Large Housing Estates – Analysing the Morphologic Similarities and Differences of a Specific Town Planning Concept

Hannes Taubenböck, Manuel Murawski, Michael Wurm

(Dr. Hannes Taubenböck, German Aerospace Center, Münchner Straße 20, hannes.taubenboeck@dlr.de)
(Manuel Murawski, German Aerospace Center, Münchner Straße 20, manuel.murawski@gmx.de)
(Dr. Michael Wurm, German Aerospace Center, Münchner Straße 20, michael.wurm@dlr.de)

1 ABSTRACT

Urban Landscapes show different urban structures. The physical face of cities is the result of complex city planning and general principles of spatial planning. And this physical face can be seen as the theater of life influencing life quality, social justice, mobility patterns, etc. In this work we focus on a specific phenomenon in post-war Germany: the town planning concept of large housing estates and their physical realizations. Same principles seem to lead to very similar urban structures and morphologies. However, over time different principles of spatial planning directions were applied for large housing states in the 1950/60s (the principle of the 'structured and low dense city') and the 1970/80s (the principle of 'urbanity by density') in Western Germany and for the entire time period until 1990 in the German Democratic Republic (the principle of the 'socialistic city'). In this stuy we analyze whether large housing estates resulted in similar or different urban morphologies. And, whether different urban morphologies developed across variations of the specific town planning concept applied. To do so, we base our work on spatial data capturing the large housing estates in Level of Detail-1 (LoD-1) 3D building models and the street network. These geoinformation are derived from multi-sensoral Earth observation data as well as from Volunteered Geographic Information (VGI) (in our case from OpenStreetMap). For the measurements and analyses of the morphologies of large housing estates we develop and apply spatial features such as building density, floor space index, orientation of buildings, orientations of streets, among others. We reveal that different directions of the same town planning concepts for large housing estates generally create physical variabilities of the urban morphologies within a relatively small range. A closer look, however, reveals that variations do exist and that specific town planning principles had de facto influence on the resulting morphologies.

Keywords: large housing estates, volunteered geographic information, remote sensing, urban morphology, urban structure

2 INTRODUCTION

Building types and their spatial arrangement predominantly define the appearance of a city. These structures are often the physical result of urban planning ideas, a mixture of changing ideas over long periods of time, and related social and economic developments (Heineberg, 2006). Across the globe spatial layouts of the built structure are of high variability from informal, organic, irregular, complex, often high dense utilizations of space to formal, planned, geometric, structured and often low-dense lay-outs. In the domain of town planning manifold concepts have been developed such as the garden city (e,g, Will & Lindner, 2012), new towns (e.g. Hardy, 1991), large housing estates (Dekker & Van Kempen, 2005), among many others. They all aim to steer city building to bring the physical structure into geometric order (e.g. Patel, Crooks & Koizumi, 2012) and with it to create a physical environment for a better, new society (e.g. Streich, 2011). In general these town planning concepts formulate specific goals and provide architectural guidelines with a range of variations in realizing them (Reicher, 2014).

A specific phenomenon in post-war Germany are large housing estates. With about five million people living in these estates in Germany today (BBSR, 2015) and about 41 million (excluding the former USSR) in Europe (Dekker & van Kempen, 2004), this concept remains of high relevance for living spaces. In the following we aim at spatially describing and analyzing the built-up morphologies of such large housing estates for differents parts of Germany. To do so, we compile land cover information on the built structures (houses and streets) using a multi-source approach: We use OpenStreetMap data (OSM, 2017), very high resolution satellite data as well as ground-based photographs for deriving three-dimensional city models at individual building level. Based on these geoinformation we aim at quantitatively comparing large housing estates based on one main question and two variations of it: Do large housing estates feature similar or different urban morphologies? And have different urban morphologies developed across variations of the specific town planning concept applied? And have different urban morphologies developed within the respective town planning concept?

Inherently these questions carry varying spatial locations of large housing estates and, thus, for periods of construction before 1990 different political systems in them. Beyond, these questions carry references to different periods of construction as well.

2.1 Large housing estates

After the second world war there was an urgent demand for new housing units in Germany. This was due to destroyed buildings, population growth, or rising individual demand for living spaces. The "Federal Ministry Environment, Nature Conservation, Building and Nuclear Safety" – as it is called today – defined large housing estates by the following indicators: built after 1945, functional independent estates, dense, high-rise, homogeneous settlement structures, larger than 2,500 housing units, and predominatly social housing development (BMUBau, 1994).

