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GIS-based Identification of Infill Development Potentials on the Basis of Topographic and Cadastral Databases – Prospects and Limits

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Agenda

- Background/Motivation
- State of the Art
- Approach for automatic identification of infill development potentials (IDP)
- Pilot application and validation
- Conclusion and outlook

Background

- Reduction of land consumption (30 ha per day until 2020) ➔ infill development strategies
- No sufficient data on the amount and spatial distribution of the infill development potentials (IDP) in Germany
- Study on behalf of BMVBS/BBSR
  "Implementation of measures to reduce land consumption – Infill development potentials" (2011 – 2013)
  - Standardized survey of cities and municipalities (approx. 12 %) *(Presentation: Andreas Blum)*
  - Approaches and perspectives for an automated identification of IDP based on geospatial datasets

Objectives

- Development of foundations and concepts for a modeling
- Investigation of the suitability of available spatial data and services
- Development of an GIS-based approach for nation-wide application
- Validation in case studies
- Prospective approaches / further developments

Concepts

- **Infill development potential:** refers to "theoretical potential" regardless of market availability and concrete intentions of use
- **Types of IDP**:
  - **Brownfields** (abandoned areas with former usage, built-up/non-built-up)
  - **Gap sites** (non built-up parcel area)
  - **Underutilized lots** (area of a built-up lot with space for further developments)

State of the Art

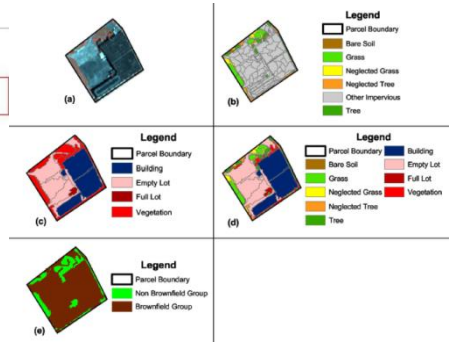
- Brand new field and part of basic research
- Only a few studies on the detection of…
  - **Brownfields** using remote sensing techniques *(e.g. Banzhaf&Netzband 2004, Nelson 2005, Atturo et al. 2008, Ferrara 2008, Volpe et al. 2008)*
  - **Gap sites/underutilized lots** using GIS-based techniques (*e.g. Fulton/Aubry 2006, Alles 2007, Elgendy 2012)*

Remote sensing techniques

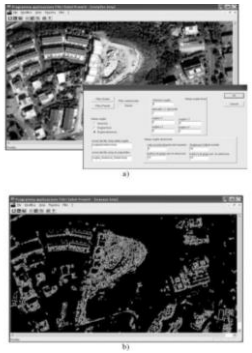
- Methods: Object-based image classification using satellite imagery, Detection of soil/roofing materials on hypersprectral data, multi-temporal imagery to analyze the frequency of use of parking lots, collapsed buildings)

Banzhaf/Netzband (2004)

Volpe et al. (2008)



Bacon (2007)

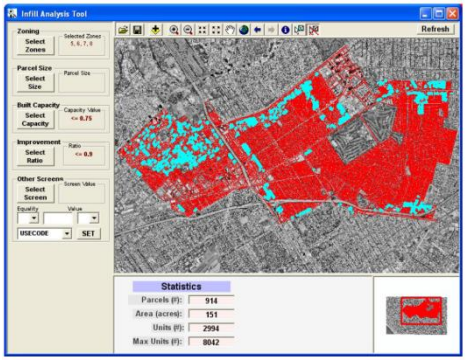


Ferrara (2008)

➔ Remote sensing approaches partly unsatisfactory and not operational yet for a nation-wide application (high data costs)

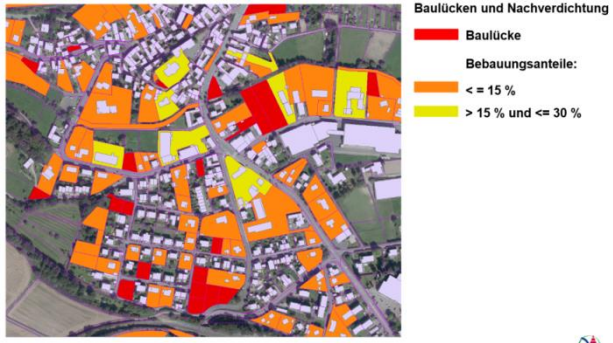
GIS-based techniques

- Identification of gap sites and underutilized lots at parcel level using vector-based cadastral data, census data, data on transport/infrastructure etc.
- Semi-automatic approaches partly in operational use on municipal/regional level



Fulton/Aubry (2006)

Elgendy (2012)



Elend (2013)

➔ GIS-based approaches seem more promising in respect of a nation-wide implementation

