New spatial dimensions of global cityscapes: From reviewing existing concepts to a conceptual spatial approach

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Abstract: Current global urbanisation processes are leading to new forms of massive urban constellations. The conceptualisations and classifications of these, however, are often ambiguous, overlap or lag behind in scientific literature. This article examines whether there is a common denominator to define and delimitate—and ultimately map—these new dimensions of cityscapes. In an extensive literature review we analysed and juxtaposed some of the most common concepts such as megacity, megaregion or megalopolis. We observed that many concepts are abstract or unspecific, and for those concepts for which physical parameters exist, the parameters are neither properly defined nor used in standardised ways. While understandably concepts originate from various disciplines, the authors identify a need for more precise definition and use of parameters. We conclude that often, spatial patterns of large urban areas resemble each other considerably but the definitions vary so widely that these differences may surpass any inconsistencies in the spatial delimitation process. In other words, today we have tools such as earth observation data and Geographic Information Systems to parameterise if clear definitions are provided. This appears not to be the case. The limiting factor when delineating large urban areas seems to be a commonly agreed ontology.

Keywords: urban concepts; large urban areas; conceptualization; urbanization; megacity; metropolis; ribbon development; urban sprawl; conurbation; city region; agglomeration; megaregion; urban corridor

1 Introduction

Megacity, Metacity, Megaregion, Megalopolis, Mega-Urban Region: these are only a few terms associated with particular concepts trying to capture the state of the current global urbanization trend. With more people now living in urban than in rural areas (UN-DESA, 2012) and cities taking the brunt of the expected population growth, urban areas will continue to physically change. Urbanization is no longer a regional phenomenon, and international borders are less of an obstacle. As a consequence, established concepts may no longer suffice to describe some of the new urban forms which are more and more *massive* and

complex in morphology, pattern or interrelations, taking on dimensions inconceivable only a few decades ago (e.g., Soja and Kanai, 2007; UN-DESA, 2011, Taubenböck *et al.*, 2014). Over time, new concepts—such as metacity, mega-urban region or megapolitan—have been introduced (e.g., Lang and Dhavale, 2005; UN-Habitat, 2009; Morrison Institute, 2008) to describe these new configurations of urbanization.

There is, thus, an abundance of terms describing urban areas of various types, shapes and sizes (see also Taylor and Lang, 2004), some of which are very similar and show considerable overlap: as Brenner (2013) puts it, “definitional contours have become unmanageably slippery”. It seems, however, that some terms lack a proper, universal definition, while others have changed and adapted over time: for example, a megacity is now commonly defined as having at least 10 million people (e.g., Kraas, 2010), whereas earlier definitions were using lower thresholds (e.g., Schwentker, 2006).

Since no unambiguous classification criteria and indicators for a distinction between city and surrounding areas exist, the first and foremost challenge in defining urban areas is their delimitation. Size, population, density, statistical boundaries or economic activities are often used to describe cities but all these indicators fall short of morphologically separating urban from non-urban areas. For example, China’s population register differs from that of most other countries, and statistical boundaries fail to delimit urban expansion. Different authors, countries and statistics use different approaches (Goldstein, 1994), which can even change over time (Brenner and Schmid, 2014), and data sources—such as the reference area for population information—are often not published, thus hampering global comparisons (Bronger and Trettin, 2011).

Although the problem of delimiting urban areas applies to all scales—from small towns to massive constellations—this study focuses on large and very large urban systems on a global scale. In this paper, we aim at providing an outline of the most prevalent of those concepts in order to suggest a common spatial understanding of these heterogeneous units. This is achieved through reviewing the existing literature and summarizing the main identifiers in a descriptive way. Over 500 journal papers, book chapters and conference papers were scanned for their descriptions and definition of concepts describing large urban areas. We then combine these concepts from a morphological (as opposed to functional) perspective, thus reducing the complexity of the multidimensional concepts from various scientific disciplines to one perspective showing their distinct differences and similarities. Our breaking down of various concepts of large urban areas to their spatial features attempts to reduce ambiguities and to increase data consistency and transferability. This will contribute to overcome the lack of robust comparisons of urban areas worldwide observed by OECD (2012).

Despite the fact that we predominantly follow a structural approach, we need to acknowledge that cities are functionally connected through economic, cultural, institutional or political ties. To express these interrelations, information gained from various sources can be used: population/statistical/economic/etc. data. Recent studies have also used airline, mobile phone and collective sensing data (e.g., Derudder and Witlox, 2005; Ratti *et al.*, 2006; Blaschke *et al.*, 2011). We are aware that these functional or relational perspectives play a significant role in shaping cities and regions. However, data are not available globally and consistently since the thresholds or delimitations used by different institutions are not homogenous, adding even more complexity to a uniform delineation of urban areas worldwide.

