#47

MULTIVARIABLE MEASURES OF PLOT SYSTEMS:

Describing the potential link between urban diversity and spatial form based on the spatial capacity concept.

EVGENIYA BOBKOVA
Chalmers University of Technology
evgeniya.bobkova@chalmers.se

LARS MARCUS
Chalmers University of Technology
lars.marcus@chalmers.se

META BERGHAUSER PONT
Chalmers University of Technology
meta.berghauserpont@chalmers.se

ABSTRACT

Urban diversity is a widely recognized concept used to describe vitality in cities and is often associated with cities that perform successfully both from an economic and social perspective.

The concept of urban diversity was introduced to the broader public by Jane Jacobs, later inherited by the New Urbanism movement and has been extensively used in contemporary urban discourse. While theoretical definitions of urban diversity are manifold, measures that allow for a description of a more rigorous kind are less developed (Talen, 2006, 2008).

The aim of this paper is to identify fundamental variables of spatial form that could potentially contribute to urban diversity and socio-economic performativity. In particular, the paper investigates the concept of spatial capacity, that is, the impact of plot systems (i.e. land division) on urban diversity (Marcus, 2000, 2010; Sayyar & Marcus, 2013)

While the link to urban diversity is presented here as an essential starting point, the aim of this paper is to develop purely morphological measures of plot systems and to test if these measures can identify the difference among particular urban contexts. The study of the direct relation between spatial form and socio-economic performance is beyond the scope of this paper and will be presented in forthcoming studies.

The first part of the paper presents a theoretical framework to establish the fundamental morphological parameters of plot systems that can potentially contribute to urban diversity. The second part of the paper describes an empirical study of selected areas in Stockholm, Sweden, where essential morphological aspects of plot systems are explored and measured, using the proposed parameters of the plot systems.

Importantly, the plot systems are measured here in geometric terms, capturing size, openness and compactness of plots, and also in configurational terms through accessible number and diversity of plots using the Place Syntax Tool (Ståhle, 2008).

The paper is set within the framework of a bigger project aimed at developing and testing sound methodologies for measuring central variables of spatial form: density, diversity and distance (Berghauser Pont et al. 2017; Berghauser Pont & Marcus, 2015; Marcus & Berghauser Pont, 2015).

KEYWORDS

Urban diversity, plot systems, spatial capacity, area-based measures, location-based measures.

1. INTRODUCTION: THE FORGOTTEN VARIABLE OF DIVERSITY

Urban diversity is a widely recognized concept used to describe vitality in cities and is often associated with cities that perform successfully both from economic and social perspectives. However, it is not always clear whether diversity in this context refers to diversity in the spatial form of cities or diversity in socio-economic processes. This paper will briefly review various theories about urban diversity and then address how certain properties and attributes of spatial form may create and support socio-economic diversity. Based on the hypothesis that configuration of plot systems can potentially have an impact on urban diversity, several measures of spatial form will be proposed and demonstrated that can potentially grasp the differences among particular urban contexts and contribute to establishing a firmer link between spatial form and socio-economic performance.

The morphological measures discussed here are set within the framework of an international project called SMoL[1] (Berghauser Pont et al. 2017) which aims to develop and test sound methodologies for measuring spatial urban form, focusing on the variables of density, diversity and distance that correspond to fundamental elements of urban space: buildings, plots and streets. (Berghauser Pont & Marcus, 2015; Marcus & Berghauser Pont, 2015) (Figure 1). Theory and techniques supporting such measurements related to distance and density are well developed and found first in Space Syntax (Hillier 1996), and second in Space Matrix (Berghauser Pont & Haupt, 2010). However, this is not the case with diversity. The point of departure is earlier research focused on the spatial capacity concept, arguing that land division into plots typically influences the number of owners of space within an area, which in extension also influences the number of owner strategies, which ultimately is likely to influence the diversity of land uses within an urban area (Marcus, 2000; 2010).Urban diversity is discussed here as an essential

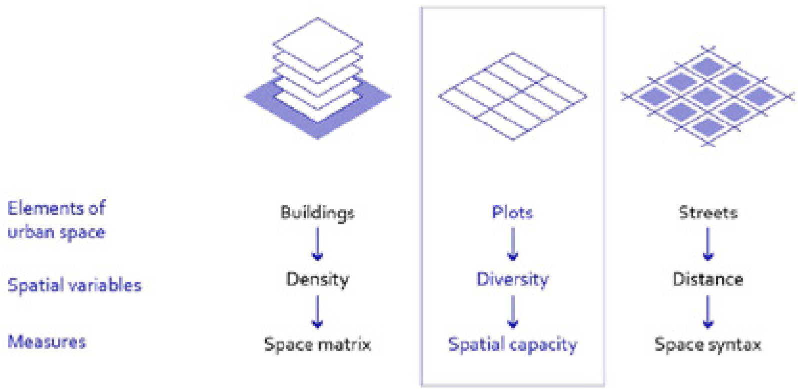

Figure 1 - Three variables of urban form, corresponding to three basic elements of urban space and that can be measured using spacematrix, Space syntax or the concept of Spatial capacity. (Marcus & Berghauser Pont, 2015)

theoretical basis for the proposed morphological measures of plot systems, which is the aim of this particular paper. Further, this paper shows the test results using these measures and discusses whether they can identify differences among particular urban contexts. The relation between plot systems and socio-economic diversity is a next step of a more extensive study and will be explored in forthcoming papers.

1 Spatial Morphology Lab (SMoL) is a three year project financed by Chalmers foundation, led by Lars Marcus and Meta Berghauser Pont

The first part of this paper presents a brief overview of urban diversity theories and a theoretical framework that allows for the establishment of the fundamental morphological parameters of plot systems that can potentially contribute to urban diversity. The second part describes an empirical study of selected areas in Stockholm, Sweden, where essential aspects of the plot systems are explored and measured with the proposed parameters. The concluding part summarises the results of empirical study of the proposed measures and lays the ground for future research: developing plot systems typologies and co-relating plot system configurations with socio-economic data in order to arrive to a more substantial theory about relation between spatial form and urban diversity.