Approach for automatic identification of IDP using German topographic databases

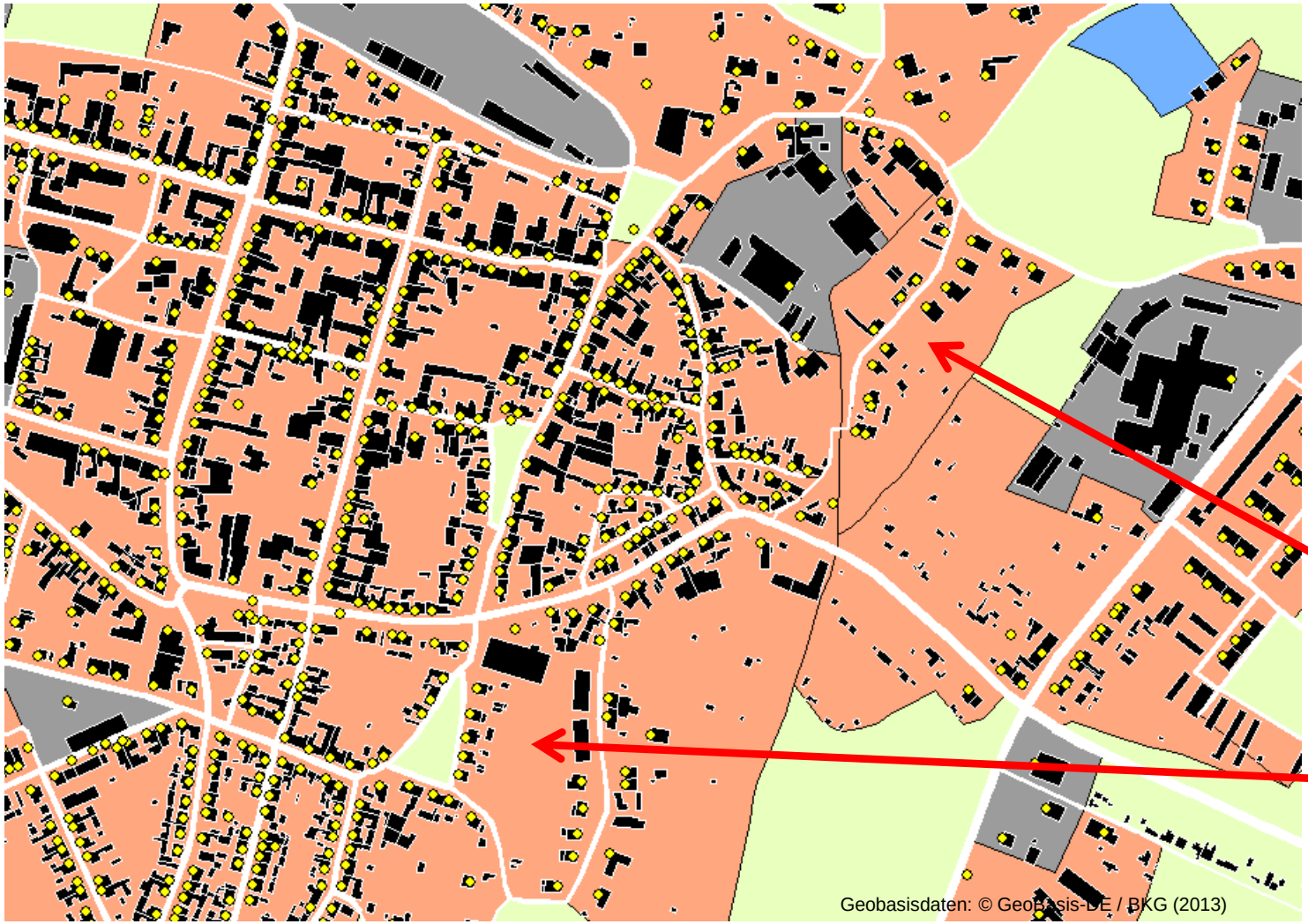
Possible data sources

- Data requirements: nation-wide availability, homogenized, central data provision/access, guaranteed updates
- Currently only fulfilled by:
  - **Digital Landscape Model (ATKIS Base-DLM)** Authorative Topographic-Cartographic Information System
  - **Official building polygons and coordinates** (HU-DE, HK-DE)
- Note: ALKIS (Authoritative Real Estate Cadastre Information System) not available for nationwide usage (licence restrictions)

Data base

- ATKIS Base-DLM:
  nation-wide uniform representation and description of geo topography (settlement boundary (Ortslage), urban block, land use, street network etc.)
- Official Building polygons:
  approx. 50 million building footprints of the German real estate cadaster (without attributes)
- Official House Coordinates:
  Location of all addressed buildings from the real estate cadastre