Due to different political systems until 1990 the town planning concepts related to large housing estates varied between Western and Eastern Germany. The "structured and low-dense" city was the main concept in Western Germany in the 1950s and 1960s. It featured a spatial (and often dogmatic) separation of functions between residential or commercial areas (Heineberg & Krajewski, 2014). The concept included large green spaces and recreation areas in close distances. In the 1960s this concept was adapted to "urbanity by density" (Heineberg & Krajewski, 2014). This conceptual idea featured the spatial integration of urban functions and aimed at higher utilization of space. In eastern Germany the town planning concept of the "socialistic city" was applied. It was meant to be socially inclusive. Social differences should not be seen by built environments (Bähr & Jürgens, 2009). In comparion to the "structured and low-dense" concept, the urban functions were spatially mixed (Senatsverwaltung für Stadtentwicklung und Umwelt, 2012; Altrock, Grunze & Kabisch, 2018).

	Town planning concept	City	Settlement	Time period of construction				Living units
				1950s	1960s	1970s	1980s	
Western Germany	Structured, low-dense mixed large housing estate	Braunschweig	Weststadt [B]		X			>5,000
		Bremen	Neue Vahr	X	X			>10,000
		Karlsruhe	Waldstadt	X	X			>5,000
	Urbanity by density	Berlin	Gropiusstadt		X	X		>10,000
		Braunschweig	Weststadt [C]			X	X	>5,000
		Dortmund	Scharnhorst-Ost		X	X		>5,000
		Frankfurt a.M.	Nordweststadt		X	X		>5,000
		Hamburg	Steilshoop		X	X	X	>5,000
		München	Neuperlach		X	X		>10,000
		Regensburg	Königswiesen			X	X	>2,500
Eastern Germany	Socialistic city	Berlin	Hellersdorf				X	>10,000
		Dresden	Gorbitz			X	X	>10,000
		Erfurt	Nord		X	X	X	>10,000
		Jena	Neulobeda		X	X	X	>10,000
		Leipzig	Grünau			X	X	>10,000

Table 1: Large housing estates in Germany - the 15 selected study sites

2.1.1 Selection of study sites

In 1994, 240 large housing estates were documented in Germany (BMVBS, 2013). For our quantitaive analysis of the built structures, we select 15 large housing estates (Table 1) by the following criteria:

- study sites which have been built under the guildline of one of the three town planning concepts: “structured and low-dense”, “urbanity by density” or “socialistic city” and thus, the selected samples inherently refer to different periods of construction or political systems.
- study sites across entire Germany for a basically geographic even distribution.

Table 1 provides an overview of the 15 selected study sites, their names and locations, their related town planning concepts, their construction time and the size by living units.

Fig. 1: Three-dimensional view of the urban morphology of the sample Dortmund Scharnhorst-Ost

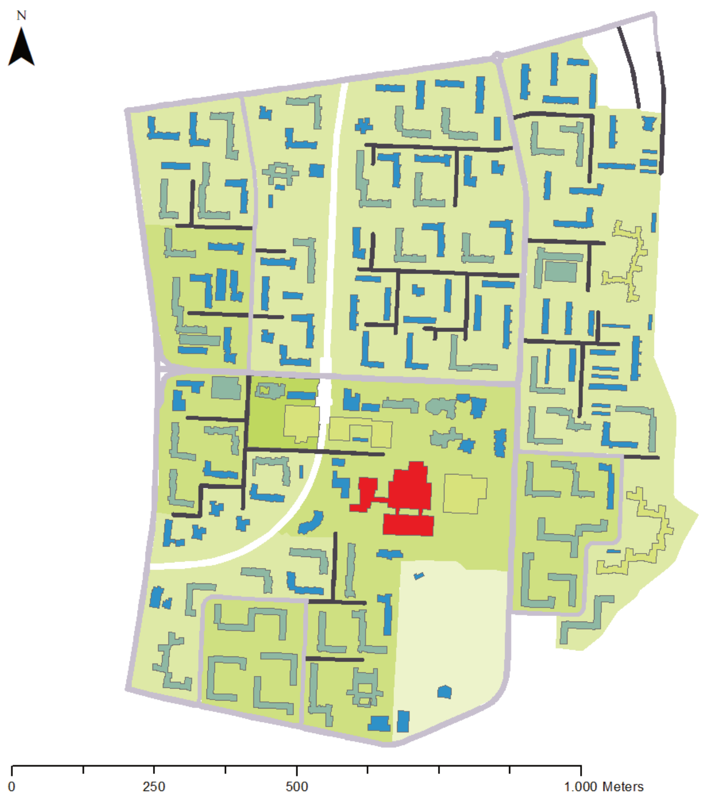

Fig. 2: Two-dimensional view of the urban morphology of the sample Dortmund Scharnhorst-Ost illustrating the spatial features building size, building density and type of street

Figure 1 gives an impression of the derived geoinformation in a three-dimensional perspective for the example of the large housing estate of Scharenhorst-Ost in Dortmund. The figure illustrates the planned, geometric alignments or the different building types or heights. Figure 2 illustrates further spatial features such as the building ground floors sizes, the building density and the types of streets used for quantitatively measuring the patterns.

3 METHODOLOGY

Our approach aims at comparing the built-up structures, i.e. the buildings and the streets definig the structures and patterns of large housing estates. The measurement of spatial patterns is, however, a complex task and needs a clear definition of the spatial units of measurement and the spatial indicators applied.

