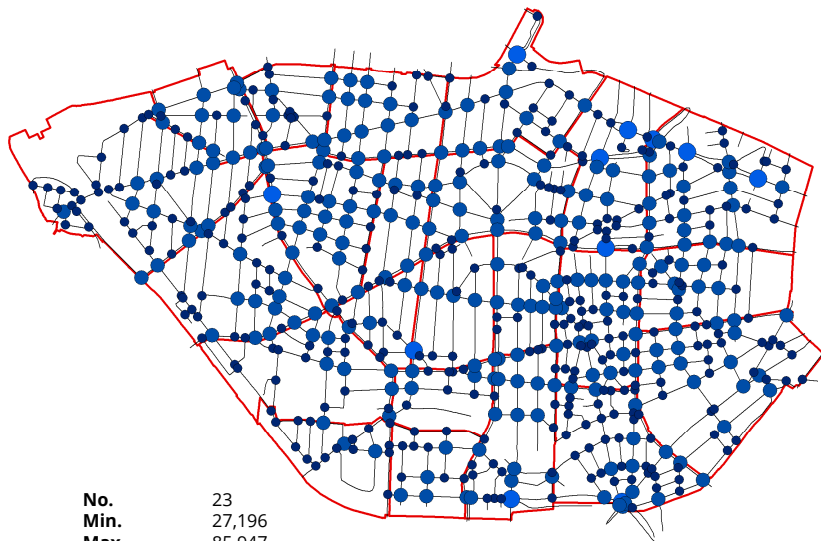
Connectivity

Walkable Street Intersection Density per LEA

Intersections
km²

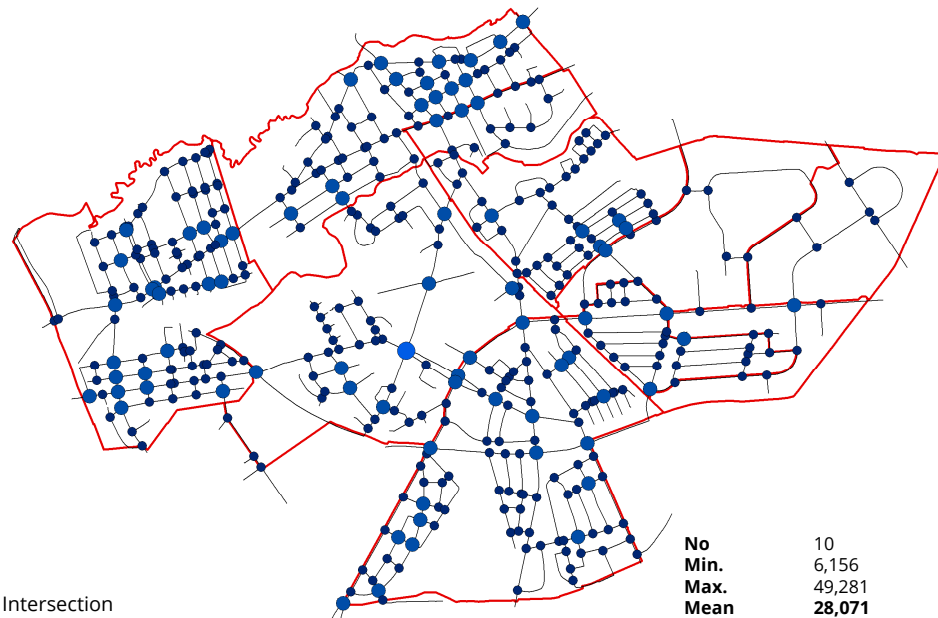
Schöneberg - Wilmerdorf

Wittenau – Märkisches Viertel



| | |
|--------------|---------------|
| No. | 23 |
| Min. | 27,196 |
| Max. | 85,947 |
| Mean | 47,410 |
| SD | 15,093 |
| Total | 47,105 |

- 3-leg Intersection
- 4-leg Intersection
- 5-leg Intersection



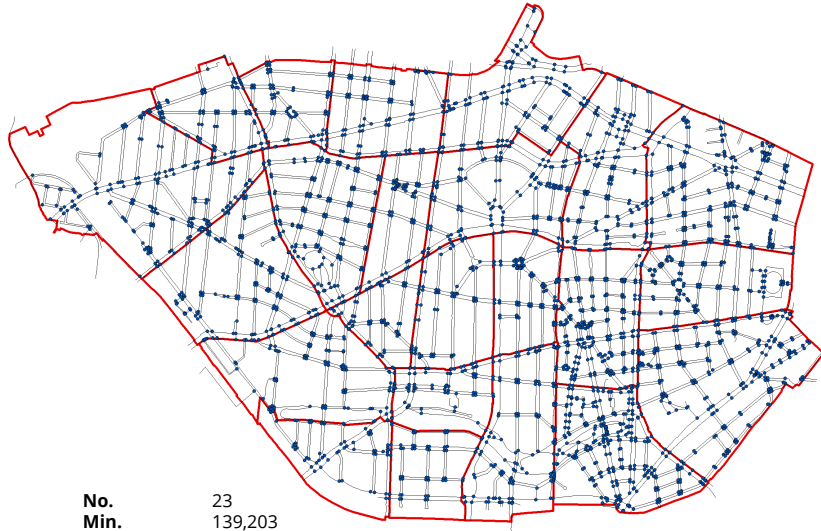
| | |
|--------------|---------------|
| No | 10 |
| Min. | 6,156 |
| Max. | 49,281 |
| Mean | 28,071 |
| SD | 14,845 |
| Total | 29,580 |

Data: SenUVK Berlin / Detailnetz Berlin (DL-DE/BY-2-0)
SenSW Berlin / LOR Vektordaten (CC BY 3.0 DE)