Data base



ATKIS Basis DLM

House polygons

House coordinates

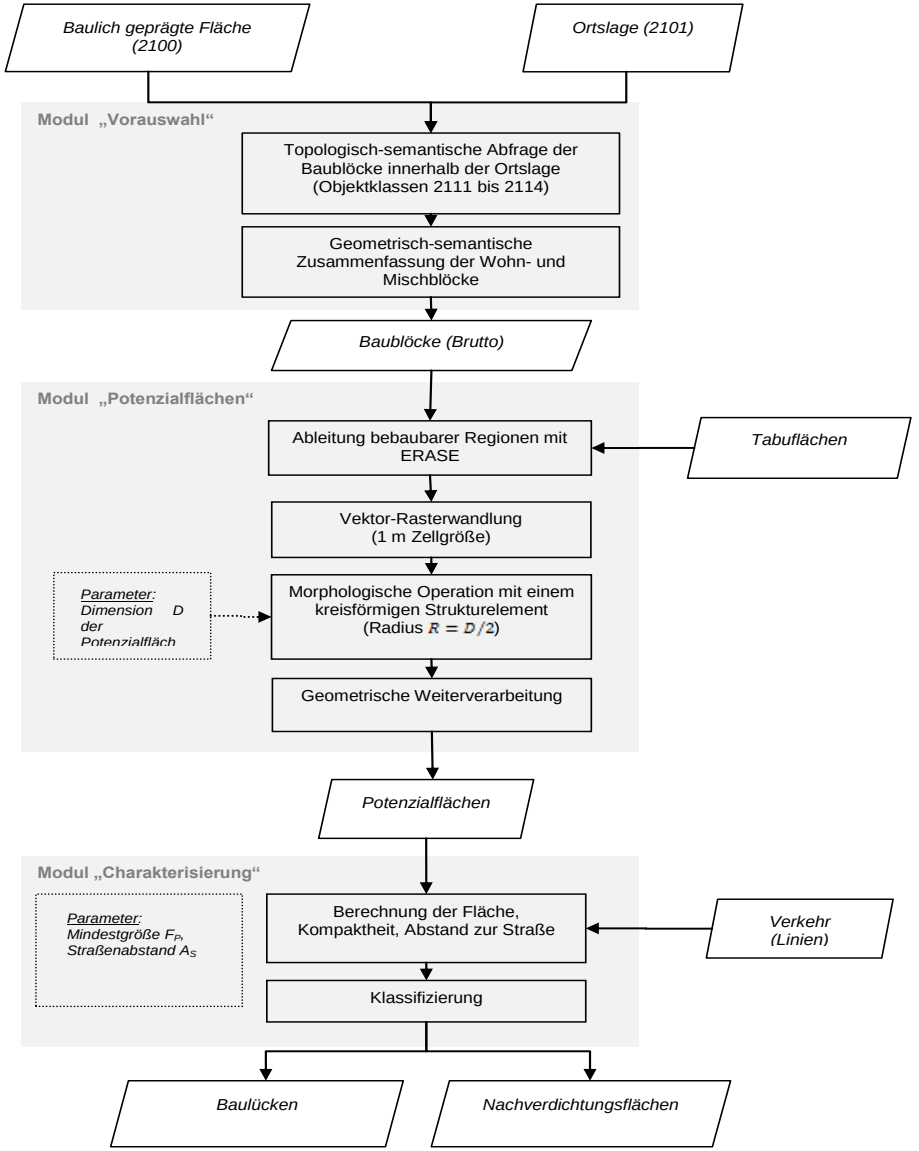
Gap site

Underutilized area

Methodology

- Definition of inner urban area using the geometry of ATKIS-Ortslage
- Definition of relevant land use classes (residential, mixed, industrial/commercial usage)
- Delineation of unbuilt areas
- Constraint-based exclusion of areas not suitability for infill development
- Classification of the detected IDP areas into gap sites and underutilized lots
- Charaterization of the IDP

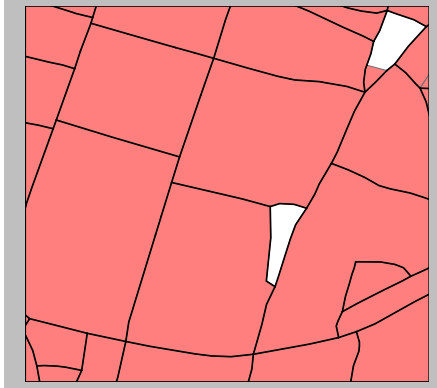
Procedure for automatic IDP identification



Implementation using ESRI ArcGIS geoprocessing tools and Python

Procedure

Input data

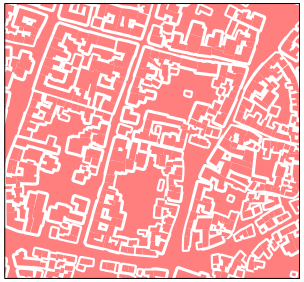


ATKIS Basis-DLM: built-up areas (residential and combined use area, commercial/industrial area) within the urban area, transportation

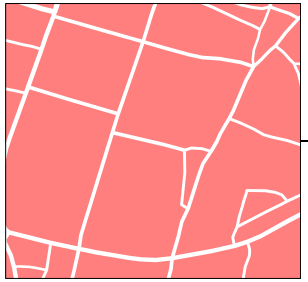
Official building polygons and coordinates

Exclusion layers (not suitable for ID)

All building footprints larger than 20 m²



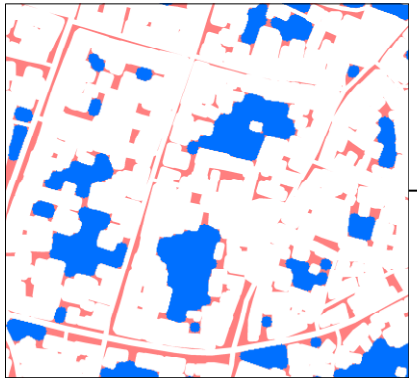
Clearance areas by buffering buildings according to clearance guidelines



Identification of transport areas by buffering roads according to usage

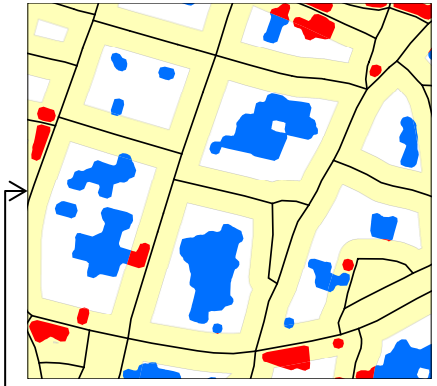
Excludes areas

Excluded areas defined by logical merging of c) to e)