This article therefore aims at identifying *physical* criteria to describe urban areas universally. A common ground between the various concepts, from a spatial perspective, has not been established in urban research. These physical properties, however, are core characteristics of urban areas and can be objectively measured using a globally consistent data source: remote sensing imagery can provide such a harmonious dataset.

Based on our literature review of the most common large urban concepts and their definition, this article focuses on the question: *Can we identify physically measureable parameters for the plethora of concepts describing large urban areas which can serve to establish a spatially consistent approach?* Our aims are, thus,

- to bring clarity to the plethora of concepts (functional, physical or process-based) which are often used synonymously,
- to reduce the complexity and multidimensionality of these concepts to a clearly identifiable and delimitable form from a *physical* perspective,
- to produce a schematic spatial juxtaposition of concepts for large urban areas, and
- to provide a result which is applicable on a global scale, not limited to case studies and which can be verified using one consistent global dataset without ancillary data.

These aims are intended to form a conceptual backbone for new urban research, which can be triggered by the recent and new availability of globally consistent geodata derived from new remote sensing products with a geometric resolution of 15 m and less (see section 4). With these products, physically consistent classifications of urban landscapes are available which allow for a consistent identification and spatial delimitation of the spatial concepts described in this paper.

2 Conceptualization of large urban areas

Urban form has long been the subject of interest in urban theory. In essence, it describes the physical built environment. A particular focus for many researchers is on sustainable urban form (e.g. Jenks *et al.*, 2004; Breheny, 1992): Frey (1999), for example, describes different city models such as core, satellite, star, galaxy, linear or polycentric net and evaluates their performance based on sustainability characteristics (e.g., viability of public transport, compactness, population density). Tsai (2005) identifies four dimensions of urban form: size (population), population density, distribution and clustering. Other studies show how urban form affects travel behavior (e.g., Handy, 1996; Boarnet and Crane, 2001), transportation (Banister *et al.*, 1997), liveability (Aziz and Hadi, 2007) and health (Frank and Engelke, 2001).

Some of the concepts described below are derived from descriptions of individual or a small number of examples. This is the case for *Megalopolis*, *Metroplex*, *Urban Corridor*, *Conurbation* or *Megapolitan*. Others have been established because of the growing number of areas that surpassed existing thresholds, as is the case for *mega*- and *metacity*.

In this paper we outline the most common concepts for (very) large urban areas without going into detail regarding the above-mentioned forms and models. In line with Liu *et al.*'s (2014) suggestion of a hierarchy of definitions for "urban", we include built-up areas as well as vegetation, barren land and water bodies in our "urban areas", but unlike Liu, we do not take into account administrative boundaries (which have their own inherent delineation issues). We describe concepts for large urban areas based on an extensive literature as a basis

for narrowing them down to their physical parameters which show differences and similarities in their shape and extent.

2.1 Urban form: Monocentric vs polycentric

Early urban studies were dominated by the prevailing monocentric urban form (Figure 2a) which is generally associated with a centralized and continuous settlement (Tsai, 2005). Among the most important theories are (e.g., Pacione, 2009):

- von Thünen's 1826 ring model in an isolated state,
- Burgess's 1923 concentric circles of land use zones around the center,
- Christaller's 1933 central place theory of hierarchically organized centers,
- Hoyt's 1939 sector model which assumes an expansion of cities along transport lines,
- Alonso's 1964 monocentric city model which he adapted from von Thünen's rings.

Over time, theories developed on the basis of a city as "one place" increasingly failed to adequately describe urban morphologies. Few of today's large cities (such as Dublin or Helsinki) (EC, 1999; Davoudi, 2006) have mainly monocentric characteristics; the model, on this scale, is therefore more or less outdated.

A *polycentric* spatial organization (Figures 2b and 2c) was first noted in the first half of the 20th century, but initially did not receive much attention (Yue *et al.*, 2010). The main contributors to the development of polycentric forms were technological advances. Diesel trains, electric streetcars and—later—subways and automobiles replaced earlier forms of transport which were limited to walking or horse-drawn carriages. Although production had moved out of the core, monocentric forms prevailed until after World War II because of the dependency on central harbors and rail terminals (Anas *et al.*, 1997). Over the last decades, the *polycentricity* concept gained more influence but still lacks a proper definition (Curtis, 2006; Green, 2007). Dieleman and Faludi (1998) use the term *polynucleated metropolitan region* to describe a single functional unit formed by a number of cities in close proximity. Pacione (2009) calls it a "system of cities", while Lambooy (1998) suggests a "loosely connected set of cities" with a name of its own (e.g. Randstad, Rhine-Ruhr). In Van Houtum and Lagendijk's (2001) view, *polycentric urban regions (PURs)* are "spatially closely connected and strategically planned regions, with historically and politically distinct cities, without a clear hierarchy ranking between them, and separated by open spaces". Other definitions specify that the number of cities is at least two or three (Van Eyck, 2005 in Jagadisan and Fookes, 2009; Davoudi, 2006) and there is no dominant city in terms of population, workforce, or firms. While usually the rule of thumb of a one-hour journey (Geddes, 1915) is applied for the maximum distance between the cities, Bailey and Turok (2001) challenge this assumption since defining polycentricity is also a matter of scale.