2. THE CONCEPT OF URBAN DIVERSITY: CURRENT DESCRIPTIONS

The importance of a closer look at the variable of diversity in urbanism is demonstrated by the inconsistent use of definitions found within the literature. The idea of urban diversity was first introduced to the general public by Jane Jacobs (1961), who primarily looked at it from an economic point of view. It was extensively built on by the New Urbanism movement (Krier, 1984; Duany, Speck, & Lydon, 2010; Calthorpe & Van der Ryn, 1986), though rather in terms of how to create urban quality and attractiveness. Emily Talen (2006; 2008) presents an academic and thorough review of aspects of urban diversity, covering themes such as place vitality, economic health, social equity, and sustainability, and discusses alternative measures of diversity. Although the definitions of urban diversity in the literature are manifold, we repeatedly find them mixing morphological dimensions of diversity with socio-economic dimensions, where morphological dimensions often refer to small blocks and a mix of housing types, while socio-economic dimensions contain such parameters as a mix of uses/activities, and social/ethnical mix.

Hence, while fully recognizing that socio-economic dimensions such as mixed use may in themselves further generate urban diversity, it is essential, from the point of view of urban design, to understand how spatial form may influence and even generate urban diversity. We propose here that based on the concept of spatial capacity, that is, the division of land into different plots, we can bridge spatial form and socio-economic diversity. The ability of any spatial form to accommodate various uses over time, will here be understood as closely related to urban diversity as it enables diversity over time.

3. THE CONCEPT OF SPATIAL CAPACITY: THE ABILITY OF SPATIAL ARTEFACTS TO CARRY CATEGORICAL DIFFERENCE

The concept of spatial capacity, introduced by Marcus (Marcus, 2000, 2010; Sayyar & Marcus, 2013) describes the impact of land division, i.e., plot systems, on urban diversity. It proposes that the configuration of plot systems has a direct impact on the potential to host diverse owner strategies, and, consequently, uses (Figure 2). While here discussed on the urban level, we may see the principle at work in any artefact aimed at storing people, things or functions, whether they be cities, buildings or cupboards. The more such artefacts are divided into separate spaces, the more they create the opportunity to sort people, things or functions into a greater number of categories. As for any spatial form, this is not a deterministic relation but a conditional relation; we may not choose to sort people, things and functions according to this spatial form, but the conditions to do so are there.

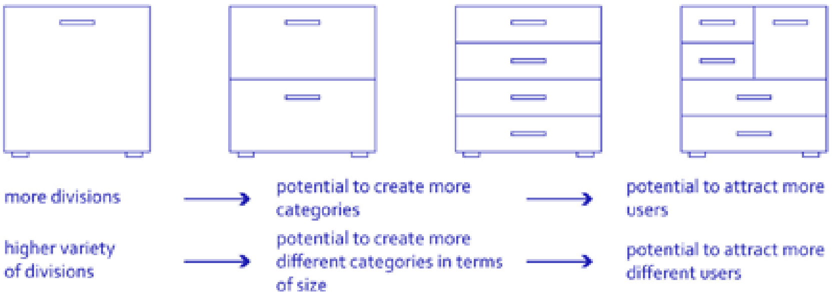

Figure 2 - Illustrative diagram of the concept of Spatial capacity.

Related to this is the idea that a greater variety in size of plots can also have an impact on the degree of categorical diversity, due to differences in size of the things or functions. For example, in a vibrant central neighbourhood we usually find a diversity of activities that also vary in scale: a small grocery shop, an office building with middle-size companies and even an opera house. The same goes for a cupboard: a small drawer may be sufficient for the category socks, but a large one is needed for the category shoes, while small drawers would exclude certain categories, thus restraining diversity.

4. THE AMBIGUOUS CHARACTER OF PLOT SYSTEMS: STRADDLING INSTITUTIONAL AND SPATIAL SYSTEMS

The importance of the plot (also often referred to as 'property', 'parcel' or 'lot') as a fundamental element of urban form is well recognized within the field of urban morphology (Moudon, 1994; 1997; Whitehead, 2001). Conzen (1960) described the plot (not the block) as the basic element in the pattern of land division that works as the organizational grid in his ontology of urban form (Moudon, 1994). He also reflected on the dual character of the plot, being both a physical and a legal entity (Kropf, 1997). Furthemore, he introduced the concept of 'burgage cycle', that is the evolution over time of the built space bound by the spatial and legal framework of the plot – a concept directly related to the idea of adaptivity of urban form over time. The modification of plot and block patterns over time has been extensively studied by Siksna (1998) and Vialard (2012). According to Vialard (2012): there are certain block sizes that are more resilient to land use modifications over time than others. Smaller blocks within regular grids can better absorb changes, but at the same time, their geometric parameters do not allow for certain types of buildings and land uses because of their particular shape and size. Large-scale blocks are capable of accommodating a great variety of different uses, but their fragmentation or amalgamation caused by land use change can have a negative effect on the street network, because the size and complex shape often leads to the formation of dead-ends, incisions and blocks within the block (Vialard, 2012). Though Siksna and Vialard mainly discuss blocks, the hypothesis put forward here is that these observations may be relevant also on the scale of plots.

French typomorphologists also recognize the plot as one of the primary elements of urban space, along with buildings and streets (Moudon, 1994). Panerai et al. (2004) emphasize that the urban block should not be understood as a separate architectural element, but as a group of interdependent building plots. They stress the importance of a dialectical relationship between the plot and the street network (Panerai et al., 2004). The French school of urban morphology also discusses the role plot systems play in providing spatial and legal conditions for the evolution of built space over time (Panerai et al., 2004).