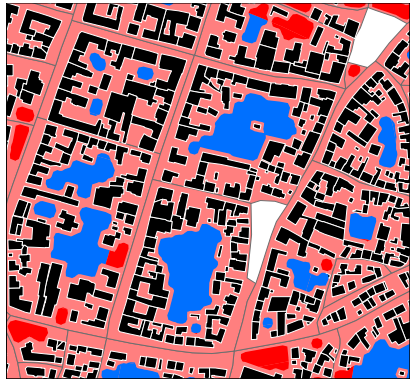


Identification of IDP sites by morphological filtering

Classification



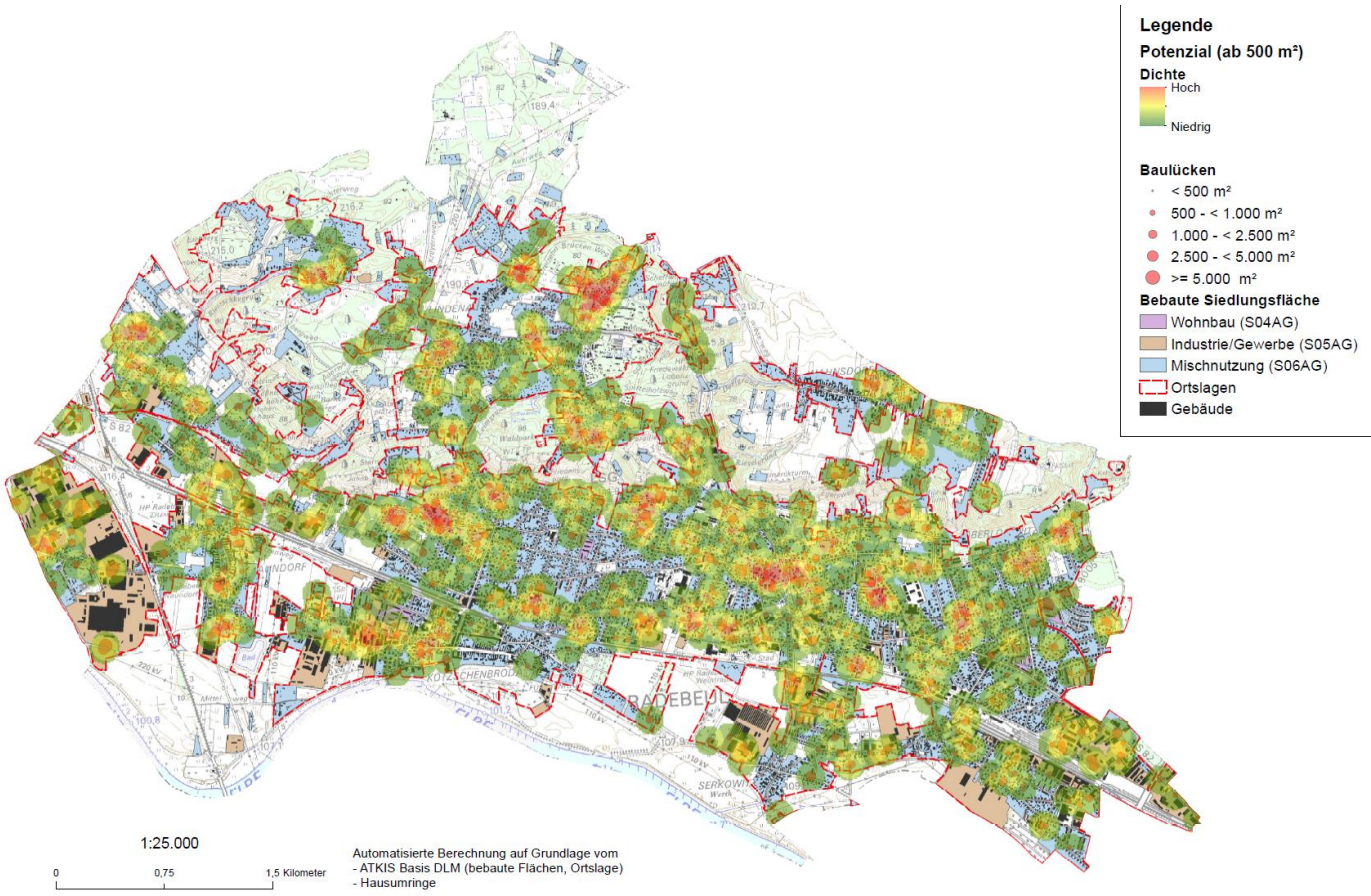
Classification of gap sites and underutilized sites by access distance to roads



Result of the automated analysis (gap sites – red, underutilized sites – blue)

Identified IDP areas

- Characteriz
  IDP areas
  - current la
  - area
  - form inde
  - distance
  - etc.
- Allows use

