Innovations in Measuring Density
From area and location density to accessible and perceived density

Meta Berghauser Pont
TU Delft Faculty of Architecture
meta.berghauser@arch.kth.se

Abstract/Summary of the Presentation
In the rapidly growing field of *measuring urbanism*, the oldest and most frequent measure by far concerns *urban density*. As such the concept of *density* is of fundamental importance for both theoretical discourse and professional practice in urban development. Not least, it is of strategic importance for the urgent issue of sustainable urban development.

Over the last decade, various strategies for sustainable urban development have been presented, e.g. *new urbanism, urban containment* and *transit-oriented development* (Calthorpe & Fulton, 2001; Duany et al., 2000). These have increasingly fused under the heading smart growth (Frumkin et al., 2004) and have as such gained wide support, not least by the United Nations , as the viable way forward. The goals of these strategies vary in their details, but most often include preservation of natural land, as well as farmland, and cost-efficient construction and use of urban infrastructure. More than anything, however they are characterised by the aim to create higher-density land use patterns that encourage a mix of uses and the patronage of public transit, leading to less energy consumption and a more efficient utilization of land in urbanized areas (Pendall, Martin, and Fulton, 2004).

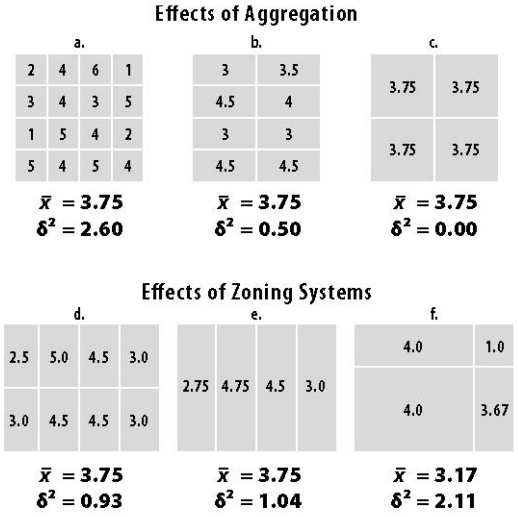

Figure 1: The MAUP problem. Effects of aggregation and zoning systems on the mean value (x) and variance (δ2). (Jelinski and Wu, 1996 in Dark & Bram, 2007: 473).

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A review of research regarding smart growth, published since 1985, reveal how *density*, or its counterpart *sprawl*, are highly imprecise concepts and, moreover, that the way they are measured is decidedly inconsistent and almost by rule varies from article to article (Colding et al, forthcoming). We therefore find an urgent need to readdress the issue of measuring urban density in preparation for more consistent practice in research.

Three problematic areas can be defined when it comes to measuring density: the difficulty of consistent definition of areas for measurement (generally referred to as the Modifiable Area Unit Problem, MAUP, see figure 1); the dominance of descriptions of conceived space rather than perceived space (addressed in space syntax); the lack of relation in conventional density measures to urban form or, more specifically, building typologies (addressed by the Spacematrix-concept, see figure 2 and 3).

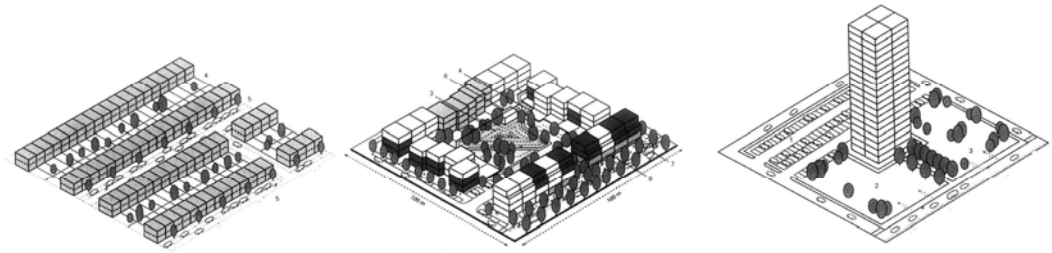

Figure 2: The lack of relation between density and urban form when using conventional density measures. Three areas with 75 dwellings per hectare (Fernandez Per & Mozas 2004: 206-207).

We propose therefore a new measure of *accessible* density that, first, gets around MAUP by using location measures instead of area measures (Ståhle 2008), that is, it includes the number of opportunities accessible within a fixed distance (Breheny, 1978). Second, it measures perceived density rather than conceived density by including cognitive distance in such location measures (Hillier 2003). Furthermore, to also capture the more qualitative aspects of urban morphological types, the accessible density measures are introduced into the multi-variable approach of Spacematrix (Berghauser Pont and Haupt 2010), where we calculate its main variables FSI and GSI by using the accessible floor space and the accessible footprint in the numerator (A) and the catchment (accessible lot area) in the denominator (B) of the fraction A/B.