While the idea of the plot is ubiquitous in studies on urban form, its definition is often ambiguous; blending its different meanings of legal unit of control, land use unit and physical entity (Kropf, 1997). What is more, different countries have different property registrations, for example, in the United Kingdom no cadastral system exists and legal rights of use are organised instead in a system of freehold and leasehold properties. So, while recognizing the importance of the plot as the entity that provides a legal and spatial framework for action, it is necessary to define what the essential properties of a plot are that make it such an important element of urban form. A more general definition of a plot would be useful so that it could be applied to any urban context, taking into account fundamental properties of the notion of plots, while dealing with local differences separately.

Overall, we can define three basic aspects of plots. First, as a basic unit of control, the plot provides a fundamental link between spatial and non-spatial medium (Marcus, 2000; Kropf, 1997). Second, because a plot binds a building to a movement network, it serves as a connection between built space and space of movement (Panerai et al., 2004). Third, the plot provides the framework for building evolution over time (Conzen, 1960; Panerai et al., 2004).

All the above aspects are usually related to the idea of the plot as a private or privately owned space, corresponding to the common division of urban space into private or public, where plots, generally speaking, are private spaces, used for stationary uses supported by buildings, while the surrounding space, constituting the street network, is public, and primarily used for movement (Marcus, 2000). In reality it is not always that clear cut. For example, built plots can also be publicly owned and used for public facilities. Further, streets and what we perceive as public spaces are not necessarily publicly owned: they can be simultaneously privately owned and for public use. There are also cases where built plots can be transformed into public spaces as well as the other way around. Hence, dividing urban space into public and private and referring the latter to the system of plots is not always accurate.

The ontology of urban form used in this paper is based on the concept of generic function as introduced by Hillier (1996), which divides urban space into a continuous and publicly accessible space of streets and squares, primarily used for the generic function of movement on the urban scale, whether it be by car, public transport or on foot , and a discontinuous space constituted of blocks divided into plots that generally but not always are inaccessible to the public and primarily used for the generic function of long term occupation (Marcus, 2000).

5. METHODOLOGY FOR MEASURING PLOT SYSTEMS

5.1 CRITICAL ASPECTS OF PLOTS MEASURED THROUGH AREA-BASED AND LOCATION-BASED MEASURES

We will now discuss how to measure the plot systems as discussed in the prior sections, aiming for a method that effectively captures their morphological aspects that potentially can be related to socio-economic diversity. The aim is to develop a method both effective and fitting the adage of Occam's razor: "Whenever something can be described in more fundamental terms, it should be done so" (Berghauser Pont & Haupt, 2010, p. 99). These measures need to capture the essential qualities of the plot systems as listed above: the potential to carry diverse owner strategies, the connection to movement space, and the framework for building evolution over time (Figure 3). We will proceed by testing potential measures one by one.

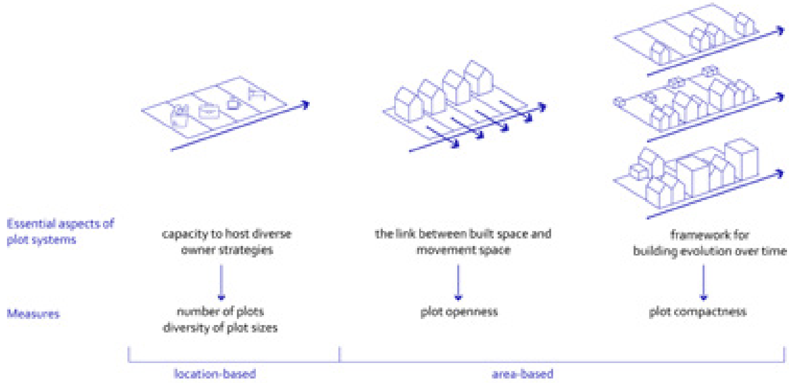

Figure 3 - Essential aspects of plot systems and related measures.

Firstly, related to the ability to carry difference, we will measure the number of plots and their diversity in terms of sizes. Secondly, related to the ability to connect buildings and the street network, the *degree of openness* of each plot will be measured, where the notion of plot frontage is essential, referred to as "plot or block face" by Vialard (2012), that is, the portion of the plot boundary where transition from the plot to the street network takes place (Vialard, 2012). This is measured as the relationship between plot frontage and total plot perimeter. Thirdly, based on previous findings of Siksna (1998) and Vialard (2012), it is suggested that the ability of the urban fabric to adapt to land use changes is related to the degree that plots are able to amalgamate into bigger plots or to divide into smaller ones. We assume that the degree of regularity of the plot is of importance for this adaptivity which we propose to measure as *plot compactness*.

These measures will be applied in two conceptually different ways: first, as area-based measures and second, as location-based measures (Ståhle, 2008) (Figure 4). Applying area-based measures, plots are measured geometrically in relation to each other, and each plot only stores information about its own parameters. Applying location-based measures is sensitive to the surrounding context and can be described as more life-like, since plots here are measured closer to how they may be perceived by moving agents; and each plot is here described by contextual information taken from surrounding spaces. Hence, this measurement does not concern only a particular geographical unit, such as a plot or a block, but the area accessible within a certain radius from a particular geographic unit[1]. Location-based measures are here measured as accessibility through the street network, using the Place Syntax Tool[2].

