TYPOLOGIES OF THE BUILT ENVIRONMENT - AN APPROACH FOR INVENTORY, BENCHMARKING AND MONITORING TOWARDS SUSTAINABILITY

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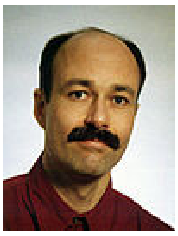

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Abstract

Urban environmental monitoring and informed decision making towards sustainable use of resources depends on the availability of spatially differentiated information. However, statistical data often at best allow estimates for a city as a whole or on the level of a national economy. Extensive on-site inventories of the built environment are prohibitive resource consuming.

Against this backdrop typology approaches are used for bottom up modeling of the built environment with respect to buildings, infrastructure and open spaces. Typologies of the built environment offer a consistent set of (pre-)defined representative buildings, building blocks or urban structures with typical properties like embedded resources, energy demands, land-coverage, infrastructure demands, resource consumption for renovation/upgrading and waste streams to be expected in case of restructuration or demolition etc.

Building typologies support large scale inventories as well as micro scale rapid assessments of specific objects. Typologies of urban structures support differentiated models of the urban built environment for a national economy or the city as a whole as well as micro scale screening of stocks and flows on neighbourhood level or for housing market segments. It is also possible to illustrate short and long term effects of development scenarios.

This paper presents a synopsis from several research and policy advice projects on sustainable urban development issues working with typologies on building and neighbourhood level.

1. Introduction

Research on the built environment deals with a complex and interdisciplinary subject. Especially with the objective of sustainable development multidimensional and multivariate approaches are needed. Hence, as in other fields of environmental research, linear approaches relying on mean values and standard deviations will usually not be appropriate to structure a complex reality (Haan, 2001), in particular if options for action on micro scale level are searched for. Statistical data tend to be very general and at best allow estimates on large or medium scale level, such as for a city as a whole or on the level of a national economy. A lot of statistical data often can not be broken down to the micro-scale of neighbourhoods, building blocks or single buildings and extensive on-site inventories are prohibitive resource consuming.

As an example, on the basis of the average energy consumption figure for an urban building stock no refurbishment programs can be defined. Not until the urban built environment is structured along categories like housing, office and industrial buildings and usually more detailed along for example housing construction periods and types more specific analyses and assessments are possible. We are then able to identify hot spots of energy consumption or saving potentials as well as actors to be involved etc.

Typology approaches are an essential way to structure a set of given objects with respect to specific relevant research questions. Thereby types can be defined from a theoretical perspective on the basis of conceptual considerations and experience or based on statistical analysis and classification for example by cluster analysis. For complex (sets of) objects and research designs often a combined approach will be adopted leading to “constructed types” (Kluge, 1999, 70).

As a methodology typologies can be applied for empirical analysis in two ways: They at first are a means to estimate a given empirical object (e.g. a building, a neighbourhood) with respect to specific characteristics by comparison with predefined types (of buildings, neighbourhoods). Second, typologies (e.g. of typical building blocks) can be used for a modeling and fast screening of characteristics of a superordinate system (e.g. an

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entire city) by representing relevant, typical elements of this system with typical characteristics. Given empirical objects (building blocks within a city) can then be classified and quantified along the typology and through aggregation of the characteristics of the elements an aggregated estimation of characteristics of the system under investigation (the city) is possible.

In spatial research typology approaches are used to describe, model, analyze, benchmark and monitor the built environment with respect to buildings, infrastructure and the urban structure. Typologies of the built environment offer a consistent set of (pre-)defined representative buildings, building blocks or urban structures with typical properties like embedded resources, energy demands, typical land-coverage (relation and pattern of built and non-built spaces), infrastructure demands, resource consumption for renovation/upgrading and waste streams to be expected in case of restructuration or demolition. Building typologies as an example classify buildings along construction periods and technologies. Urban structure types classify basic urban spatial units with morphological and functional homogenous character, defined by characteristic structures and development patterns of buildings, infrastructures and open spaces.