In this study we rely on three different scales – the individual object, the block unit and the district. At the level of individual objects we capture the elements consitituting the urban structure and pattern we are interested in; these are the building footprints, their heights and the streets (compare Fig. 1). We use the block level to aggregate the geoinformation of individual objects onto structural information such as building density (Wurm et al., 2014). The block unit is generally defined by a spatial entity which captures a structurally homogeneous area, often circeled by the street network (Taubenböck & Kraff, 2014). However, if the street network is not close meshed we introduce additional borders at obvious structural change overs of the built environment (e.g. from a built area into a park area). We use the district level to aggregate all generated geoinformation – either structural information on block level such as building density, or layout information which has not been aggregated onto block units such as street orientation. In consequence, the aggregation onto the district level is the ultimate spatial entity of comparing the spatial indicators between study sites; the comparison relies either on medians, means or the variability of measured values visualized in boxplots.

For a quantitative spatial analysis of the urban structures we use eight spatial indicators: Five indicators capture the appearance of building structures and three indicators capture the layout of the streets. We rely these indicators based on the suggestions for measuring the morphology of cities and their structures by Taubenböck, Kehrer & Wurm (2015). The five indicators capturing the building structures are: 'building density'; it is calculated in percent as the sum of all building ground floors per block unit; 'floor space index'; it is a non-dimensional number calculated by the sum of the available floor space per block unit; 'row house ground floor areas'; it is derived in percent as the share of building groundfloors belonging to row developments relative to all building ground floors per block unit; 'height of buildings' is calculated as the avaerage height of buildings in meters per block; and 'orientation of row development'; it is calculated by the main orientation of each individual building in degree.

The three indicators capturing the layout of the street network are: 'Percentage of non-linear streets'; it is calculated as the percentual share of street curves relative to the street network of the entire district; 'percentage of dead end streets'; it is calculated as share of dead ends relative to the entire amount of street segements of network per district; and 'orientation of streets'; it is calculated in degree based on the main orientation of every street segment. The histogramm at district level allows conclusion on the degree of geometric layouts.

For a descriptive analysis of the structural patterns we use boxplots provding the variability and medians of the measured indicators building density and floor space index at district level. For row house ground floors and building heights we simply use the mean values, and for orientation of row developments we use histogramms displayed in spider charts.

For the analysis whether settlement morphologies and patterns of large housing estates differ statistically we apply a single-factor analyis of variance (ANOVA). We apply the analysis for the spatial features, 'building density' and 'floor space index' at block level, and 'row house ground floor areas', 'height of building' and 'orientation of row development' at individual objects level. For the street layout we apply the single-factor analyis of variance onto the spatial features 'percentage of non-linear streets', 'percentage of dead end streets' and 'orientation of streets'. The ANOVA analyzes the differences among group means and their associated procedures (such as "variation" among and between groups) (e.g. Bahrenberg et al., 2008). In consequence, the approach tests if differences are more frequently than random, thus statistically significant. The variances among averages within a group of data are therefore compared to averages between groups of data. The data groups in our case are our spatial features quantitatively measuring spatial pattern of our large housing estates. The amplitude of the variance between groups measures the differences, with the determination of significance set to 0.05 (5%).

For the analysis which town planning concept features statistically different urban morphologies in general we apply a honest significance test (Tukey-HSD). We apply the same to detect which large housing estates within one town planning concept feature significant different spatial characteristics. The approach compares the values of the individual data groups to each other. Non-significant differences will be classified as one data group.

4 RESULTS

The results are structured into two different sections – a descriptive section giving insights into the measured structures of the large housing estates and an analytical section providing a statistical analyses for classifiying similarities of the measured structures.

4.1 The measured structures of large housing estates

Built-up structures and lay-outs found across the globe show a very high variance – from organic, irregular, complex high dense utilizations of space for example in slum areas to geometric, ordered low dense utilizations of space e.g. in suburbs. Using the example of building density, the documented variance spans from 10% density in suburbs (Taubenböck, Kehrer & Wurm, 2015) to 90% density in informal slums (Taubenböck, Kraff & Wurm, 2018).

In relation to this high variability of structural layouts found across the globe, the measured structural variability for the town planning concept of large housing estates is very low; using the example of one spatial feature –building density–, the utilization of space is with measured values generally from 13% to 19% also comparatively low. Figure 3 illustrates the measured results in boxplots for two examples of the introduced spatial features: building density and floor space index.