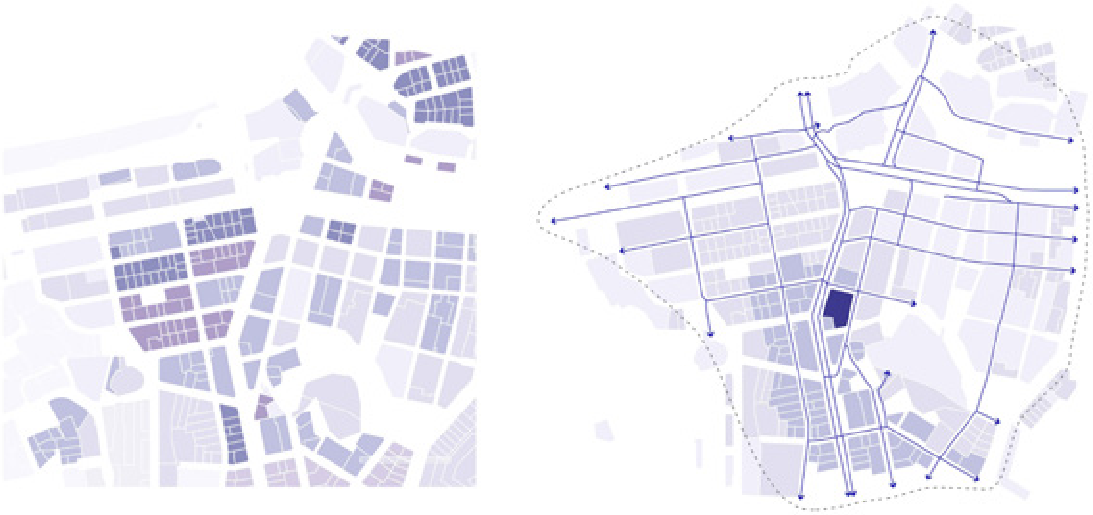

Figure 4 - Number of plots as measured per blocks (on the left) or within 500m walking distance radius reach (on the right) Diagram illustrates the principal difference between area-based and location-based measures.

Applying area-based measures, we measure and classify plot sizes, degree of plot openness to public space and the degree of *plot compactness*. Plot sizes are defined with GIS using the data classification method "geometric interval" which allows for a more fine-grain differentiation of plot sizes within urbanised areas. The degree of openness is measured as the ratio of total plot frontage divided by the total plot perimeter. The degree of plot compactness is calculated as the ratio of plot area divided by the area of minimum rectangular bounding of each plot. Plots with shapes closest to rectangles are regarded as the most compact (Figure 5).

1 For density, this mode of measurement has been extensively discussed (Berghause Pont & Marcus, 2014).

2 PST is a plugin application for the desktop software Mapinfo that combines space syntax with regular accessibility analysis in one tool.

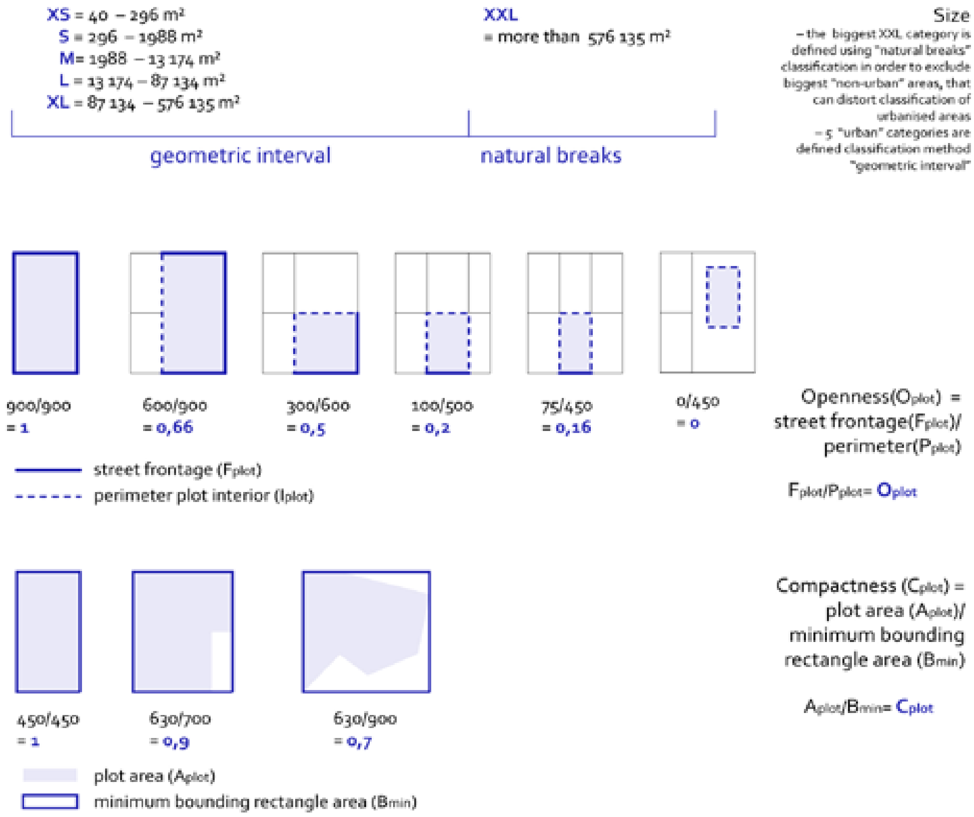

Figure 5 - Area-based measures of plot size, openness and compactness. Size categories are defined using natural breaks and geometric interval classification methods. Openness index rises to 1 when a plot does not have any neighbouring plots and falls to zero when a plot does not have any connection to movement space. For the compactness, index 1 shows the highest degree of compactness.

Applying location-based measures, we measure the accessible number of plots and the accessible diversity of plots meaning how different are plots in terms of sizes within certain reach. In order to calculate accessible diversity, plots are classified into several categories by size, after which accessibility to each category within 500m reach is measured. Finally, accessible diversity is calculated using the inverted Simpson Diversity Index[1] (Figure 6).

Figure 6 - Location-based measures of plots accessibility (on the left) and accessible plots diversity (on the right).

1 In the Simpson Diversity Index the bigger the value of D, the lower the diversity. To make it more intuitive the value of D is subtracted from 1, so the values cloest to 1 mean higher diversity.

5.2 DESCRIPTION OF CASES

In this paper, the proposed measures of spatial form are not related to socio-economic data, but a comparison is made between regularities in the plot systems captured by our new measures with known facts and characteristics of different urban areas. The investigation is made on the scale of the entire city of Stockholm, but a set of smaller areas with distinct morphological and socio-economic characteristics is chosen for comparison. These are: Östermalm, representing the city centre close to the CBD (case 1), Stureby, suburban single-family housing area (case 2), Årsta, a modernist multi-family housing area (case 3) and Slakthusområdet, a small-industry area (case 4) (see Figure 7).