Building typologies support large scale inventories as well as micro scale rapid assessments and may even provide quick info on easy to apply good practice solutions. A typology of urban structures can support highly aggregated models of the urban built environment for a national economy or a the city as a whole as well as micro scale screening of stocks and flows on neighbourhood level or for housing market segments. Combined with scenario-techniques it is also possible to illustrate short and long term effects of planning and development decisions. Examples for urban structure types used in different projects and presented in more detail below neighbourhoods dominated by single-detached family homes or open structure apartment block developments like neighbourhoods dominated by residential concrete slab buildings.

As an interdisciplinary methodological approach, typologies of the built environment can be utilized from three perspectives:

i) “Direct link”: For research with a focus on the spatial and material physis of the urban built environment (e.g. land use, material inputs, energetic properties, etc.), its evaluation and development, typologies of the built environment are directly linked with the object of investigation.

ii) “Vehicle”: For spatial research, that does not directly deal with material or physical issues of the built environment (e.g. socio-economic research on housing preferences of citizens, demographic change in different sectors of the housing market) typologies of the built environment can serve as a vehicle for the transmission of results into categories of urban planning and development. From this perspective a typology of the built environment can be understood as a material representation of urban lifestyle preferences.

iii) “Interface”: For interdisciplinary spatial research a primarily morphologically defined typology of the built environment can serve as an intermediate starting point and synoptic focus for the definition of a shared subject. A “boundary object” (Bowker & Star, 1999), that has to be further elaborated or specified for investigations from the perspective of each of the involved disciplines but serves as an interface for communication, projection and the integration of multi-criteria analysis.

In the following paragraphs the work with typologies for the built environment is presented with examples from research projects focusing urban housing analyses in which the authors participated.

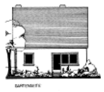
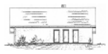
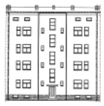
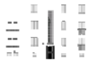
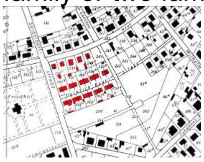
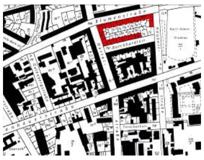
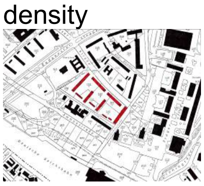
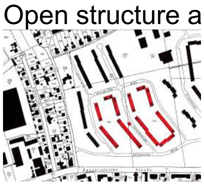
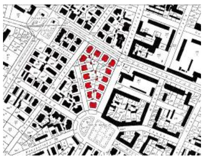
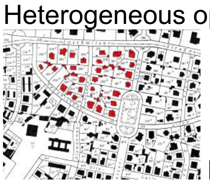
2. Examples from spatial research projects

In the following paragraphs we very briefly present three examples to illustrate the above mentioned three perspectives. The first example, *“direct link”*, was drawn from a project working with types of housing areas and types of urban built structures for an analysis and scenario generation of land use and use of resources for housing development in two case study cities for 2020 (Deilmann & Gruhler, 2007). The second example, *“vehicle”*, is a project that defined structure types of urban housing areas as a basis for housing market development analyses (Banse et al., 2004). The third example, *“interface”*, presents urban structure types as a projection screen for an interdisciplinary and multi-criteria visioning of sustainability issues for the development of the housing stock in Saxony, Germany until 2030 (Deilmann & Gruhler, 2002).

2.1 “Direct link”

The objective of the project was the identification, description and analysis of land use and resource consumption effects of development scenarios for two different medium-sized cities with different dynamics of growth and shrinkage. In order to trace out the range of options, the project took a scenario approach to reflect the “reaction” of the built environment (building stock organized in specific urban design structures) to different strategies of housing supply. As a methodological core a municipal land-use and material-flow-model was developed. In order to link the development of housing demand with the development of housing stock the development started by assigning relevant variables and characteristics to typical housing market segments represented by typical housing areas. Also statistical population-, household- and housing-demand-data was broken down to this spatial level.