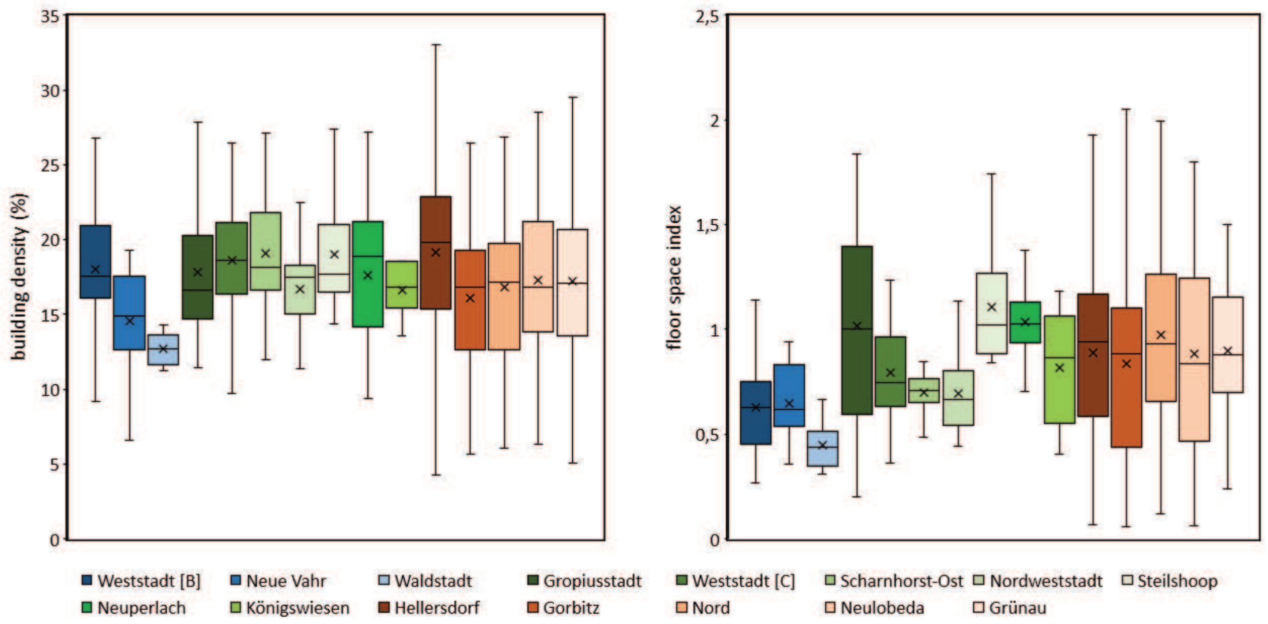

Fig. 3: Boxplots illustrating the building density of large housing estates; ordered by town planning concepts – blue: structured and low dense; green: urbanity by density; orange: socialistic city.

In general, we find building densities varying in median from a minimum of 12.7% in Waldstadt in Karlsruhe to a maximum of 19.1% for Scharnhorst-Ost in Dortmund. In relation to other structural urban types mentioned above, the relating structural variance within this specific town planning concept can be considered very low showing the steering effects of guidelines (and land use regulation) for architectural realization.

The floor space index reveals a varying usage of space from a minimum median of 0.4 in Waldstadt in Karlsruhe to a a maximum median of 1.1 in Steilshoop in Hamburg. It is remarkable that the 'structured and

ISBN 978-3-9504173-4-0 (CD), 978-3-9504173-5-7 (print)
Editors: M. SCHRENK, V. V. POPOVICH, P. ZEILE, P. ELISEI, C. BEYER, G. NAVRATIL

low dense' large housing estates mirrows its conceptual goal in de facto lower dense built structures with medians of 0.4 to 0.65 and low variances. For the concept of 'urbanity by density' the variability is highest with medians from 0.65 to 1.1, while the 'socialistic' city results in very homogeneous densities of a floor space indices of 0.9 across the samples.

The measured row house ground floor areas vary in median from the minimum of 357m² in Nordweststadt in Frankfurt a. M. to very large building footprints with 4,585m² in Steilshoop in Hamburg as maximum. It is remarkable that again, the variance of physical realizations is highest for the town planning concept of 'urbanity by density', while both other concepts result in relatively homogeneous row house sizes. The socialistic city features constantly larger row house sizes.

The measured heights of buildings show that in median large housing estates are characterized by heights of about 15 – 20m, which relates to about 5 floors. However, the variance of measured buildings heights is generally high as many building structures also show heights of up to 70m (e.g. Gropiusstadt in Berlin) or 50m (e.g., Neue Vahr in Bremen, Neuperlach in Munich or Gorbitz in Dresden).

Regarding the 'orientation of row development' we expected –as it is typical for most town planning concepts – that regular, geometric spatial building layouts are dominating. These layouts would resonate in geometric orientations either in parallel or orthogonal alignments. Figure 4 illustrates these row development lay-outs in spider charts using histograms of measured orientations.