The issue of scale has also been addressed by Davoudi (2003) who separates three different spatial levels: intra-urban, inter-urban and inter-regional. The first level on which the concept of polycentricity was applied was the *intra-urban scale (meso level)* (Davoudi, 2006). At this scale, polycentricity is formed by sprawl and sub-centers (Curtis, 2006). These sub-centers are either merged existing centers or new *Edge Cities* (Garreau, 1991): new centers away from the original Central Business Districts (CBDs) that developed when first people, then shopping malls and offices moved out to form new urban centers with a high share of office and retail space, located close to main highway intersections, usually on

land which was either pasture or thinly populated in 1960. As to the transition between polycentric and sprawling cities, Ewing (1997) remarks that there is only a thin line between multiple centers and scattered development. A main difference is the relatively high degree of organized growth in polycentric regions vs. the rather unorganized dispersed sprawl.

The *inter-urban scale (macro level)* is characterized by a high degree of interaction between conurbations, which have generally developed through merging of expanding settlements such as Randstad, RhineRuhr or Southern California (cf. Kloosterman and Musterd, 2001; Pacione, 2009).

On Davoudi’s *inter-regional scale (mega level)*—the scale of interest for this study –, the concept of urban corridors is used synonymously to “megalopolis” (see below) and “extended metropolitan region” (Ginsburg *et al.*, 1991; Firman and Dharmapatni, 2007) and includes regions such as the European *Blue Banana* or East Asia’s *BESETO* (Choe, 1998). Davoudi himself (2006) applies these terms to an area in the UK dubbed “The Northern Way” and includes eight city regions within the Liverpool-Hull and Newcastle-Sheffield axes. Figure 1 illustrates these three scales using the example of a relatively small metropolitan region, Munich (Germany).

Figure 1 Different scales for Munich: City (with sub-centres), Region, Metropolitan Region

Inter-urban and inter-regional patterns have also been described as *polynucleated urban fields* (Dieleman and Faludi, 1998; Champion, 2001).

Figure 2 Mono- and polycentric urban forms

2.2 Concepts describing large urban areas

This section reviews and describes different concepts intended for a classification of different large urban areas. While this list is not exhaustive, we believe that it includes the most established terms. Most of these concepts are well recognized in urban geography, sociology or policy, but not all of them are clearly defined. Since there is a considerable overlap be-

tween some of the terms, a particular region usually fits into several categories.

Our aim is to find a common denominator to limit those concepts to just their morphological features, leaving aside relational and functional aspects. From this purely physical perspective—which is our point of interest –, the differences between them are minimal.

The concepts are structured as follows: starting with megacities as “one” place, we then describe different functional urban types before dealing with large regions which, over time, potentially develop towards massive mega-urban regions or urban corridors.

2.2.1 Single cities: Megacity, metacity, metropolis

Megacities are typically defined using quantitative criteria, most commonly a minimum population of ten million (Kraas, 2010; Kraas and Mertins, 2008; UN-Habitat, 2006); other dimensions—four, five or eight million (Schwentker, 2006; Gilbert, 1998; Chen and Heligman, 1994)—are less common or obsolete. A minimum population density of 2000 inhabitants per km² is also frequently assumed in order to exclude urban agglomerations such as Randstad/Holland or RhineRuhr/Germany (Kraas and Nitschke, 2008; Bronger and Trettin, 2011). Bourdeau-Lepage and Huriot (2006) use the term *Large Urban Agglomerations (LUAs)* for cities over five million inhabitants (the 2001 threshold in the United Nations’ megacity definition) and “Megacities proper” above ten million (the UN’s 2004 threshold). Figures like these, however, are often criticized as arbitrary (Gilbert, 1998). Furthermore, population data (e.g. due to artificial administrative borders) and their accuracy are not consistent globally and therefore inadequate for a harmonized definition of urban areas on a world level.

Figure 2a shows an ideal abstract model of a megacity with a single center plus the surrounding, less densely populated, fringe area. Today’s megacities, however, are generally polycentric in nature at an intra-urban or inter-urban scale due to their growth and incorporation of previously independent cities. Still, megacities are frequently perceived as one city due to the place name they carry. While the general development pattern reflects regional differences (Taubenböck *et al.*, 2012), megacities have “more in common with each other than with their rural hinterlands whether they are located in developed or developing countries” (Laquian, 1994). This includes their effect on global change (environmental, socio-economic, political), ecological impacts and increasing informality (Kraas, 2007).