The data on the plot systems used in the analysis is received from the Swedish Land Registry (www.lantmateriet.se). Because land plots from the Land Registry cover all types of land, including streets and water, the particular plot types have been extracted based on Bill Hillier's concept of generic function (1996), where we defined the plot systems of interest to be 'land used for long term stationary functions' (according to the discussion above).

The comparative investigation between our new proposed measures in the chosen cases of distinct morphological and socio-economic character will begin with area-based measures and proceed to location-based measures.

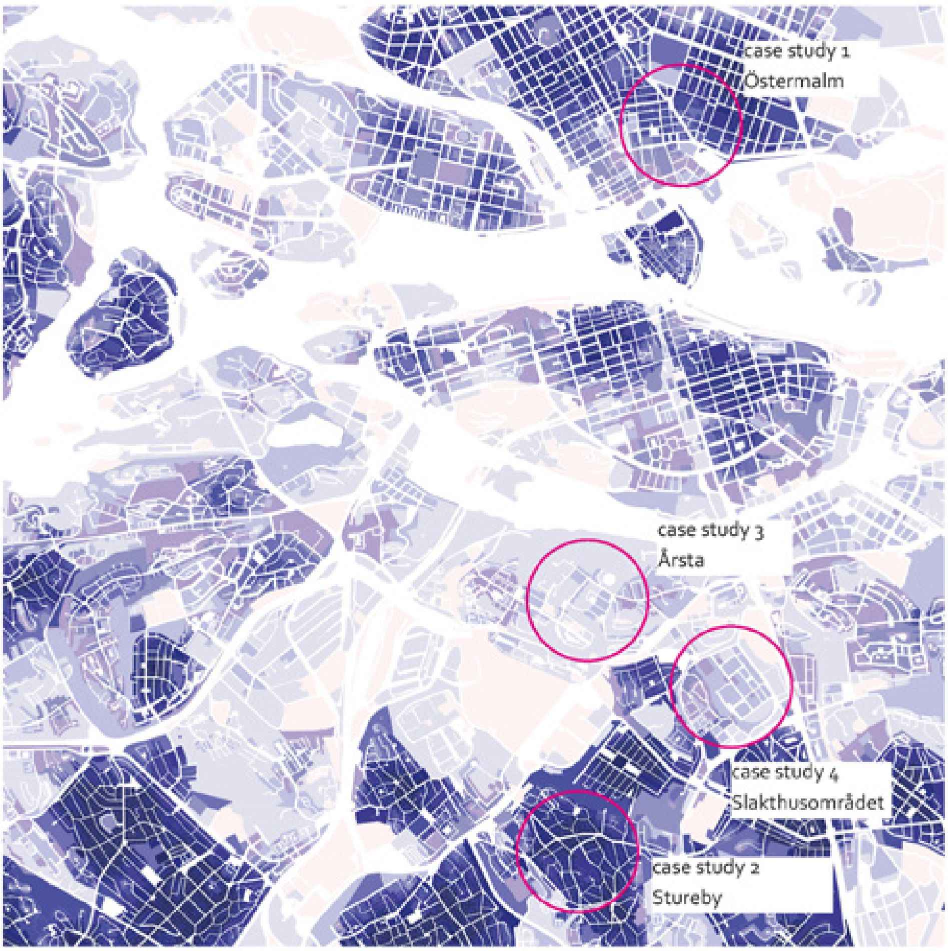

Figure 7 - Map of a section of Stockholm showing accessibility to plots within 500m walking distance with the case studies marked. Data source: Swedish Land Registry.

6. DEMONSTRATION OF PLOT SYSTEMS MEASURES BASED ON COMPARATIVE CASE STUDIES

6.1 AREA-BASED MEASURES

Geometrical properties of the plots are analysed by classifying them into plot sizes, plot openness and plot compactness (see figure 8).

Simple comparison of *plot sizes* gives an overview of the principal differences between the four areas. The grain of the plot systems in Östermalm (case 1) is generally very fine but increases gradually towards the CBD to the South-West, where more "global" functions are located, reflecting the common trend in such areas for larger properties and land owners. Stureby (case 2) has a fine-grained pattern similar to Östermalm but its character is more isotropic. Årsta (case 3) and Slakthusområdet (case 4) show a great variety of sizes. In both cases groups of smaller plots are surrounded by large chunks of land creating 'islands' of smaller plots segregated from their surroundings, which contrasts with Östermalm, which demonstrated a gradual change in plot size from smaller to bigger. This similarity in plot sizes and their configuration in areas of very different land-uses is interesting to note.