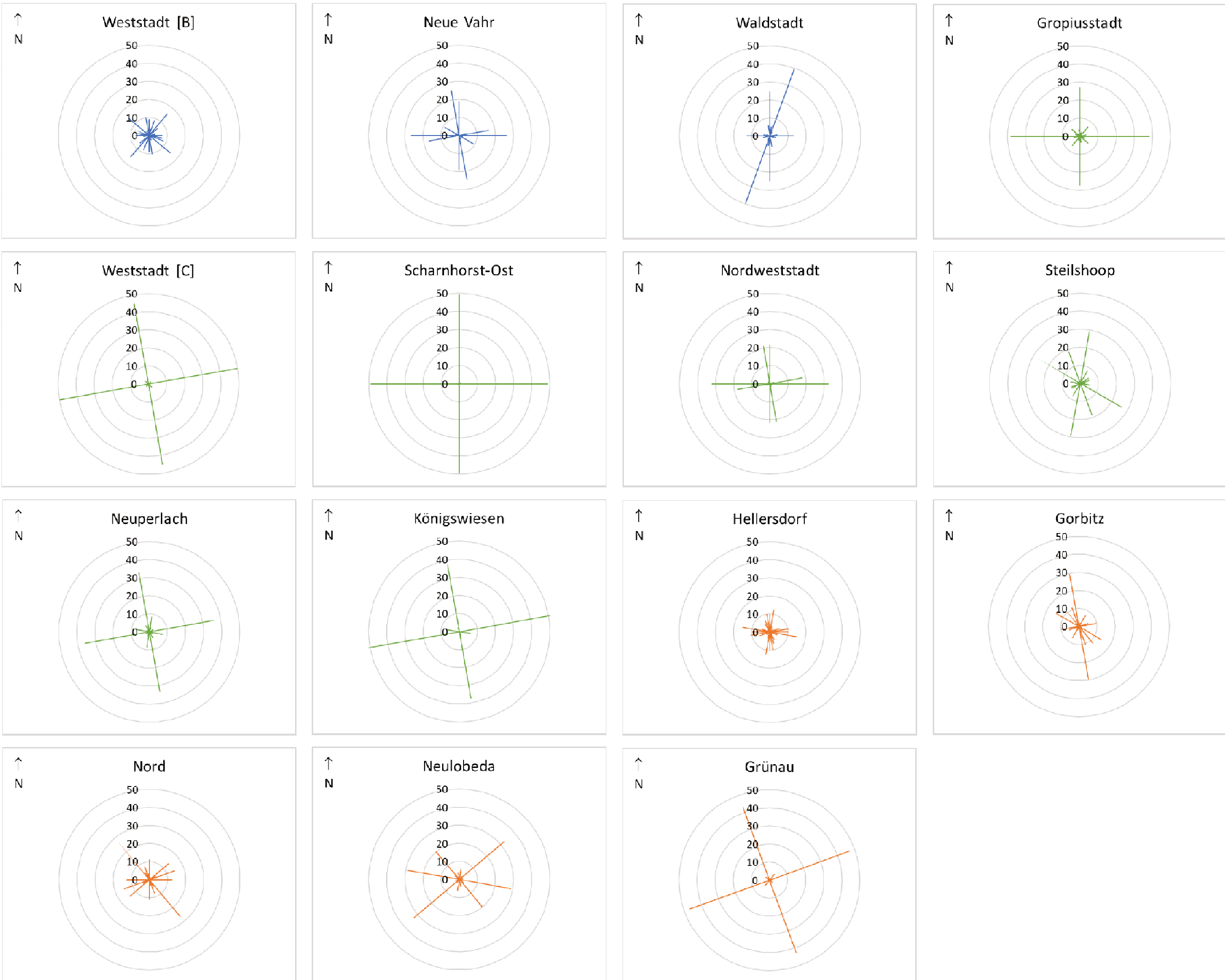

Fig. 4: Spider charts illustrating histograms of building orientations in large housing estates –blue: structured and low dense; green: urbanity by density; orange: socialistic city.

We find that some large housing estates almost perfectly meet the hypothesis that these town planning concepts result in perfect geometric, regular layouts. Perfect examples are Weststadt [C] in Braunschweig, Scharnhorst-Ost in Dortmund, Königswiesen in Regensburg and Grünau in Leipzig, which feature exclusivly row development alignments in parallel or orthogonal spatial order. However, the hypothesis is not met everywhere. For instance, in Hellersdorf in Berlin or Weststadt [B] in Braunschweig the row development alignments are realized in more non-regular layouts.

The lay-outs of streets are measured by the three spatial features 'percentage of non-linear streets', 'percentage of dead end streets' and 'orientation of streets'. For the spatial feature 'percentage of non-linear streets' a clear trend within or across town planning concepts is not recognizable in our results. The town planning guildines seem to not affect the street layouts. Beyond this, we also measure for the feature 'percentage of dead end streets' high variabilites: We find no significant dependence of this structural element with respect to the town planning concept. However, we find in general that this structural element with the objective of traffic calming in residential areas is a typical instrument established by planners. This element is often used for more than a 20% share (maximum is Waldstadt in Karlsruhe with 45%) of the entire street network in the quarter. The spatial feature 'orientation of streets' is strongly related to the spatial feature 'orientation of streets'. As examples, Weststadt [C] in Braunschweig or Scharnhorst-Ost in Dortmund do feature almost perfect geometric, regular layouts not just for the building developments, but also for the street orientations. This shows the dependence of street layouts and building structure alignment.