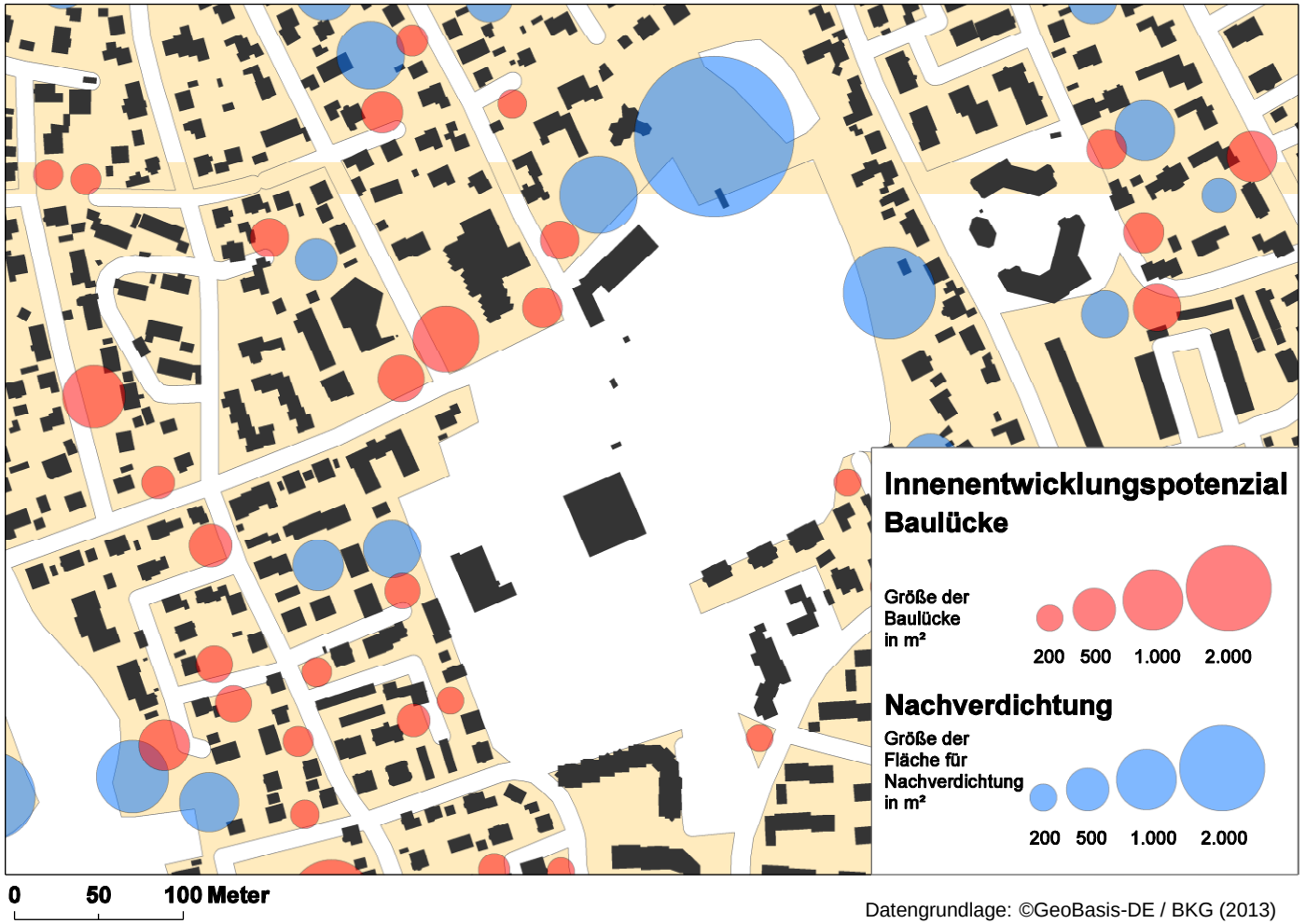


Pilot application

- Application to 16 case studies (part of the survey)
- Thematic maps as an associated instrument during on-site interviews with representatives from the municipalities)
- Purpose of implementation:
  - Stimulate the discussion process in the interview
  - Validation of the approach
  - Discuss opportunities for model improvements

Thematic maps

Visualization of IDP through proportional area symbols



Datengrundlage: ©GeoBasis-DE / BKG (2013)