Connectivity

Pedestrian Intersection Density per LEA

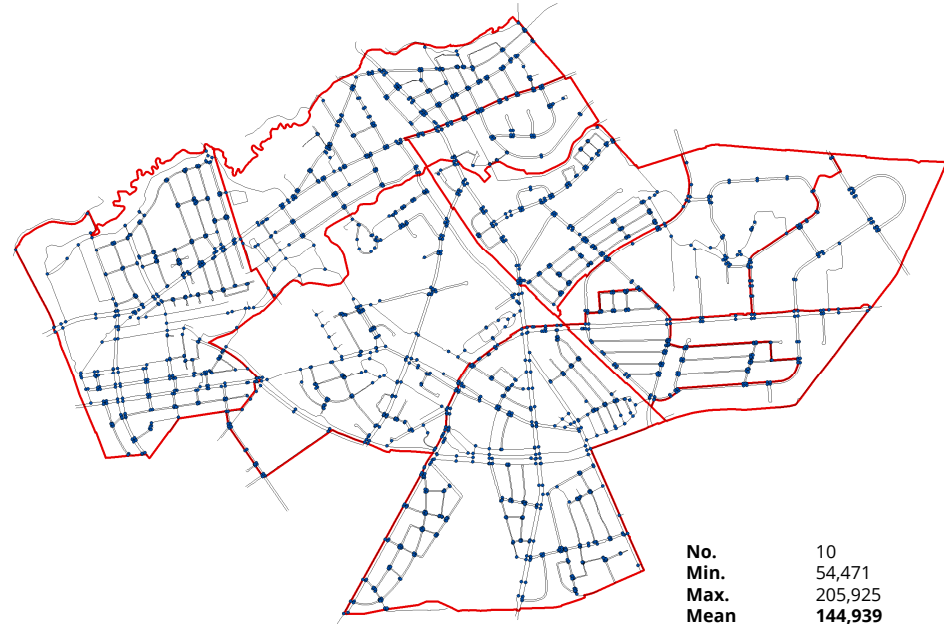
Schöneberg - Wilmersdorf



| | |
|--------------|----------------|
| No. | 23 |
| Min. | 139,203 |
| Max. | 489,746 |
| Mean | 246,855 |
| SD | 86,680 |
| Total | 247,579 |

Intersections
km²

Wittenau – Märkisches Viertel



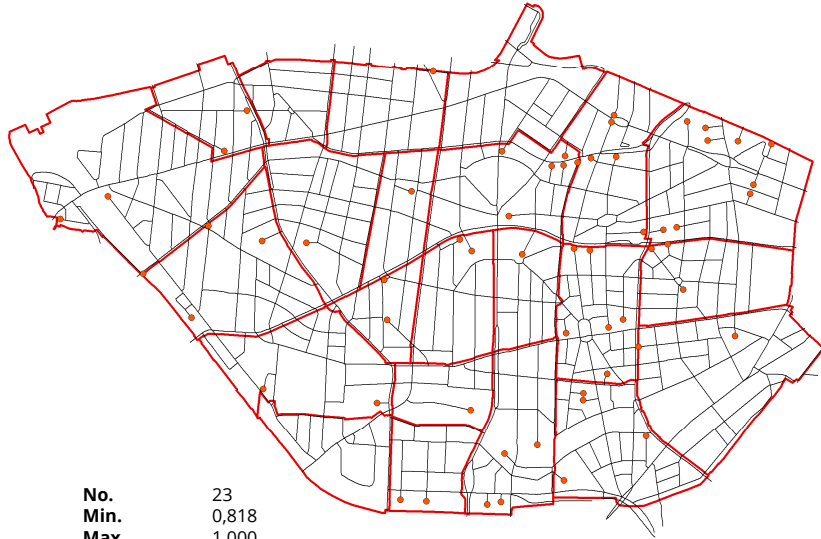
| | |
|--------------|----------------|
| No. | 10 |
| Min. | 54,471 |
| Max. | 205,925 |
| Mean | 144,939 |
| SD | 55,922 |
| Total | 151,092 |

Data: SenUVK Berlin / Fußgängeretz Berlin (DL-DE/BY-2-0)
SenSW Berlin / LOR Vektordaten (CC BY 3.0 DE)

Connectivity

Connected Node Ratio per LEA

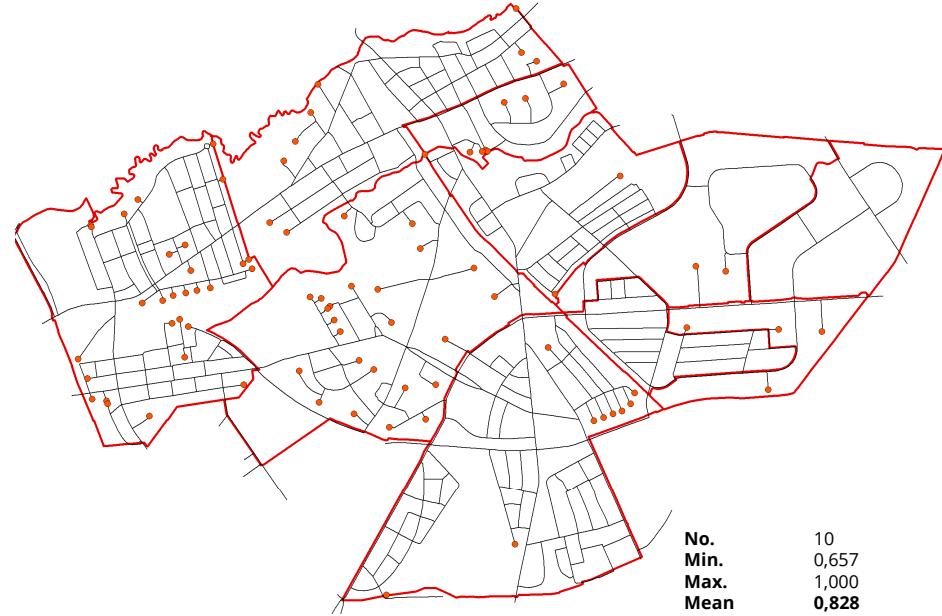
Schöneberg - Wilmersdorf



| | |
|--------------|--------------|
| No. | 23 |
| Min. | 0,818 |
| Max. | 1,000 |
| Mean | 0,909 |
| SD | 0,060 |
| Total | 0,908 |

$$\frac{\text{Intersections}}{\text{Intersections} + \text{Cul de Sacs}} = [0 \dots 1]$$