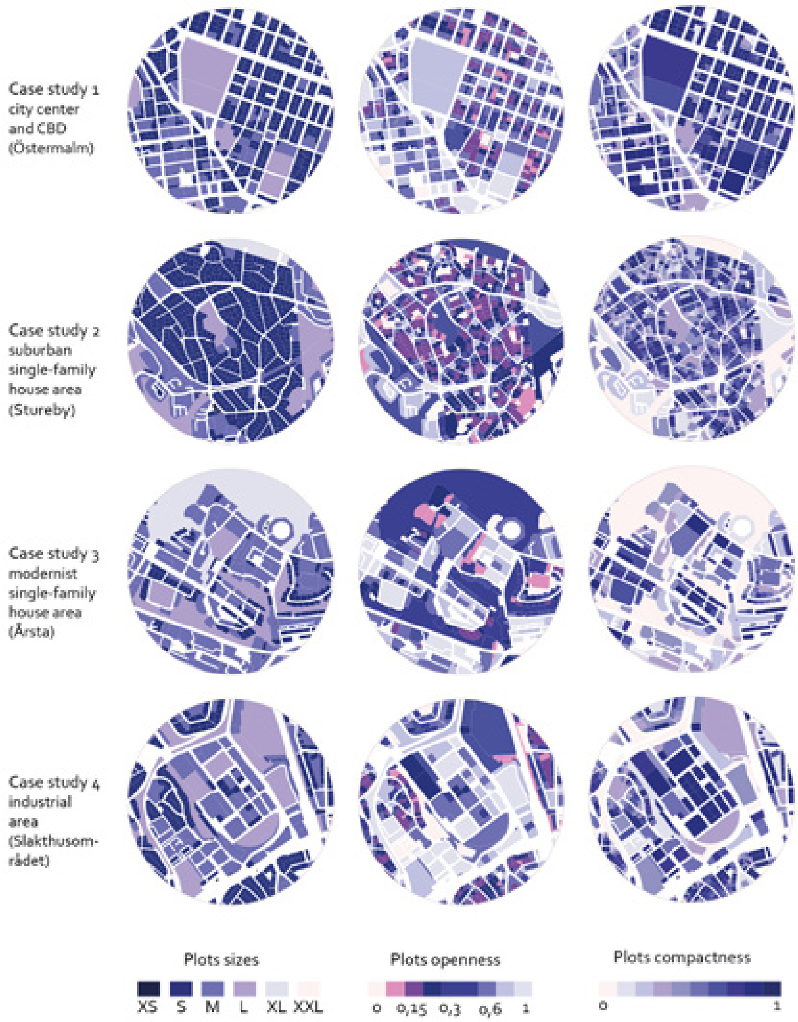

Figure 8 - Area-based measures of plot systems in the four cases. Plot sizes (a), plot openness (b) and plot compactness (c).

The parameter *plot openness* is measured as the ratio between total length of street frontage of the plot and total perimeter of the plot. When a plot is located within another plot without direct connection to movement space, openness index falls to zero, and when a plot does not have any neighbouring plots, its openness index rises to 1. Groups of plots located next to each other and connected to movement space then have various average openness values. It is important to note that these indices are more applicable to plots in urbanised areas, and also more intelligible when analysed together with plot size. Stureby (case 2) has average ratios of this kind that gravitate towards 0,1, from which we can conclude that they have a relatively small proportion of street frontage. Östermalm (case 1) exhibits average values of openness between 0,5-0,6, which indicates a higher proportion of street frontage. Again, both Årsta and Slakthusområdet (case 3 and 4) demonstrate a high degree of plot openness, which may indicate a negative effect on the constitution of public space. A high degree of plot openness (close to 1,0) is reasonable when it concerns publicly accessible spaces, such as parks, but when such spaces are over-represented (typically in modernist areas) or fenced off (industries), their spatial openness may be described as overused, as in case 3, or underused, as in case 4.

In regard of *plot compactness*, we can clearly see that Östermalm, built following an orthogonal grid, is demonstrating the highest values of plot compactness. This means that this type of plot, according to the author's hypothesis, in principle has the potential to be divided or merged to accommodate land use of different scales. Slakthusområdet, like many industrial areas, is delineated according to principles of broad functionality and the need of adaption, and also demonstrates a high degree of compactness. Stureby has average values in plot compactness, which can be explained both by the topography of the area, being rather hilly, and the "romantic" intentions of the architect behind the plan. Årsta, lastly, with the greatest variety in plot size, demonstrates the least compact plots grouped into highly complex patterns, which again may reflect the rather hilly landscape, but possibly also a low concern for the flexibility of the plot systems in the modernist era, driven by large public projects. However, the latter is something that would need further study.

From the first observations, through the combination of these parameters, a rich and informative description of the areas can be gathered, where certain things are as expected but others are surprising. For instance, while plots in Stureby and Östermalm are relatively similar in size, perhaps surprising and informative in itself, the latter are more compact and have greater openness, which suggests greater flexibility in terms of land use change and higher potential for interaction with public space, important for instance for retail. In Slakthusområdet and Årsta, on the other hand, it is surprising and informative that these are similar in the sense that both demonstrate a high variety of sizes and a high degree of openness; though plots in Slakthusområdet are more compact, which may allow for a greater flexibility.

In summary, it seems that although the measures presented above might be difficult to interpret when analysed separately, there is a potential for formulating multi-variable geometrical measures that enable a full description of the qualities of the plots. It is suggested that, similar to the multi-variable measures used in the spacematrix tool, developed for built density (Berghauser Pont & Haupt, Spacematrix: Space, Density, and Urban form, 2010), informative and revealing descriptions of plot systems can be arrived at.

6.2 LOCATION-BASED MEASURES

While the area-based measures of plot systems explored above capture the individual properties of each plot, location-based measures can describe plot systems in a more comprehensive manner. We here measure accessibility to plots, or, more precisely, how many plots can be reached within a certain radius (in this case 500m walking distance), and accessibility to diversity of plots, or, more precisely, how different in terms of size the plots are, again accessible within 500m walking distance (figure 9). It is important to note that the accessibility of plot systems of this kind, captures something different from, for instance, accessible built up area (i.e. accessible footprints). In order to make this clear, the accessible built-up area is shown along with the maps representing the accessible plots and accessible diversity of plots.

As seen from the overall map of accessible plots (figure 7), Östermalm and Stureby have the highest levels of accessible plots, where in the latter area this is equally distributed, while in Östermalm has a more hierarchical character emphasizing the centre. Slakthusområdet, although it generally has bigger plots, demonstrates a medium value in plot accessibility, which may be due to its rather regular grid structure which increases accessibility. Årsta, although it has plots similar in size to Slakthusområdet, demonstrates the lowest degree of accessibility. Based on the hypothesis that higher accessibility to plots may support higher economic diversity, we may tentatively conclude that this seems to be supported by the diverse central area of Östermalm, but not by the suburban single-family area of Stureby. It appears that something more is needed for socio-economic diversity than accessibility to plots. Interestingly, the great land use diversity of the industrial area Slakthusområdet seems to some degree to be captured by accessibility to plots, and the less diverse in terms of land use area of Årsta, also seems to confirm the hypothesis. However, these are very premature conclusions. The point rather is that we see how these measures start to capture some interesting properties of areas that call for further study.