4.2 Morphological similarities and differences across and within large housing estates – a statistical classification

4.2.1 Morphological differences across town planning concepts for large housing estates

We apply the ANOVA to identify statistical differences between the urban morphologies of the three town planning concepts. The urban morphology is described by the introduced spatial features on buildings and streets. In addtion, the Tuckey-HSD creates statistical groups within the specific spatial features. Table 2 presents the respective results of the ANOVA and the Tukey-HSD between the town planning concepts. The same numbers indicate similarities for the measured spatial features. Different numbers indicate statistical deviations for the respective spatial feastures.

Parameter	Structured, low-dense, mixed large housing estate	Urbanity by density	Socialistic city
building density	1	2	2
floor space index	1	2	2
building size	1	2	3
building height	1	2	2
building orientation	3	2	1
street orientation	2	2	1

Table 2: Results of the ANOVA and the Tukey-HSD test between the town planning concepts and classification into sub-groups

In general, we find for the town planning concept of the 'structured, low dense large housing estates' characteristic spatial features differing from the other concepts. As the concept suggests by terminology, lower built-up densities are realized (with higher shares of urban green spaces). With an average building density of 15.9% and a floor space index on average of 0.53 the usage of space is significantly below the averages measured across our 15 samples in Germany. Beyond, row house footprints are on average with 621m² signifcantly smaller and building heights are with 13.5m on average significantly lower than the measured building morphologies in other large housing estate planning concepts. The building orientations are measured to be predominantly in geometric order of parallel or orthogonal arrangements, as it is characteristic for plannend quarters. The anaylsis of the street layout reveals no charcteristic arrangement for this town planning concept regarding percentage of non-linear streets, dead end streets or orientation of streets.

For the town planning concept 'urbanity by density' we find in general that spatial features deviate significantly from the structured, low dense conceptual idea. We measure the ultilization of space (e.g. by building densites and floor space index) is higher by trend (e.g. Neuperlach in München 17,6 % or Gropiusstadt in Berlin): The conceptual requirement of creating more urbanity has been reached by increasing two dimensional building densities; however, absolute numbers reveal that the increase compared to the structured, low dense concept is with a few percent relatively low. The increase in utilization of space predominattly can be referred to the floor space index, which has been increased on average from 0.5 to about 0.8. When relating this town planning concept to the one of the socialistic city the measured spatial features show many similar structural elements (e.g. building density, floor space index and building height).

Consequently, we find for the concept of the ‘socialistic city’ significant structural deviations from the structured, low dense concept, and partly similar structural features to the concept of urbanity by density. As examples, realized building densities, floor space indices and building heights correspond to the concept of urbanity by density. Building sizes as example are on average with 1,578 m² significantly larger than for the other two concepts.

Concluding we find that different directions of the same town planning concepts due to political background or construction times have influence on the realized built structures. However, the general physical variability of the large housing estates appear to be within a realtively small range.

4.2.2 Morphological differences within town planning concepts for large housing estates

Here, we apply the ANOVA and the Tuckey-HSD to identify statistical differences within the three town planning concepts. Therefore, we apply only the basic population of data per town planning concept for the analysis. And, we create sub-groups within the town planning concepts. Table 3 presents the respective results of the ANOVA and the Tukey-HSD. The same letters (A, B, and C) indicate to which town planning concept the respective large housing estate belongs to. The same number indicates statistical simularities within the spatial features of the settlements of one town planning concept. Lower numbers indicate lower average values. If more than one number is given, the structural appearance belongs to more than one sub-group. Settlements indicated with a star are unique.

Parameter	Weststadt [B]	Neue Vahr	Waldstadt	Gropiusstadt	Weststadt [C]	Scharnhorst-Ost	Nordweststadt	Steilshoop	Neuperlach	Königswiesen	Hellersdorf	Gorbitz	Nord	Neulobeda	Grünau
building density	B 2	B 1 2	B 1*	C 1	C 1	C 1	C 1	C 1	C 1	C 1	A 1	A 1	A 1	A 1	A 1
floor space index	B 1	B 1	B 1	C 2 3	C 12	C 1	C 1	C 3	C 2 3	C 12	A 1	A 1	A 1	A 1	A 1
building size	B 2	B 2	B 1*	C 2	C 3	C 2	C 1*	C 4*	C 3	C 2	A 2 3	A 1	A 123	A 1 2	A 3
building height	B 1	B 2*	B 1	C 123	C 12	C 1	C 1	C 123	C 2 3	C 3	A 1 2	A 1	A 2 3	A 3	A 123
building orientation	B 2*	B 1*	B 3*	C 4 5	C 1	C 5*	C 2 3	C 3 4	C 12	C 1	A 2	A 1	A 2	A 2	A 1
street orientation	B 2	B 1*	B 2	C 1 2	C 1	C 2	C 1 2	C 1 2	C 1	C 12	A 2	A 1	A 1 2	A 1 2	A 1

Table 3: Results of the ANOVA and the Tukey-HSD test within the town planning concepts and classification into sub-groups

Within the concept of the ‘structured, low dense’ we detect generally similar built morphologies. Predominately row house developments and sporadic high rise buildings are charateristic with low floor space indices.