Insights from the case studies

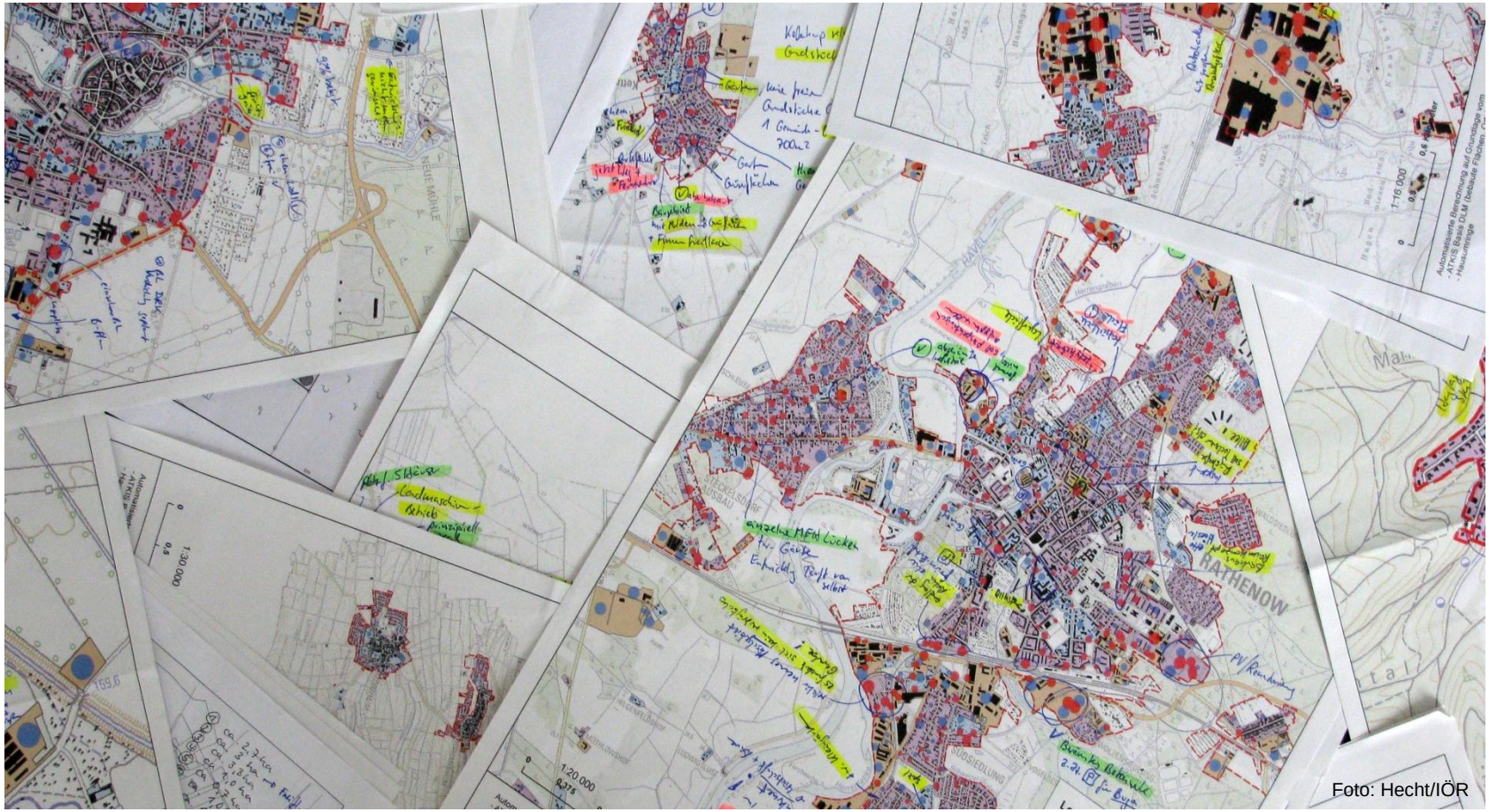


Foto: Hecht/IÖR

Insights from the case studies

- Error of commission (false positive candidates) lead to an overestimation
- Identified IDP (only gap sites) on average three times higher than the IDP from the survey (small towns: factor 1,4, medium towns: factor 3,7)
- Categorization of the errors according to the reasons of a wrong identification

Categorization of errors

Category	Examples	Effect	
Missing information on parcel geometry	wrong delineation (identified IDP belongs to more than one parcel, unfavourable parcel geometry permits development)	over- / underestimation	39%
Conflicts with other land uses (degree of abstraction of ATKIS® Basis-DLM)	commercial or industrial use without buidlings (storage area, waste water facilities, landfills, waste industry, junk yard)	overestimation	57%
	public green and recreational areas (playground, roadside greenery),	overestimation	
	sealed public space (parking spaces, small public city squares, marketplaces)	overestimation	
Restrictions not considered in the model	relief (e.g. steep slopes)	overestimation	4%
	flood protection (e.g. within flooded areas, retention basin)	overestimation	
	immission control (e.g. „Autobahn“, highways, bypass roads, rail ways)	overestimation	
	infrastructure (e.g. cable and overhead transmission lines)	overestimation	
	contaminated sites	overestimation	
Issues with inner zone boundary (ATKIS-Ortslage)	Non-conformity with the inner urban araa boundary according to planning law	over- / underestimation	
Data quality issues	Geometric errors due to missing buildings (already built-up)	overestimation	
	Semantic errors (e.g. wrong land use category in ATKIS Base DLM)	over- / underestimation	

Categorization of errors

Identified gap sites and underutilized lots using Authoritative Real Estate Cadastre Information System (ALKIS)

Legend

Gap site by size
(data: ATKIS and official building polygons)

- small (500 - < 1 000 m²)
- medium (1 000 - < 2 500 m²)
- large (> 2 500 m²)

Gap sites/underutilized sites
(data: ALKIS)

Gap site

- Residential and combined use
- Industrial and commercial

Underutilized sites

- large (building coverage up to 15 %)
- small (building coverage 15 to 30 %)
- none

Land-use types with no IDP

- Buildings and other built structures
- Specific functional area
- Sport, leisure and recreation area
- Grazing land, allotments, agriculture

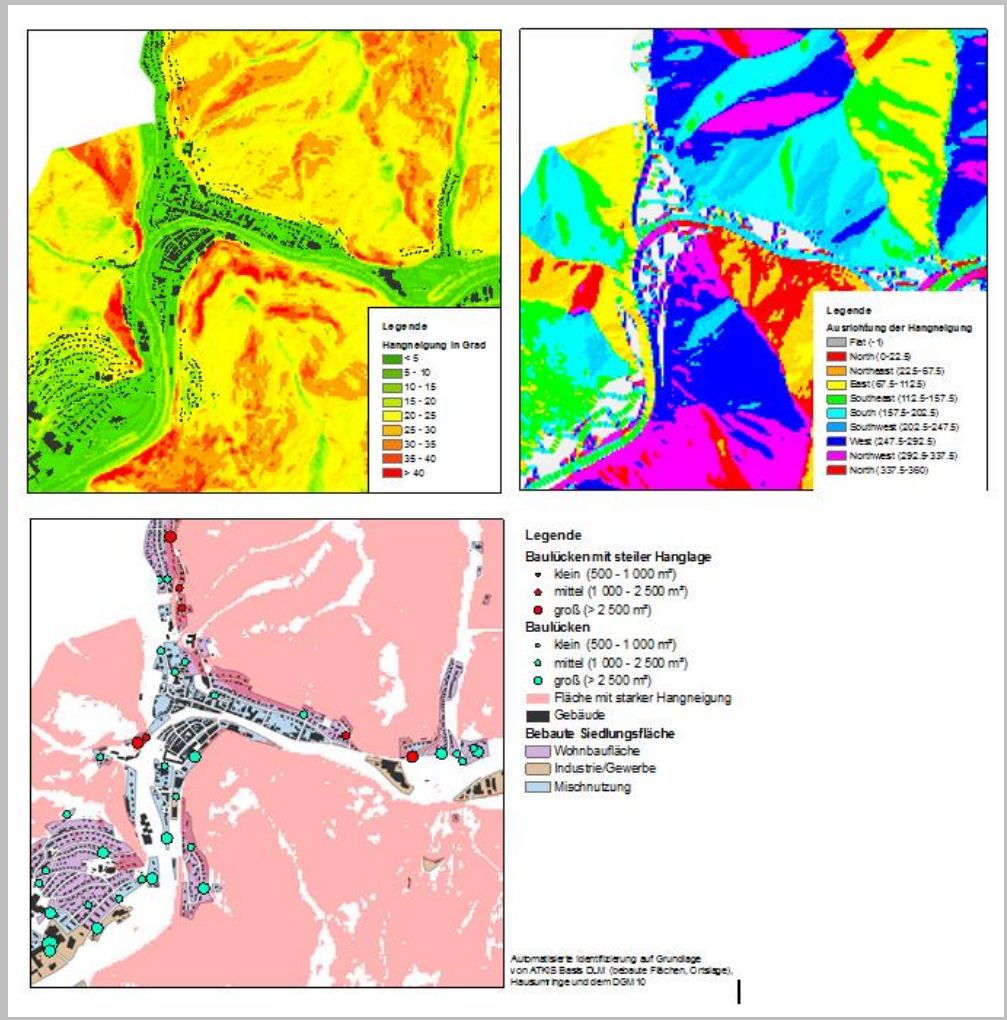
Computation: ©IOER (2013) on behalf of BBSR/BMVBS;
Geobasisdaten: ©GeoBasis-DE/LGB (2013)