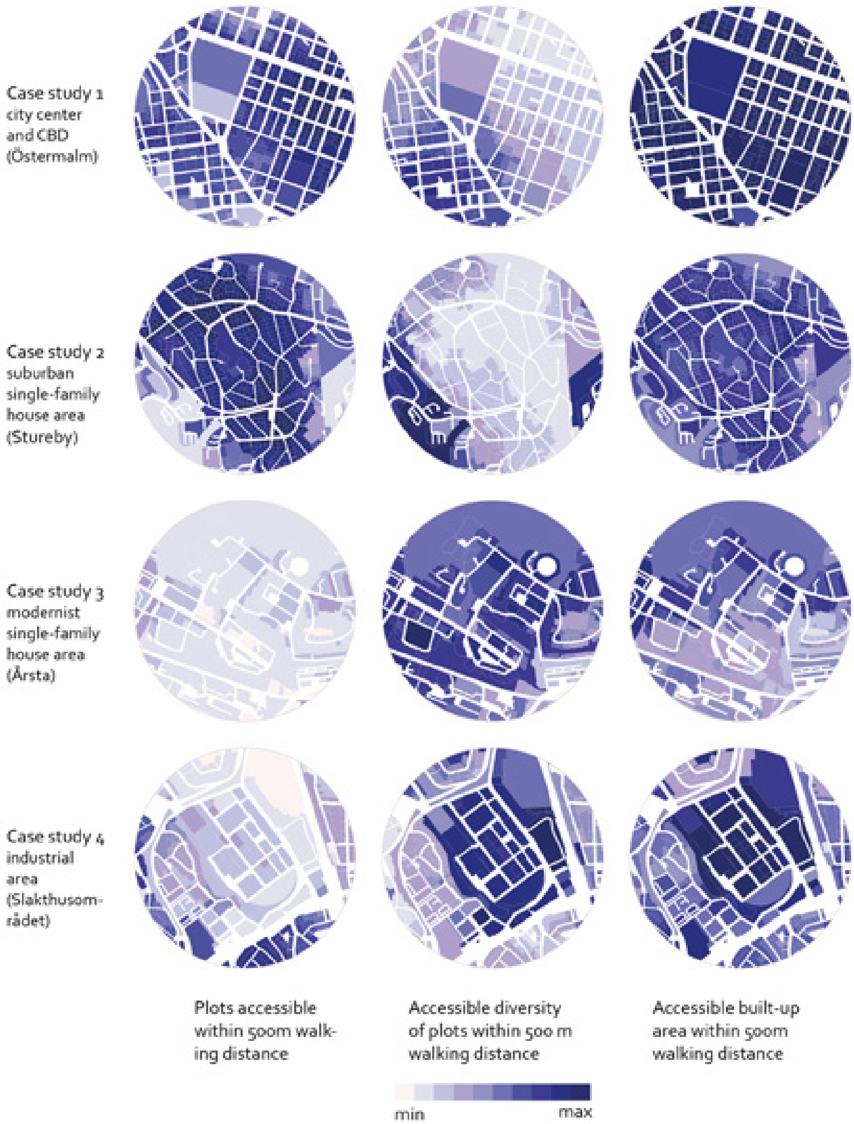

Figure 9 - Location-based measures of the four chosen case studies. Accessible number of plots (a), and accessible diversity of plots (b) within 500m walking distance, are compared with accessible built-up area (c), in order to show principal differences between configuration of plot patterns and built form.

When it comes to accessible diversity of plots, the results are, in a way, inverted. Generally speaking, Årsta and Slakthusområdet demonstrate high values of accessible diversity, which is understandable given the complexity of the patterns earlier observed. Stureby, on the other hand, has the lowest values, while in Östermalm, the value increases towards the CBD. We have, however, reason to be a bit critical about this measure as it becomes apparent, and this might be problematic, that an area with 1 big plot, 2 medium sized plots and 20 small plots are considered as less diverse than an area with one plot in each category. The issue is that Simpson Diversity index 'weights' all the categories equally. So, translating this to urban functions, this would mean that an area with 1 theater, 2 banks and 20 shops will be considered as less diverse than an area with 1 shopping mall and 1 café.

7. CONCLUSION AND DISCUSSION

Based on these preliminary tests of new measures we see reason to develop multi-variable measures that enable a full description of the qualities of plots that described the potential of urban space to afford difference. While this relation, using socio-economic data, will be tested in following papers, this paper already supports the general idea and also gives hints on how to evaluate the different measures. Size, compactness and degree of openness to public space, all appear important when the individual qualities of plots are described. If the aim is to understand performance of whole neighbourhoods, accessibility to numbers of plots and accessibility to diversity of plots may be more effective. Equally important is the impact of what is measured, be it number or diversity of plots, as well as the scale of the investigation, that is, which radii are measured, and lastly, comparison between different scales. Many of these issues we will return to after the testing with socio-economic data in upcoming papers.

We do know that city centres usually perform as diverse and vital areas (socio-economically), since several scales are nested through the overlapping of local and global networks (Read, 2009), and fail in this respect when the local scale is insufficiently treated. It can then be assumed that while a high number of plots is necessary for establishing a fertile ground for socio-economic diversity to emerge, a greater variety in size is needed when local areas are scaled up from local to more globally performing centres. In other words, high accessibility to diversity of plots is important in situations of high plot accessibility, but makes less sense in situations with low plot accessibility. This again calls for the development of multi-variable measures, but also puts the question of the Simpson diversity index discussed earlier high on the agenda for further study. The lack of acknowledgement in the measure of the total amount of large or small plots in the whole system needs to be looked into. The development of a normalized Simpson Index, which would deal with these scalar issues and would be adapted to the specificities of urban spatial analysis, could be an interesting path to follow.

Within the bigger project, within which this paper is positioned, several goals are described that partly are based on the methodology and empirical studies introduced in this paper: developing a plot typology, relating the plot systems measures to other attraction measures (Marcus et al., 2017) and, studying the relation between these spatial variables and socio-economic data, in order to establish more fundamental theory linking use of space with spatial structures.