Wittenau – Märkisches Viertel



| | |
|--------------|--------------|
| No. | 10 |
| Min. | 0,657 |
| Max. | 1,000 |
| Mean | 0,828 |
| SD | 0,125 |
| Total | 0,824 |

• Cul-de-Sac

Data: SenUVK Berlin / Detailnetz Berlin (DL-DE/BY-2-0)
SenSW Berlin / LOR Vektordaten (CC BY 3.0 DE)

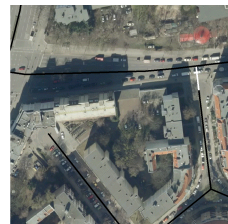
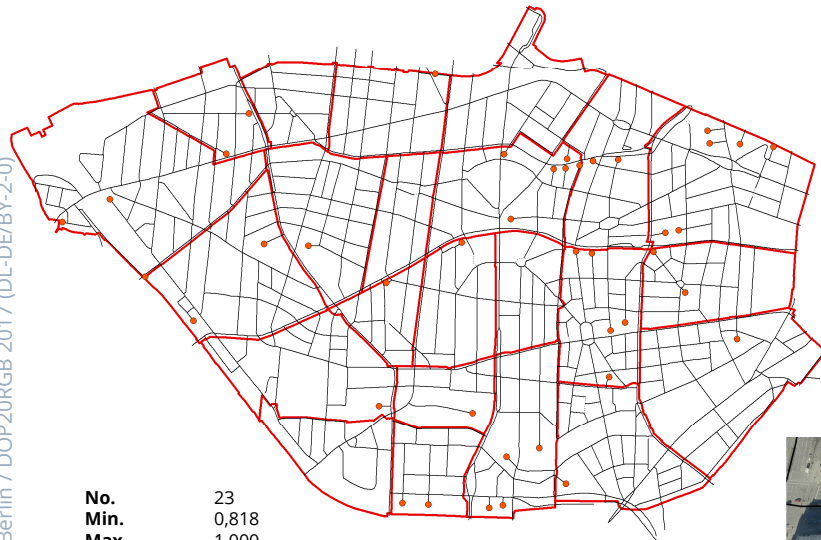
Connectivity

Connected Node Ratio per LEA (incl. Pedestrian Links)

$$\frac{\text{Intersections}}{\text{Intersections} + \text{Cul de Sacs}} = [0 \dots 1]$$

Schöneberg - Wilmersdorf

Wittenau – Märkisches Viertel



| | |
|--------------|--------------|
| No. | 23 |
| Min. | 0,818 |
| Max. | 1,000 |
| Mean | 0,937 |
| SD | 0,050 |
| Total | 0,934 |

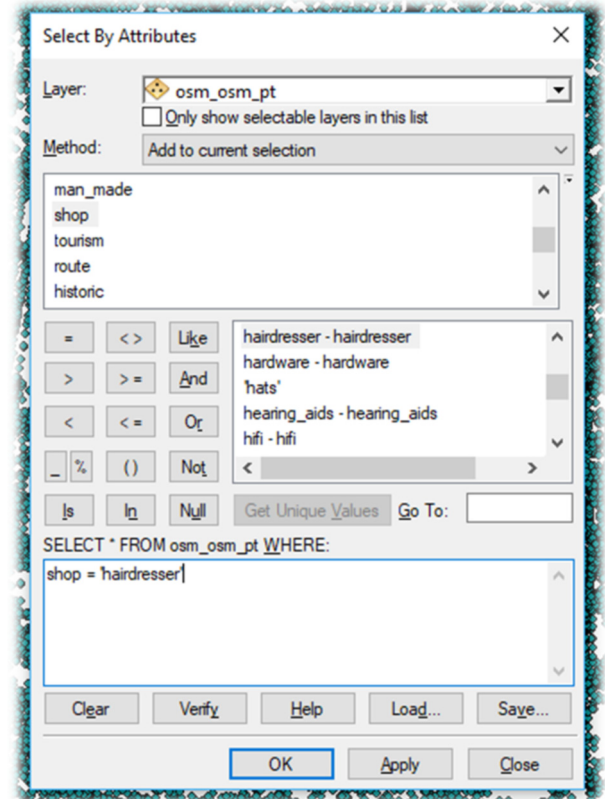
| | |
|--------------|--------------|
| No. | 10 |
| Min. | 0,667 |
| Max. | 1,000 |
| Mean | 0,864 |
| SD | 0,112 |
| Total | 0,874 |

● Cul-de-Sac — Pedestrian Link

Data: SenUVK Berlin / Detailnetz Berlin (DL-DE/BY-2-0)
 SenSW Berlin / LOR Vektordaten (CC BY 3.0 DE)
 SenSW Berlin / DOP20RGB 2017 (DL-DE/BY-2-0)