Solution
Cadastral data (ALKIS)
Cadastral data (ALKIS)
Cadastral data (ALKIS)
Cadastral data (ALKIS)
DEM10
HQ100 maps
Cadastral data (ALKIS)
-
-
-
-
-

Categorization of errors

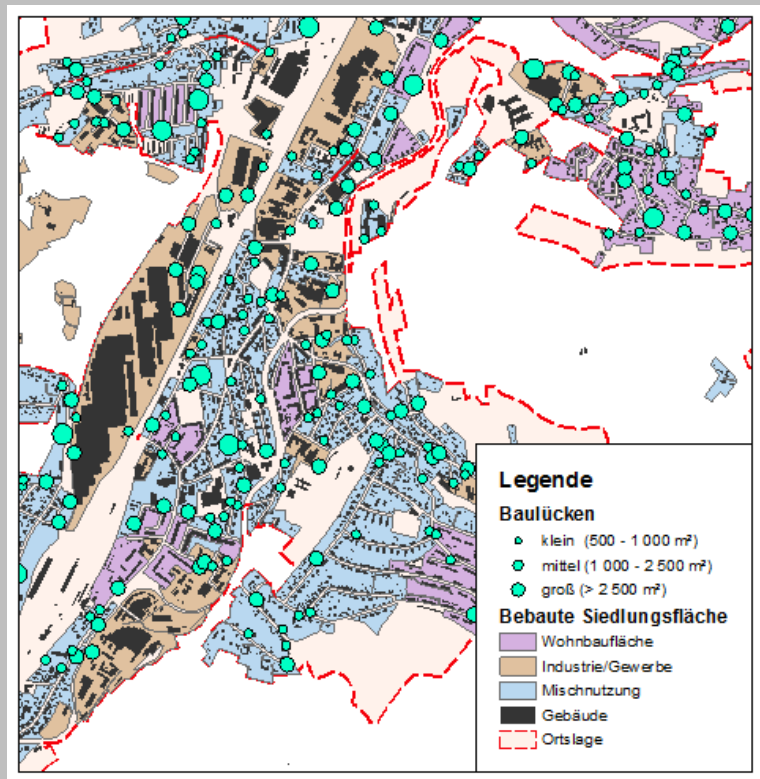
Category	Ex	n
Missing information on parcel geometry	wi ur	al data
Conflicts with other land uses (degree of abstraction of ATKIS® Basis-DLM)	co wa	al data
	pu gr	al data
	se m	al data
Restrictions not considered in the model	re	
	flo	naps
	im wa	al data
	int	
	co	
Issues with inner zone boundary (ATKIS-Ortslage)	No pla	
Data quality issues	Ge	
	Se DI	

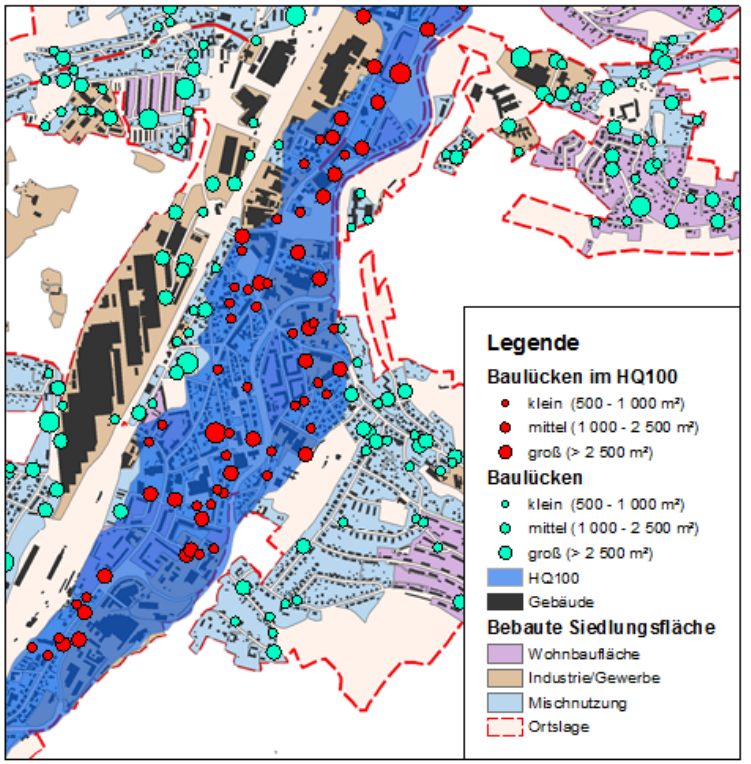
Consideration of the surface topography (slope and exposition) using a Digital Terrain Model with a grid width 10 m (DTM10) provided by Federal Agency for Cartography and Geodesy (Bundesamt für Kartographie und Geodäsie, BKG)