A plot typology including different variables as introduced in this paper can be developed using clustering analysis as proposed by Berghauser Pont et al. (2017). It could show, for instance, that small plots with low openness index and low accessible diversity index, are often found in certain urban areas and that non-compact plots of various sizes and with low value of plots accessibility are grouped in other urban areas. In a next step this could be related to socio-economic performativity where the first type might show low socio-economic diversity.

Besides relating to socio-economic data, we will also relate the measures presented in this paper to distance and density measures. Configurational properties of the street networks and building density have earlier repeatedly been demonstrated to play a decisive role in generating particular socio-economic outcomes, including socio-economic diversity. Including analyses of plot systems, as suggested here, may enhance these findings and add greater precision when it comes to the vital notion of diversity in cities (Marcus et al., 2017).

Studying the statistical co-relations between these spatial variables and socio-economic data, may also help to better distinguish which spatial variables are more important for socio-economic diversity and in what combinations.

REFERENCES

Berghause Pont, M. and Marcus, L., (2014), 'Innovations in measuring density: from area and location density to accessible and perceived density'. In *Nordic Journal of Architectural Research*, Volume 2, pp. 11-31.

Berghauser Pont, M. and Haupt, P., (2010), *Spacematrix. Space, denisty and urban form*. Rotterdam: NAI Publishers.

Berghauser Pont, M. and Marcus, L., (2015), *Connectivity, density and built form: integrating ´Spacemate´ with space syntax*. Rome, "Sapienza" University of Rome, Italy.

Berghauser Pont, M., Stavroulaki, G., Gil, J., Marcus, L., Serra, M., Hausleitner, B., . . . Dhanani, A. (2017). 'Quantitative Comparison Of Cities: Distribution Of Street And Building Types Based On Density And Centrality Measures'. *Proceedings of the 11th International Space Syntax Symposium*. Lisbon: Instituto Superior Técnico. Paper under review

Calthorpe, P. and Van der Ryn, S., (1986), *Sustainable Communities: A New Design Synthesis for Cities, Suburbs and Towns*. San Francisco: Sierra Club Books.

Conzen, M., (1960), *Alnwick, Northumberland: a study in town-plan analysis*. London: Institute of British Geographers.

Duany, A., Speck, J. and Lydon, M., (2010), *The smart growth manual*. New York: McGrawHill.

Hillier, B., (1996), "Space is the machine. A configurational theory of architecture". Cambridge: Cambridge University Press.

Jacobs, J. (1961). *The Death and Life of Great American Cities*. New York: Vintage books.

Krier, L., (1984), "Critiques" and "Urban components". In: *Houses, Palaces, Cities*. London: Architectural Design AD editions Ltd..

Kropf, K., (1997). 'When ia a plot not a plot: problems in representation and interpretation'. *Unpublished*. Birmingham, University of Birmingham.

Marcus, L., (2000), *Architectural knowledge and urban form. The functional performance of architectural urbanity*. Stockholm: KTH University.

Marcus, L., (2010), Spatial Capital. 'A proposal for an Extension of Space Syntax into a More General Urban Morphology'. In *The Journal of Space Syntax*, pp. 30-40.

Marcus, L. and Berghauser Pont, M., (2015), 'What can typology explain that configuration can not?' In: *Proceedings of the 10th International Space Syntax Symposium*, London: UCL Bartlett, 2015, pp. 43:1 - 43:16.

Marcus, L., Bergauser Pont, M., & Bobkova, E. (2017). 'Cities as Accessible Densities and Diversities: Adding attraction variables to configurational analysis'. *Proceedings of the 11th International Space Syntax Symposium*. Lisbon: Instituto Superior Técnico. Paper under review.

Moudon, A., (1994), 'Getting to know the built landscape'. In: *Getting to know the built landscape: typomorphology. In Ordering space: types in architecture and design* (pp. 289-311). New York: Van Nostrand Reinhold. p. 289.

Moudon, A. V., (1997), 'Urban morphology as an emerging interdisciplinary field'. In: *Urban morphology*, Volume 1, pp. 3-10.

Panerai, P., Castex, J., Depaule, J.-C. and Samuels, I., (2004), *Urban forms. The death and life of urban block*. Oxford: Architectural press.

Read, S., (2009), Acting Across Scales. Describing Urban Surfaces as Technical 'Fields of Action'. In: *Proceedings of the 7th International Space Syntax Symposium*, Stockholm: KTH, 2009, pp. 092:1- 092:8

Sayyar, S. S. and Marcus, L., (2013), Designing difference: interpreting and testing Jane Jacobs' criteria for urban diversity in space syntax terms. . In: *Proceedings of the 7th International Space Syntax Symposium*, Seoul:Sejong University, 2013, pp. 94:1 - 94:15.

Siksna, A., (1998), City centre blocks and their evolution: a comparative study of eight American and Australian CBDs. In: *Journal of Urban Design*, October, 3(3), pp. 253-283.

Ståhle, A., (2008), *Compact sprawl: exploring public open space and contradictions in urban density.* Stockholm: KTH University.

Talen, E., (2006), Design that enables diversity: the complications of a planning ideal. *Journal of Planning Literature*, February, 20(3), pp. 233-249.

Talen, E., (2008), Design for diversity. Exploring socially mixed neighbourhoods. Oxford: Elsevier Ltd..

Vialard, A., (2012), Measures of the fit between street network, urban blocks and building footprints. In: *Proceedings of the 8th International Space Syntax Symposium*, Santiago de Chile: PUC, 2012., 2012, pp. 8101:1-8101:17.

Vialard, A. and Carpenter, A.,(2015), Building density of parcels and block-faces from a syntactical, morphological and planning perspective' In: *Proceedings of the 10th International Space Syntax Symposium*, London: UCL Bartlett, 2015, pp. 100:1 - 100:17.

Whitehead, J., (2001), British urban morphology: the Conzenian tradition. In: *Urban Morphology*, 5(2), pp. 103-109.