Within the concept of ‘urbanity by density’ we measure similar structures; however, more morphologic variations between the settlements exist. As urban land use planning defines maximum densities, it is not surprising that measured densities remain within a small range. They do not show significant differences among our selected seven samples with a minimum density measured of 16.6% for Königswiesen in Regensburg vs. a maximum of 19.1% for Scharnhorst-Ost in dortmund. However, at indivdual building level land use planning provides grades of freedom to architects. Consequently, building sizes, building heights as well as the orientation of the streets reveal many different types of design.

Within the concept of the 'socialistic city' we find highly homogenous morphologies of building structures. Serial building types produce very similar morphologies across space and time. No significant differences in building density, floor space index, orientation of the buildings as well as streets could be identified among the five samples. In general, the measured variations between the urban morphologies are significantly smaller then within the other two concepts. However, some grades of freedom in architectural or town planning realizations are identifed as for example comparatively high spatial variance of building density or floor space index across block units within one area is measured.

Concluding we find that the same town planning concept creates generally homogoenous urban morphologies; although variations exist across examples of large housing estates, they remain within a relatively small range.

5 DISCUSSION

In this work we classify the urban morphology of large housing estates and relate their structures and patterns to different town planning concepts. The approach of combining multi-source geodata (VGI and remote sensing) proves capable of measuring and modeling the built appearance of cities. The geodata we use for the analysis are at the spatial level of individual buildings and street segments where we assume we capture the urban morphology well. Today the capabilities of very high resolution multi-temporal remote sensing data even allow the documentation of changes of the built-environment at LoD-1 (e.g. Leichtle et al., 2017). In consequence, in future physical adaptations in these large housing estates can be monitired.

In general, the measurement of urban morphologies has been documented as a complex task due to the manifold influences of thematic, spatial and calculative issues (e.g. Openshaw, 1983; Taubenböck et al., 2016). Based on the literature we apply commonly suggested features, i.e. a combination of thematic spatial features such as building density, floor space index or street orientations. Beyond, we apply the often suggested spatial entity of block units for aggregation. Thus, we assume that it allows to characterize the built environment in a comprehensive multidimensional way. However, we have to ackowledge that further spatial features such as green fraction or the like, which characterize the spatial appearance as well may provide additional relevant information not considered in our study. Beyond, the trends identified for urban morphologies in large housing estates are based on a relatively small sample of 15 and are thus at risk to be not fully representative. It also remains an open question how the physical realizations of large housing estates in other parts of Europe or across the globe relate to our samples analyzed.

6 CONCLUSION

In this study we find that the town planning concept of large housing estates and their guidelines in physical realization lead to – from a very general perspective – similar physical built structures and spatial layouts. A closer inspection reveals that different epochs with different guiding ideas ("structured and low-dense", "urbanity by density" and "socialistic city") of town planning concepts led to varying physical realizations of the built environment. This, in turn shows that abstract town planning guidelines hold certain degrees of freedom. Assuming that the built structure seen as the theater of life (Jacobs, 1961) has significant influence on the society (as suggested for example by Saunders, 2010) a consequential analytical step forward would now be the systematic correlation with socio-economic parameters such as income, quality of life, subjective feelings, etc. in these areas. This analysis would be a necessary reflection of the specific town planning concept and its capability of providing living environments of high quality.

7 REFERENCES

Altrock, U., Kunze, N. & Kabisch, S. (2018): Großwohnsiedlungen im Haltbarkeitscheck. Springer. pp.335.

Bähr, J. & U. Jürgens (2009): Regionale Stadtgeographie. 2. Auflage. Westermann. Braunschweig.

Bahrenberg, G., Giese, E., Nipper, J. & Mevenkamp, N. (2008): Statistische Methoden in der Geographie. Multivariate Statistik. Gebr. Bornträger, 386 S.

BBSR = BUNDESINSTITUT FÜR BAU-, STADT- UND RAUMFORSCHUNG im BUNDESAMT FÜR BAUWESEN UND RAUMORDNUNG (BBR) (Hrsg.) (2015): Energetische Sanierung von Großwohnsiedlungen – Vertiefende Modellprojekte der Umsetzung integrierter Stadtteilentwicklungskonzepte. In: BBSR-Online-Publikation, Nr. 06/2015. Bonn.