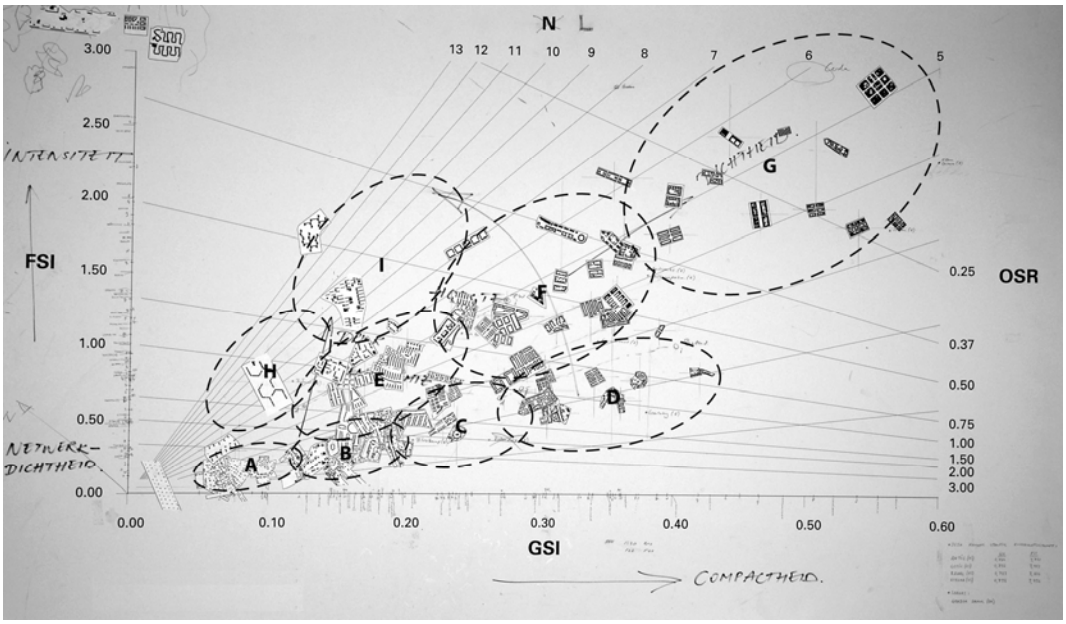

Figure 3: Spacematrix, a multi-variable method to measure density (Berghauser Pont and Haupt 2009, 2010). A=low-rise point type; B= low-rise strip type; C=low-rise hybrid type; D= low-rise block type; E=mid-

rise strip type; F= mid-rise hybrid type; G=mid-rise block type; H= high-rise strip type; I= high-rise hybrid type (measured at urban fabric or neighbourhood level).

It is shown that due to the particular scale of morphological heterogeneity in Stockholm, the distance of 3 axial steps, limited also by a maximum of 500 meter walking distance, is most suitable to capture the morphological types. However, also at other scales the introduced accessible density measure can be used to compare densities without the results being corrupted by varying boundary definitions. This is of critical importance. Mees (2010), for instance, has shown that the often cited research results by Newman and Kenworthy (1989) on the relation between density and gasoline consumption are highly dependent on the chosen definition of the urbanized land, or in other words, the definition of the denominator (B) in the fraction for density A/B. Especially the differences in this respect between cities in the USA and Europe have been pointed out as problematic. In other words, he stresses the *MAUP* problem in studies of this kind and was able to show that correlations drop from 0,9 to 0,3 when using normalised area boundaries. The use of the accessible density measure proposed here therefore represents a way forward when it comes to comparisons between areas with varying administrative boundaries and, moreover, is capable in capturing what can be described as *perceived* density.

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Meta Berghauser-Pont is Chair of Urban Design within the Department of Urbanism of the Faculty of Architecture at the Delft University of Technology. Her PhD thesis, 2009, together with Per Haupt developed a method to measure density so it can in a meaningful way be related to urban form and other performances. This has been published by NAi Publishers in 2010: 'Spacematrix. Space, Density and Urban Form'. Since her doctorate this performative approach to urban form has been further developed in cooperation with other researchers, e.g. Lars Marcus (KTH Stockholm Sweden), Erik Salomons (senior researcher TNO Delft), Birgit Hausleitner (PhD candidate TU Delft), and Eva Minoura (PhD candidate KTH Stockholm Sweden). Currently she is also working as a researcher at the KTH School of Architecture. Besides, she was member of the scientific committee of the last ISUF (International Seminar on Urban Form) conference, New Urban Configurations, organised in Delft, October 2012.