Table 1 Examples for urban structure types of housing areas and related building types (IOER)

	1/2FH until 1990	1/2FH as from 1991	MFH until 1918	MFH 1919 - 1945	MFH 1946 - 1969	MFH 1970 - 1990	MFH as from 1991
							
Detached and semi-detached single family or two families' homes  EFB-1	X	X					
Terraced houses with garden yard (single / two families' homes)  EFB-2	X	X					
Enclosed Blocks  MFB-1			X				X
Linear developments with different density  MFB-2/3				X	X		X
Open structure apartment blocks  MFB-4						X	X
Partially enclosed low density Blocks  MFB-5			X				X
Heterogeneous open developments  MFB-6	X	X	X				X

With the next step this (proto-)typology was further differentiated along physical and spatial criteria related to construction and urban design into urban structure types. This kind of categorization, in fact: typefication, can build on existing predefined typologies of urban structure with integrated building types. However, it is self evident that pre-defined typologies can only be a starting point and have to be adapted to the local situation and context. As a result, a specific typology is generated that links urban structure types and building types and encompasses integrated types like areas with detached single family homes or apartment blocks in linear alignment as two examples (Tab. 1). Based on such a typology, in total representing the spatial and physical elements of the given urban (sub-)system, and with the characteristics assigned to each of the types the environmental state of the status quo as well as the impacts related to development scenarios can be described and compared in an approximation. At the same time urban structure types and implicated building types serve for a visualization of possible development scenarios in synthetic planning documents.

Based on this typology, development scenarios for the project cities were drafted for the analysis of new developments, vacancy and demolition in the building stock with a perspective until 2020. With respect to land use parameters the results show for the city as a whole, that the city with a growth dynamic will be able to cover land use demands to more than a third by utilizing brownfield areas (existing and from future demolition) and building gaps within the building stock. For the city with a shrinking dynamic it is nearly half of the land use demand. Provided that an ambitious demolition program is implemented to reduce vacancy to a market compatible rate, brownfields and building gaps would mobilise even more land than needed for new developments with the result of an increase of brownfield areas.

In a second step the general land use analysis on city level was broken down to the level of the urban structure types. From this point of view it became clear, that certain structure types will be able to absorb future specific land use demands (e.g. enclosed block developments), while others – especially areas with detached and semi-detached single family or two families homes – will not. This has the consequence that for the latter types new developments on un-built land would be necessary.

On the level of urban structure types also material flows were calculated in order to specify general material flow balances and projections on city level concerning input of new or recycled construction materials and output of demolition waste. As a result we can see that we have urban structure types that tend to become “net material providers”, because the quantity of materials from demolition outweighs the quantity of materials needed for new developments or refurbishment activities. On the other hand we have urban structure types that are more relevant for new developments and thus remain “material consumers”. Besides the quantity (and direction) of material flows also the quality of material flows (brick, concrete, wood, steel ...) differs and can be estimated via the building types incorporated within the different urban structure types.

2.2 “Vehicle”

This project aimed at an analysis of the development of inner city housing markets with a specific focus on the localization of vacancy rates in a larger city with an almost stable number of inhabitants. With respect to data availability the analysis started on the level of urban statistical districts. However, statistical districts – as defined in Germany – usually encompass very heterogeneous physical housing development structures. Therefore the statistical structure was further specified along 41 homogeneous structure types of urban housing areas. The defined types structured the housing stock by kind and construction period of the buildings on the one hand and the “address” in terms of neighbourhood characteristics on the other. On the basis of this typology specific development trends for the housing stock and housing vacancy could be identified for different housing market segments.

Among other, the investigation showed for the structure type of pre-1918 developments in unpretentious neighbourhoods that younger households show a low potential to stay in the neighbourhood or move into the neighbourhood. A long-term utilization for this type appears problematic. At the same time housing developments of the type 1946-1969, refurbished and situated in middle and upper grade neighbourhoods have positive utilization potentials. The situation appears generally uncertain for developments of the 1970ies and 1980ies. Although the share of the population of working age as well as the share of family households and working households is above average, indicating stability of use, the quality of neighbourhood characteristics seems crucial for future development trends.