Categorization of errors

Consideration of the flooded areas using HQ100 data (flood discharge areas for floods with a 100-year recurrence interval) provided by state environmental agencies



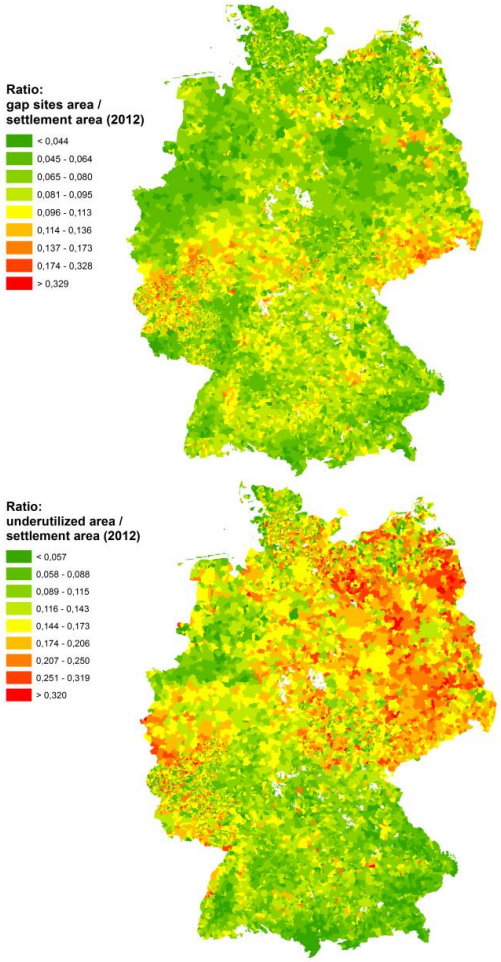


Categorization of errors

Category	Examples	Effect	Solution
Missing information on parcel geometry	wrong delineation (identified IDP belongs to more than one parcel, unfavourable parcel geometry permits development)	over- / underestimation	Cadastral data (ALKIS)
Conflicts with other land uses (degree of abstraction of ATKIS® Basis-DLM)	commercial or industrial use without buidlings (storage area, waste water facilities, landfills, waste industry, junk yard)	overestimation	Cadastral data (ALKIS)
	public green and recreational areas (playground, roadside greenery),	overestimation	Cadastral data (ALKIS)
	sealed public space (parking spaces, small public city squares, marketplaces)	overestimation	Cadastral data (ALKIS)
Restrictions not considered in the model	relief (e.g. steep slopes)	overestimation	DEM10
	flood protection (e.g. within flooded areas, retention basin)	overestimation	HQ100 maps
	immission control (e.g. „Autobahn“, highways, bypass roads, rail ways)	overestimation	Cadastral data (ALKIS)
	infrastructure (e.g. cable and overhead transmission lines)	overestimation	-
	contaminated sites	overestimation	-
Issues with inner zone boundary (ATKIS-Ortslage)	Non-conformity with the inner zone according to planning law	over- / underestimation	local knowledge
Data quality issues	Geometric errors due to missing buildings (already built-up)	overestimation	-
	Semantic errors (e.g. wrong land use category in ATKIS Base DLM)	over- / underestimation	-

Conclusions

- Development of an approach to automatically identify IDP candidates (with restriction to gap sites and underutilized areas)
- Overestimation of IDP due to missing information (e.g. detailed land use data, parcel geometry)
- Automatic approch cannot substitute a standarized survey, but may assist the process (outlier detection, plausibility check)
- Automation offers high objectivity, comparability, repeatability → Trends and spatial patterns visible



Conclusions

- Usage of ALKIS in combination with additional data would lead to more reliable results (but ALKIS currently not usable due to license restrictions in Germany)
- Validation by local expert knowledge and verification on-site necessarily needed
- Approach offers the opportunity to support cities and municipalities for IDP inventory and land use management

Outlook

- Inventory and monitoring of IDP will gain more importance among the municipalities
- Further research and developments needed (integration of additional data e.g. registry office, commercial register, consumption data, VGI etc.)
- Test and validation on other cities and regions in Europe with comparable data
- Further development to an *easy-to-use tool* for municipalities

Thank you!

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Final Report:

Schiller, G.; Blum, A.; Hecht, R.; Meinel, G.; Oertel, H.; Ferber, U.; Petermann, E. (2014) Innenentwicklungspotenziale in Deutschland - Ergebnisse einer bundesweiten Umfrage und Möglichkeiten einer automatisierten Abschätzung, BBSR, Bonn, Download via:
http://www.bbsr.bund.de/BBSR/DE/Veroeffentlichungen/AblageMeldungen/_KM_Innenentwicklungspotenziale_D.html