BMBAU = DER BUNDESMINISTER FÜR RAUMORDNUNG, BAUWESEN UND STÄDTEBAU (1994): Großsiedlungsbericht 1994. Unterrichtung durch die Bundesregierung. Hrsg. v. Bundesregierung. Drucksache 12/8406. Bonn.

BMVBS = BUNDESMINISTERIUMS FÜR VERKEHR, BAU UND STADTENTWICKLUNG (2013): Stadtumbau und differenzierte Entwicklung von Großwohnsiedlungen. Antwort der 78. Bundesregierung auf die Kleine Anfrage der

ISBN 978-3-9504173-4-0 (CD), 978-3-9504173-5-7 (print)
Editors: M. SCHRENK, V. V. POPOVICH, P. ZEILE, P. ELISEI, C. BEYER, G. NAVRATIL

Abgeordneten Heidrun Bluhm, Dr. Kirsten Tackmann, Herbert Behrens, weiterer Abgeordneter und der Fraktion DIE LINKE. – Drucksache 17/12155 –. Berlin.
Dekker, K. & Van Kempen, R. (2004): Large Housing Estates in Europe: Current situation and developments. Journal of Economic and Social Geography, vol 95(5), pp. 570-577.
Dekker, K. & Van Kempen, R. (2005): Large Housing Estates in Europe: A contemporary overview. In: Van Kempen, R., Dekker, K., Hall, S. & Tosics, I: Restructuring large housing estates in Europe. The Policy Press, Bristol, UK.
Hardy, D. (1991): From Garden Cities to New Towns. Chapman & Hall, London.
Heineberg, H. (2006a): Geographische Stadtmorphologie in Deutschland im internationalen und interdisziplinären Rahmen. In: Ganz, P., Priebs, A. & R. Wehrhahn (Hrsg.). Kulturgeographie der Stadt. Kieler Geographische Schriften 111. Selbstverlag des Geographischen Instituts der Universität Kiel. Kiel.
Heineberg, H. & C. Krajewski (2014): Stadtgeographie. 4. Auflage. UTB Schöningh. Paderborn.
Jacobs, J. (1961): The Death and Life of Great American Cities. Random House, 480 S.
Leichtle T, Geiß C, Wurm M, Lakes T & Taubenböck H (2017): Unsupervised change detection in VHR remote sensing imagery – an object-based clustering approach in an urban environment. International Journal of Applied Earth Observation & Geoinformation, 54, pp. 15-27.
Openshaw, S. The Modifiable Areal Unit Problem. Norwick: Geo Books; ISBN: 0860941345. OCLC:12052482; GeoBooks: Norwhich, UK, 1983.
Open Street Map (2017): Available online: http://www.openstreetmap.de/ (accessed on 18 January 2018).
Patel, A., Crooks, A. & Koizumi, N. (2012): Slumulation: An agent-based modeling approach to slum formations. Journal of Artifical Societies and Social Simulation 15 (4), p. 10.
Reicher, C. (2014): Städtebauliches Entwerfen. 3. Auflage. Springer Vieweg. Wiesbaden.
SAUNDERS, D. (2010): ARRIVAL CITY – THE FINAL MIGRATION AND OUR NEXT WORLD. KARL BLESSING VERLAG, P. 576 .
Senatsverwaltung für Stadtentwicklung und Umwelt (2012): IBA-Symposium. Leben mit Weitsicht – Großwohnsiedlungen als Chance. Living with a Vision – Large Housing Estates as an Opportunity. Adrian-prozessnavigation. Berlin.
Streich, B. (2011): Stadtplanung in der Wissensgesellschaft. VS Verlag für Sozialwissenschaften.
Taubenböck, H. & Kraff, N. (2014): The physical face of slums – A structural comparison of slums in Mumbai, India based on remotely sensed data. Journal of Housing & the Built Environment. vol. 29, issue 1, pp. 15-38.
Taubenböck H, Kraff N & Wurm M (2018): The Morphology of the Arrival City – A global categorization based on literature surveys and remotely sensed data. Applied Geography. Accepted.
Taubenböck, H., Kehrer, J. & Wurm, M. (2015): Zu Stein gewordene Philosophien – Die Morphologie geplanter Wohnviertel. SpringerSpektrum. S. 135-147.
Taubenböck, H., Standfuß, I., Klotz, M. & Wurm, M. (2016): The physical density of the city – Deconstruction of the delusive density measure with evidence from European megacities. ISPRS Internatl. Journal of Geo-Information, 5(11), pp. 1-24.
Will, T. & Lindner, R. (2012): Gartenstadt: Geschichte und Zukunftsfähigkeit einer Idee. W.E.B. Verlag, p. 312.
Wurm, M., d'Angelo, P., Reinartz, P. & Taubenböck, H.(2014): Investigating the Applicability of Cartosat-1 DEMs and Topographic Maps to Localize Large-Area Urban Mass Concentrations. IEEE Journal of Selected Topics in Applied Earth Observations and Remtoe Sensing 7(10), pp. 4138-4152.