Connectivity Amenities

| | |
|--|---|
| Medical | Medical Facilities (e.g. doctors) |
| Education & Society | Social Facilities (e.g. care centers) Educational Facilities (e.g. schools) |
| Culture & Religion | Cultural Insitutions (e.g. theaters, cinemas) Religious Insitutions (e.g. churches, mosques, synagogues) |
| Commercial, Retail & Service | Industries (e.g. garages) Retail Stores (e.g. bookstores) Service Facilities (e.g. hair dresser) |
| Sports, Leisure, Greenery & Recreation | Sports Facilities (e.g. fitness centers) Leisure Facilities (e.g. playgrounds) Greenery and Recreational Facilities (e.g. parks) |
| Grocery | e.g. bakeries |
| Gastronomy | e.g. restaurants |
| Public Transport | e.g. bus stops, underground access |

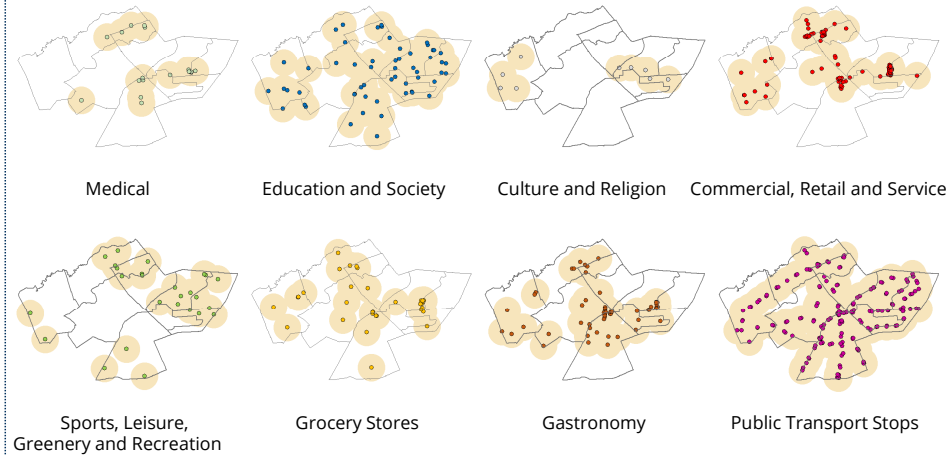
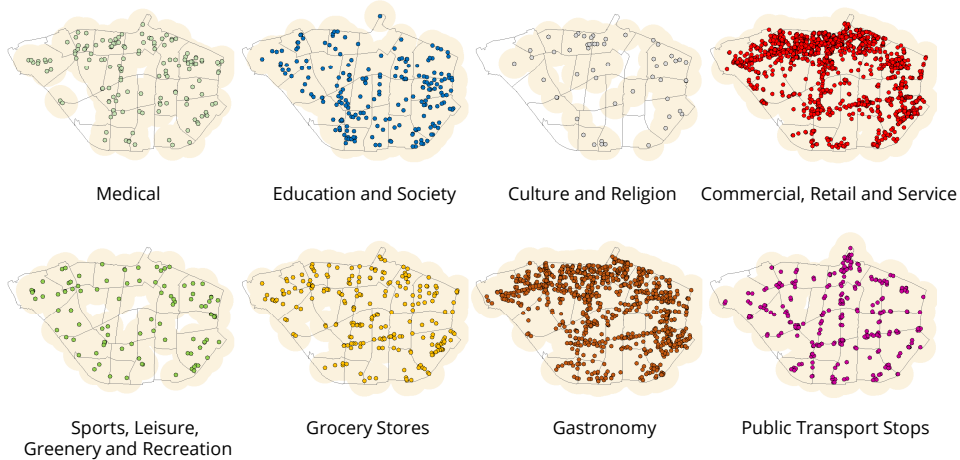


taken from esri ArcGIS

Connectivity Amenity Buffers

Schöneberg - Wilmersdorf

Wittenau – Märkisches Viertel



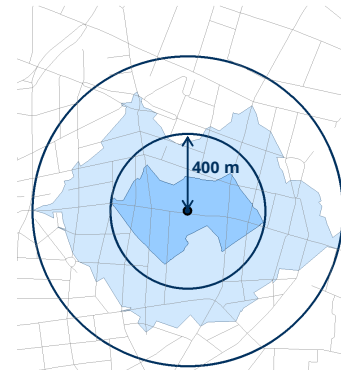
Data: OpenStreetMap-Contributors (CC BY-SA 2.0 / ODbL)
SenSW Berlin / LOR Vektordaten (CC BY 3.0 DE)

Connectivity

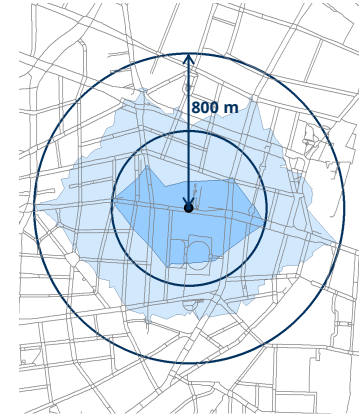
Amenity Pedsheds

$$\frac{\text{Area accessible by walking distance using network}}{\text{Area defined by geodetic buffer}} = [\%]$$

| Average Values in [%] | Schöneberg-Wilmersdorf | | | | | Wittenau-Märkisches Viertel | | | | |
|---|------------------------|------|--------------------|------|---------|-----------------------------|------|--------------------|------|-------|
| | Walkable Roads | | Pedestrian Network | | | Walkable Roads | | Pedestrian Network | | |
| | 400m | 800m | 400m | 800m | n | 400m | 800m | 400m | 800m | n |
| Medical | 49 | 55 | 53 | 59 | n=149 | 31 | 43 | 37 | 48 | n=17 |
| Education and Society | 45 | 52 | 49 | 56 | n=212 | 28 | 35 | 33 | 41 | n=57 |
| Culture and Religion | 47 | 55 | 51 | 58 | n=54 | 26 | 36 | 36 | 45 | n=9 |
| Industry, Retail and Service | 49 | 56 | 53 | 59 | n=1.625 | 32 | 43 | 40 | 49 | n=86 |
| Sports, Leisure, Greenery & Recreation | 43 | 52 | 46 | 54 | n=101 | 23 | 32 | 29 | 37 | n=27 |
| Groceries | 50 | 57 | 55 | 60 | n=232 | 31 | 41 | 41 | 48 | n=33 |
| Gastronomy | 49 | 55 | 53 | 59 | n=1.039 | 35 | 47 | 42 | 52 | n=56 |
| Public Transport Stops | 51 | 58 | 56 | 61 | n=280 | 33 | 42 | 39 | 47 | n=185 |