With respect to the development of vacancy rates also differentiated results were obtained for the different types. As a general trend we can say that hardly any vacancy rate changes could be detected for the structure type single family and two families’ homes. On the other hand vacancy rates in the older apartment building stock increased proportionally with the rate of new developments. If changes of the vacancy rate occur with future developments they are most likely to be expected within the apartment building stock.

2.3 “Interface”

Aim of this project was to identify the range of development potentials and related strategies towards sustainability for typical housing neighbourhoods in Saxony from three perspectives addressing materials and energy, design and function and socio-economic issues. As a shared representation of the physical object for this interdisciplinary investigation ten urban structure types of housing areas were defined, to a large extend by using a morphological approach. The typology served as a framework for the collection and structured presentation of disciplinary data. For on site empirical investigation representative real-world neighbourhoods were chosen in three different Saxony cities for each of the urban structure types. Finally for the analysis and interpretation of disciplinary results the typology provided a synoptic projection screen and interface for the merging of disciplinary results.

From the materials and energy related perspective the different urban structure types show different characteristics. For each of the urban structure types building density and related material intensity was calculated as a means for large scale inventories. As an example closed block developments (MFB-1) have the highest material intensity with up to 43.000 metric tons per hectare net area of land used for residential building (t/net B_{res} ha) while open structure apartment block developments (MFB-4) with 20.000 metric tons nearly equal the material intensity of partially enclosed low density Blocks (MFB-5). Considering material intensities of the infrastructures it is noticeable, that this figure differs far less between the different urban structure types. However the ratio of infrastructure material intensity to building material intensity can vary between 10% (closed block developments / MFB-1) and 70% (detached single family homes / EFB-1) (Fig. 1). Finally with the different material characteristics also typical material related primary energy input figures could be assigned to the urban structure types. Also via the different building types within the urban structure types energy consumption figures and refurbishment potentials could be analysed.