Walkable Road Network



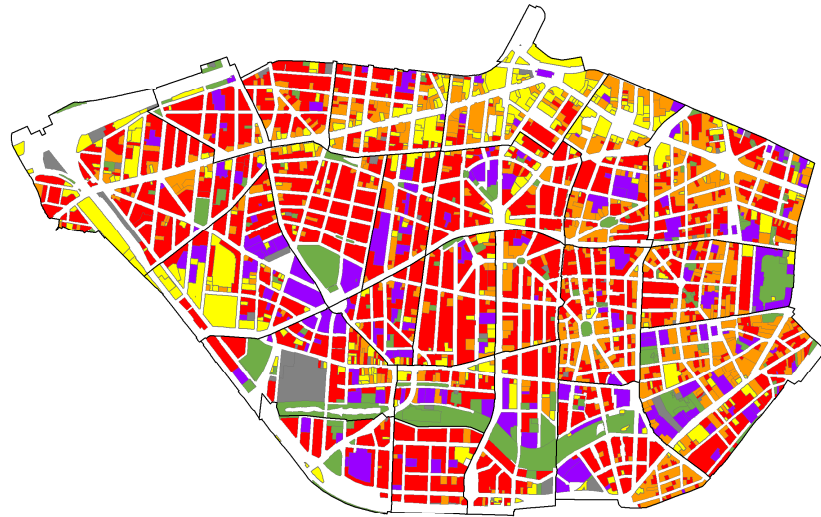
Pedestrian Network

Data: SenUVK Berlin / Detailnetz Berlin (DL-DE/BY-2-0)
SenUVK Berlin / Fußgängeretz Berlin (DL-DE/BY-2-0)

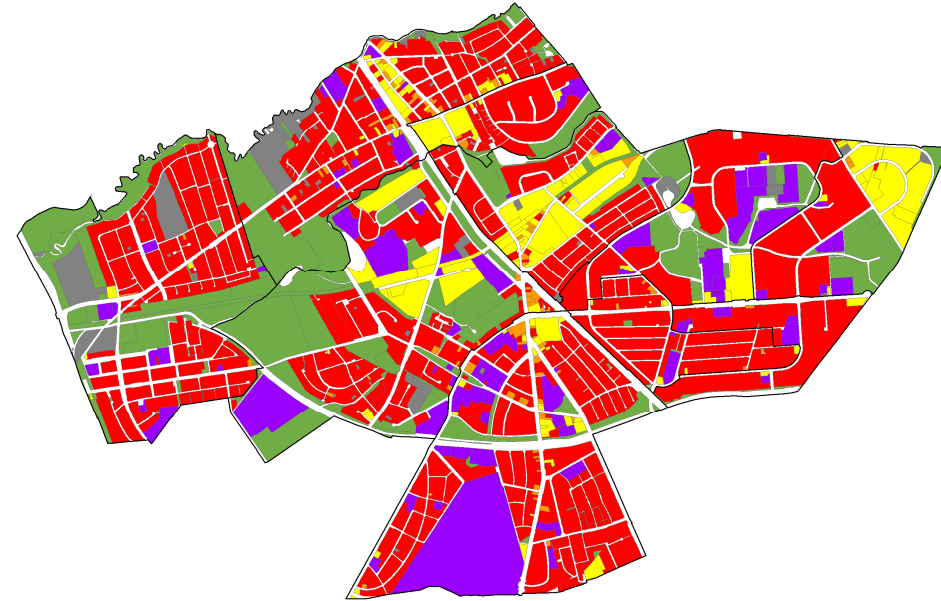
Land Use Mix

Actual Land Use

Schöneberg - Wilmersdorf



Wittenau – Märkisches Viertel



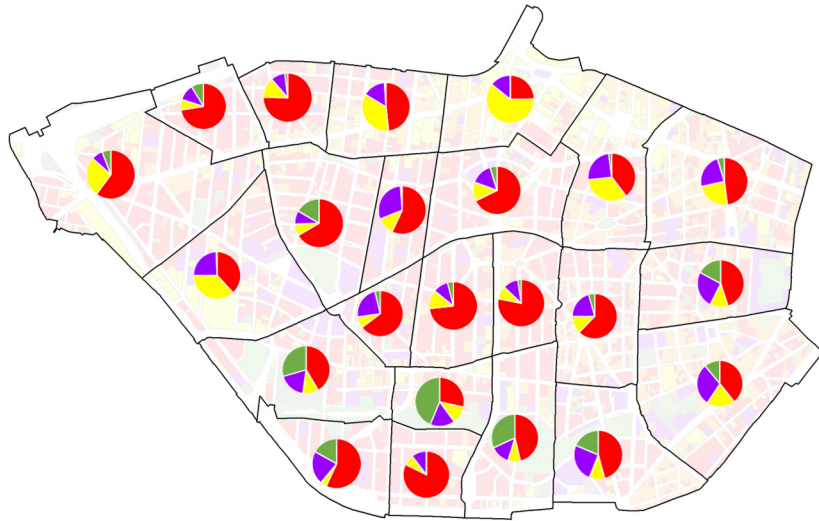
- Residential Areas
- Commercial, Retail, Industry & Agriculture
- Public Institutions
- Sports, Leisure, Greenery & Recovery
- Mixed Use
- Excluded

Data: SenSW Berlin / ALKIS Berlin Tatsächliche Nutzung (DL-DE/BY-2.0)
SenSW Berlin / LOR Vektordaten (CC BY 3.0 DE)

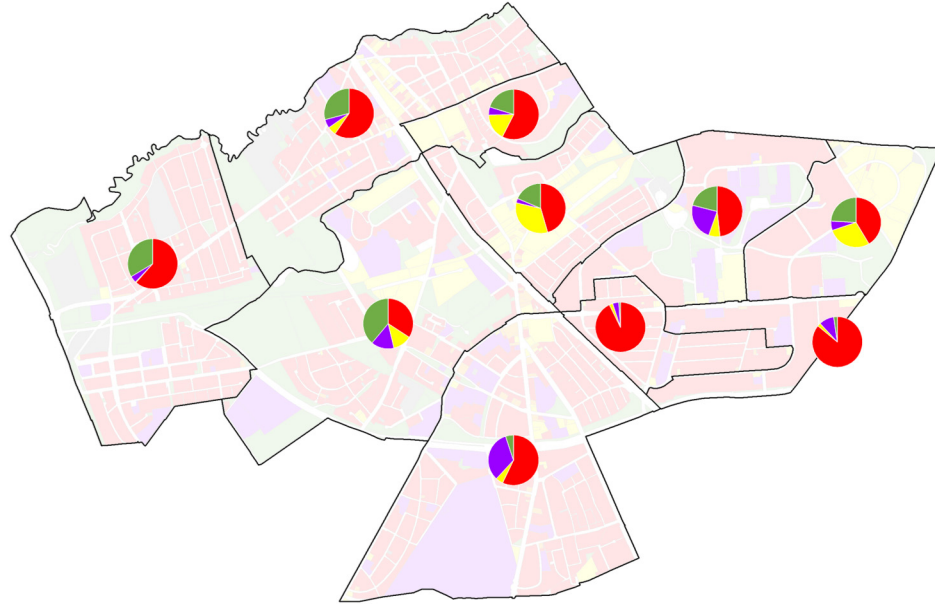
Land Use Mix

Actual Land Use (percentages per LEA)

Schöneberg - Wilmersdorf



Wittenau – Märkisches Viertel



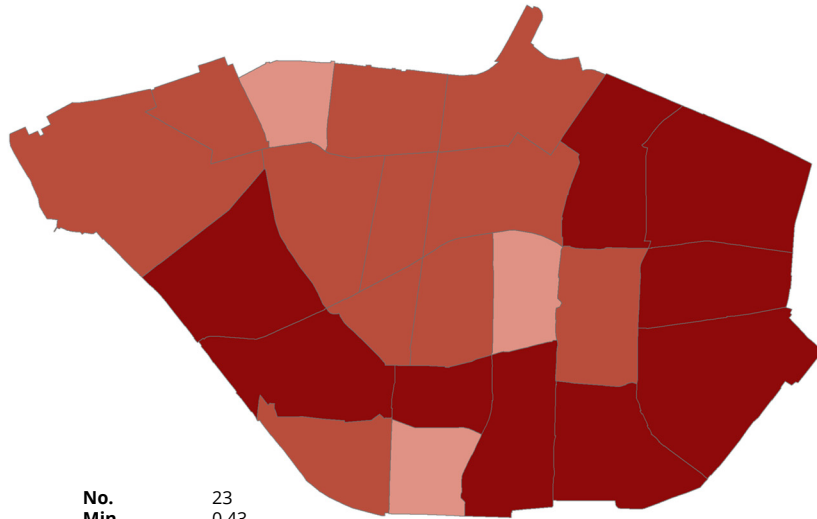
Data: SenSW Berlin / ALKIS Berlin Tatsächliche Nutzung (DL-DE/BY-2.0)
SenSW Berlin / LOR Vektordaten (CC BY 3.0 DE)

Land Use Mix Entropy Index

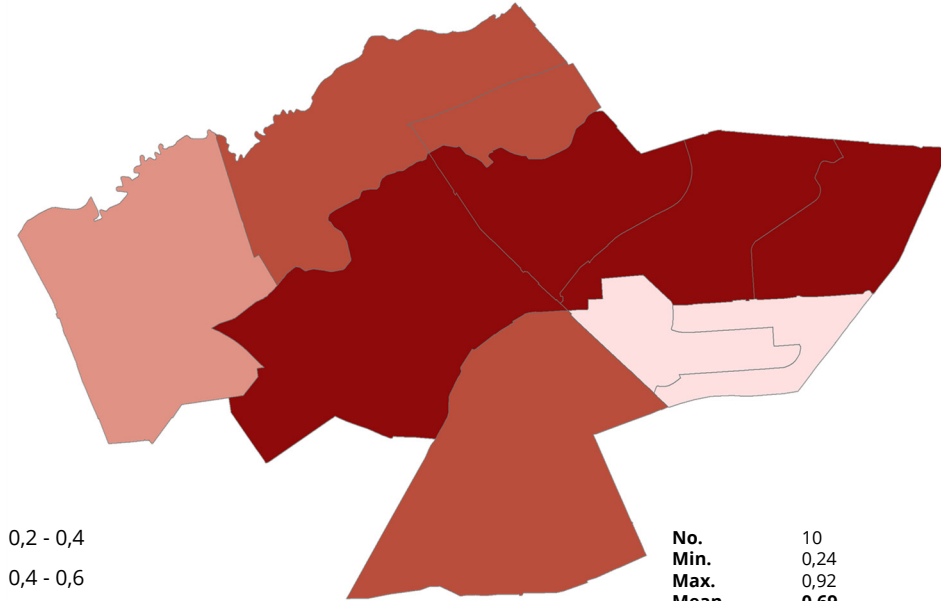
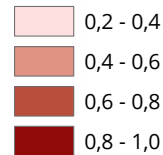
Schöneberg - Wilmersdorf

$$-\frac{\sum_k(p_k * \ln p_k)}{\ln N} = [0 \dots 1]$$

Wittenau – Märkisches Viertel



| | |
|--------------|-------------|
| No. | 23 |
| Min. | 0,43 |
| Max. | 0,93 |
| Mean | 0,75 |
| SD | 0,13 |
| Total | 0,86 |



| | |
|--------------|-------------|
| No. | 10 |
| Min. | 0,24 |
| Max. | 0,92 |
| Mean | 0,69 |
| SD | 0,22 |
| Total | 0,85 |