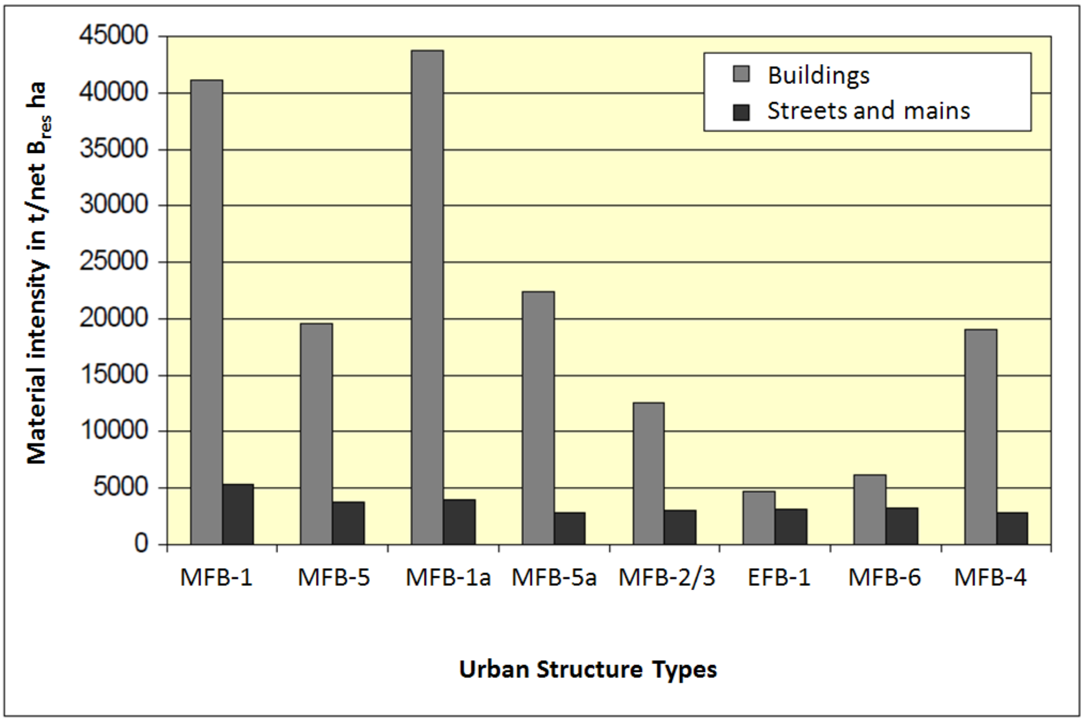


Figure 1 Material intensity of different urban structure types; comparison of buildings / streets and mains (average values for three cities in Saxony; source: IOER)

From the socio-economic perspective urban structural types can be interpreted as physical manifestation of different housing demand specifications. However, the categorization of housing areas along urban structure types alone does not pre-determine the socio-economic evaluation. Other issues, like housing quality, economic or population dynamics and social structure of households are of higher relevance.

From a design related and functional perspective building structures (building quality and use of buildings), the structures of open spaces (quantity and spatial arrangement, uses, accessibility) and traffic infrastructures were analyzed. The results show for example, that the enclosed block developments usually have un-built yards with a potential for environmental upgrading. At the same time roads and sidewalks are of little attractivity due to the closed building structures and missing connections between the semi-private yards and public spaces. The internal structure of the buildings and flats is favorable for flexible uses and restructuration due to a layout with several rooms of equal size without pre-assigned uses. On the other hand open structure apartment block developments have relatively favorable environmental conditions (green spaces, no transit traffic), while structural homogeneity and monotony (identical ‘industrial’ flats, uniform design) often are perceived as shortcomings.

3. Conclusions

The work with typology approaches in *spatial research* offers several opportunities:

Theoretical: Urban structure types in spatial research reflect and structure assumptions about the relation of specific spatial structures and development effects, e.g. with respect to environmental change, resource and energy consumption etc.

Empirical: Urban structure types in spatial research support empirical inventory. They can be empirically identified on-site or detected in planning documents. Based on other IOER research (Meinel, 2008) this (partly) is already possible automatically.

Socio-economic: Urban structure types in spatial research can be interpreted as a physical representation of specific demand and patterns of use for the urban built environment.

Methodological: Finally, as described in the examples above, urban structure types in spatial research can be used for analysis of specific objects as well as of a represented larger system and last not least as an interface for inter-disciplinary communication and analysis.

Looking at *planning and development practice*, typology approaches support decision making with respect to several core issues of sustainable development of the built environment. As shown with the presented projects, they help to estimate and compare situations and model development scenarios of resource consumption and land use demands for buildings and related urban infrastructure. The latter is particularly interesting looking at the discussion of urban density versus urban sprawl (e.g. Westphal, 2008). Urban structure typologies linked with (housing) demand models for example support better understanding of inner city brownfield regeneration potentials.

Beside that, in other transdisciplinary projects building and urban structure typologies with defined damage functions are for example used to assess vulnerability of the built environment exposed to flood risks in the context of adaptation to climate change (Neubert, 2008) Another important sustainability related issue is the analysis and modeling of energy efficiency potentials for the renovation of the existing building stock in order to reduce CO_2-emissions. Based on a building typology, Gruhler (2004) analyses heating demand development scenarios for housing in Saxony until 2030. It is shown, that the increase in heating demand from new construction can be (out-)balanced by increased energy efficiency in the building stock through renovation. It also becomes clear, that energy demand figures are dominated by detached and semi-detached single family or two families' homes. While representing roughly only one third of the overall number of flats, this building type accounts for 60% (building stock) to 80% (new construction) of heating demand and the related CO_2-emissions.

To sum up, sustainable development of the built environment needs tools for analysis, benchmarking and (ex-ante-)evaluation of a large variety of issues and criteria. To this end existing experience shows, that typology approaches can be of great help in research as well as for practitioners.

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*[*Translation of German titles A.B.; for orientation only]*