Data: SenSW Berlin / LOR Vektordaten (CC-BY 3.0 DE)

Evaluating the Analysis

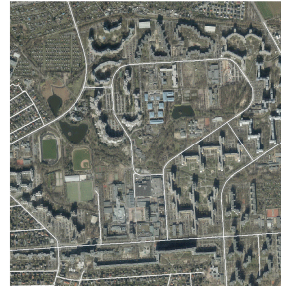
Opportunities and Challenges

Opportunities

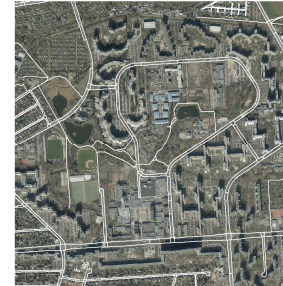
- Interoperability
- Broad spectrum of available tools

Challenges

- Differing data quality
 - Validity
 - Reliability
- Unprecise measurement methods
- Data quantity / limited resources



Walkable Road Network



Pedestrian Network



OpenStreetMap Network

Data Potential

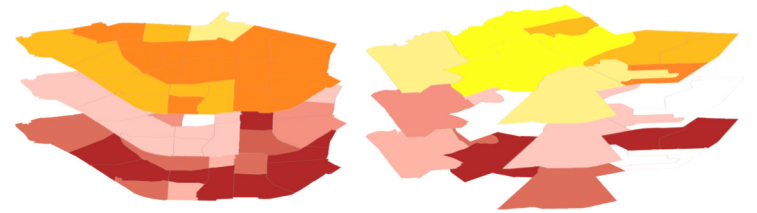
Data Quality

Data: SenSW Berlin / DOP20RGB 2017 (DL-DE/BY-2-0) | SenUVK Berlin / Detailnetz Berlin (DL-DE/BY-2-0)
SenUVK Berlin / Fußgängernetz Berlin (DL-DE/BY-2-0) | OpenStreetMap-Contributors (CC BY-SA 2.0 / ODbL)

Conclusions and Outlook

- Identification of **various correlates** from the built environment
- **Measurability** and **Comparability** by means of GIS-measurements
- Databases ↔ Measurements

→ Composite GIS-Indices



- Macroscopic method ≠ actual situation
- Collecting individual behavior by means of empirical studies necessary
- Including streetscape is of high importance

Johannes Weber, Caroline Koszowski, Regine Gerike

“Friedrich List” Faculty of Transport and Traffic Sciences

Chair of Integrated Transport Planning and Traffic Engineering (IVST)

Comparing walkability of two neighborhoods in the City of Berlin

A GIS-based study on urban and transport structure

Session 02: Planning for active transportation

Urban Transitions 2022 // Sitges, 8 November 2022

References

D'Arcy Fitzsimons, Lorraine:

A multidisciplinary examination of walkability: Its concept, assessment and applicability. Volume 1 of 2. PhD Thesis. Dublin, Ireland: Dublin City University. School of Health and Human Performance, September 2013. Available at: http://doras.dcu.ie/19387/1/Lorraine_Fitzsimons_D'Arcy_PhD_Vol_1.pdf (02.02.2018)

Dill, Jennifer:

Measuring Network Connectivity for Bicycling and Walking. Portland, USA: Portland State University. School of Urban Studies and Planning, January 2004. Available at: <http://reconnectingamerica.org/assets/Uploads/TRB2004-001550.pdf> (12.02.2018)

Ellis, Geraint; Hunter, Ruth; Tully, Mark A.; Donnelly, Michael; Kelleher, Luke; Kee, Frank:

Connectivity and physical activity: using footpath networks to measure the walkability of built environments. In: Environment and Planning B: Planning and Design, Volume 43, Issue 1, S. 130-151. Columbus, USA: SAGE Publications, January 2016. Available at: <https://doi.org/10.1177/0265813515610672> (12.02.2018)

Ewing, Reid; Handy, Susan; Brownson, Ross C.; Clemente, Otto; Winston, Emily:

Identifying and Measuring Urban Design Qualities Related to Walkability. In: Journal of Physical Activity & Health, Volume 3, Issue s1, S. 223-240. Washington, D.C., USA: George Washington University, February 2006. Available at: <https://doi.org/10.1123/jpah.3.s1.s223> (06.02.2018)

Forsyth, Ann; Oakes, J. Michael; Schmitz, Kathryn H.; Hearst, Mary:

Does Residential Density Increase Walking and Other Physical Activity? In: Urban Studies, Volume 44, Issue 4, S. 679-697. Columbus, USA: SAGE Publications, April 2007. Available at: <https://doi.org/10.1080/00420980601184729> (11.02.2018)

Frank, Lawrence D.; Stone Jr., Brian; Bachman, William:

Linking land use with household vehicle emissions in the central puget sound: methodological framework and findings. In: Transport Research Part D: Transport and Environment, Volume 5, Issue 3, S. 173-196. Amsterdam, Netherlands: Elsevier Ltd., May 2000. Available at: [https://doi.org/10.1016/S1361-9209\(99\)00032-2](https://doi.org/10.1016/S1361-9209(99)00032-2) (11.02.2018)

References

Frank, Lawrence D.; Schmid, Thomas L.; Sallis, James F.; Chapman, James; Saelens, Brian E.:

Linking objectively measured physical activity with objectively measured urban form. Findings from SMARTAQ. In: American Journal of Preventive Medicine, Volume 28, Issue 2, Supplement 2, S. 117-125. Washington D.C., USA: American College of Preventive Medicine & Association for Prevention Teaching and Research, February 2005. Available at: <https://doi.org/10.1016/j.amepre.2004.11.001> (13.02.2018)

King, Abby C.; Stokols, Dan; Talen, Emily; Brassington, Glenn S.; Killingsworth, Richard:

Theoretical approaches to the promotion of physical activity: Forging a transdisciplinary paradigm. In: American Journal of Preventive Medicine, Volume 23, Issue 2, Supplement 1, S. 15-25. Amsterdam, Netherlands: Elsevier Ltd., August 2002. Available at: [https://doi.org/10.1016/S0749-3797\(02\)00470-1](https://doi.org/10.1016/S0749-3797(02)00470-1) (07.02.2018)

Leslie, Eva; Coffee, Neil; Frank, Lawrence; Owen, Neville; Bauman, Adrian; Hugo, Graeme:

Walkability of local communities: Using geographic information systems to objectively assess relevant environmental attributes. In: Health & Place, Volume 13, Issue 1, S. 111-122. Amsterdam, Netherlands: Elsevier Ltd., March 2007. Available at: <https://doi.org/10.1016/j.healthplace.2005.11.001> (15.03.2018)

Rafiemanzelat, Reihaneh; Emadi, Maryam Imani; Kamali, Aida Jalal:

City sustainability: the influence of walkability on built environments. 3rd Conference on Sustainable Urban Mobility, 3rd CSUM 2016, 26 – 27 May 2016, Volos, Greece. In: Transportation Research Procedia, Volume 24, S. 97-104. Amsterdam, Netherlands: Elsevier Ltd., June 2017. Available at: <https://doi.org/10.1016/j.trpro.2017.05.074> (02.02.2018)

Reilly, Michael; Landis, John:

The Influence of Built-Form and Land Use on Mode Choice. Evidence from the 1996 Bay Area Travel Survey. University of California Transportation Center Research Paper. Earlier Faculty Research. Berkeley, USA: University of California. Institute of Urban and Regional Development, September 2003. Available at: <https://escholarship.org/uc/item/46r3k871> (11.02.2018)

Streich, Bernd:

Stadtplanung in der Wissensgesellschaft. Ein Handbuch. Wiesbaden, Germany: VS Verlag für Sozialwissenschaften/GWV Fachverlage GmbH, June 2005. ISBN: 3-531-14569-X

Data

Amt für Statistik Berlin-Brandenburg (AfS):

Einwohnerdichte 2016 (Umweltatlas). Melderechtlich registrierte Einwohner am Ort der Hauptwohnung in Berlin am 31.12.2016.

Web Feature Service. <https://daten.berlin.de/datensaetze/einwohnerdichte-2016-umweltatlas-wfs>.

License: <https://creativecommons.org/licenses/by/3.0/de/>

Einwohnerinnen und Einwohner in Berlin in LOR-Planungsräumen am 31.12.2016. Datenmatrix (CSV-Format).

<https://daten.berlin.de/datensaetze/einwohnerinnen-und-einwohner-berlin-lor-planungsräumen-am-31122016>.

License: <https://creativecommons.org/licenses/by/3.0/de/>

Geoportal Berlin:

ALKIS Berlin Tatsächliche Nutzung. Web Feature Service. <https://daten.berlin.de/datensaetze/alkis-berlin-tatsächliche-nutzung-wfs>

License: <https://www.govdata.de/dl-de/by-2-0>

Detailnetz Straßenabschnitte. Web Feature Service. <https://daten.berlin.de/datensaetze/detailnetz-straßenabschnitte-wfs>

License: <https://www.govdata.de/dl-de/by-2-0>

Digitale farbige Orthophotos 2017 (DOP20RGB). Web Map Service.

<https://daten.berlin.de/datensaetze/digitale-farbige-orthophotos-2017-dop20rgb-wms>

License: <https://www.govdata.de/dl-de/by-2-0>

Fußgängernetz. Web Feature Service. <https://daten.berlin.de/datensaetze/fußgängernetz-wfs>

License: <https://www.govdata.de/dl-de/by-2-0>

WebAtlas Berlin. Web Map Service. <https://daten.berlin.de/datensaetze/webatlas-berlin-wms>

License: <https://www.govdata.de/dl-de/by-2-0>

Data

OpenStreetMap-Contributors:

OpenStreetMap. Shapefiles. Downloaded: 17.01.2018. <https://download.geofabrik.de/>.

Licenses: <https://creativecommons.org/licenses/by-sa/2.0/> / <https://opendatacommons.org/licenses/dbcl/1.0/>

OpenStreetMap. OSM-Data. Downloaded 06.01.2018 via "OpenStreetMap-Toolbox"

Licenses: <https://creativecommons.org/licenses/by-sa/2.0/> / <https://opendatacommons.org/licenses/dbcl/1.0/>

Senatsverwaltung für Stadtentwicklung und Umwelt Berlin:

LOR Vektordaten. March 2015. Vektor-Dataset. http://www.stadtentwicklung.berlin.de/planen/basisdaten_stadtentwicklung/lor/de/download.shtml

License: <https://creativecommons.org/licenses/by/3.0/de/>

Umwelatlas Berlin:

Blockkarte 1 : 5.000 (ISU5, Raumbezug Umweltatlas 2015). Web Feature Service. <https://daten.berlin.de/datensaetze/blockkarte-1-5000-isu5-raumbezug-umweltatlas-2015-wfs>

License: <https://www.govdata.de/dl-de/by-2-0>