Around the year 1900, only 15 cities had more than one million inhabitants (Masini, 1994), a figure which has since increased to roughly 500 (Brinkhoff, 2013). By 1950, the only megacities (above the eight million people threshold) were London and New York (UN-DESA, 2011; Chen and Heligman, 1994). Today, there are around 30 cities with over ten million people. UN-Habitat (2006) have introduced a new term, *metacities*, to describe polycentric cities larger than 20 million people, generally governed by several administrative bodies. Among these are Delhi, Mexico City, New York-Newark and Shanghai (UN-DESA, 2012), with Greater Tokyo as the first city which passed the 20 million mark already half a century ago. The *metacity* concept has been further elaborated by McGrath and Pickett (2011) who take into account socio-ecological as well as architectural aspects.

A *metropolis*, too, is usually an individual city. It is significant in a region in terms of size and importance—a significance which is not quantified in measurable terms. A metropolis can also be part of a metropolitan area or polycentric (mega-)region (see below) (Hall and Pain, 2006).

A large number of cities fulfill additional roles which cannot be detected from their physical layout since they represent a city's *function*. These functional roles have more recently been described, classified and ranked using qualitative measures such as political and professional activities, banking/insurance, trade, or arts/culture. The most significant functional city types are *World City* (Hall, 1966, 1998) and *Global City* (Sassen, 1991; Bourdeau-Lepage and Huriot, 2006), often used synonymously (Kunzmann, 1998). New York, London or Tokyo are generally placed at the top of rankings such as Friedmann (1986), Beaverstock, Smith and Taylor (1999) or A.T. Kearney (Hales and Mendoza Peña, 2012). Further functional types include *Primate City* (Jefferson, 1939), *Informational City* (Castells, 1989), *Network City* (Castells, 1989, 2002) or *Creative Network City* (Batten, 1995). More (not only functional) types are listed in Taylor and Lang (2014) who question the need for more terminology. On a larger scale, the term *World City Region* has been applied to areas such as London or Istanbul (Kunzmann, 1998) to recognize both their local and regional dimension. Similarly, Scott (2000, 2001) proposes the name *Global City-Region* for around 300 world city regions with strong inter- and extra-regional economic and political ties. For our further analysis, however, these *functional* urban types are not taken into account.

2.2.2 Fuzzy concepts: Ribbon development, urban sprawl

Although *ribbon development* and *urban sprawl* can be regarded as processes, they are commonly used to describe urban forms in a current state (Figure 4) and are thus included in this paper. *Ribbon Development* denotes the dispersed but continuous expansion of settlements along infrastructure lines (highway, railway). This is generally multi-functional (industry, trade, residential, theme parks), often unplanned (Kraas, 2010), and is found on all scales from small villages to big cities. On a large scale, ribbon development can lead to the formation of *extended metropolitan regions* (EMRs) (Ginsburg, 1991) or *mega-urban regions* (MURs) (McGee and Robinson, 1995; Laquian, 2005; Douglass, 2000). To meet the requirements of increased vehicle traffic, highway systems lead to the evolving of corridors (see below) which are more than 100 km away from the metropolitan centers (McGee and Robinson, 1995 in Douglass, 2000), such as mega-city-centered Bangkok or Shanghai-Nanjing-Hangzhou-Suzhou, where urban nodes form a regional network (Pacione, 2009). Travel time from the main center out can easily exceed an hour.

Similarly vague is *urban sprawl*, which, according to Tsai (2005) and Siedentop (2005), does not have a universally accepted definition and can describe land use patterns, expansion processes, and causes as well as consequences of land use practices (Galster *et al.*, 2001). As a settlement pattern, it shows a low population density (one- or two-storey residential buildings, one family per unit), high car ownership rate (and limited travel routes), strip commercial areas and industrial parks, lack of a thriving center, high energy and land consumption, and scattered or leapfrog development on the fringe of a city with progressive filling of the spaces in between (Delgado *et al.*, 2006; Ewing *et al.*, 2002; Burchell *et al.*, 1998). For sprawling office development, Lang (2003) suggests the term *Edgeless City*. Whereas ribbon development is aligned to traffic infrastructure, sprawl is not constrained to existing major road frameworks despite the significance of individual car travel. Nechyba and Walsh (2004) investigate causes and consequences of sprawl whose dynamic nature is emphasized by Hasse and Lathrop (2003). Glaeser and Kahn (2003) argue that sprawl is a ubiquitous,

dominant form of urban living. Tsai (2005) recognizes that, like other urban forms, sprawl has different meanings and effects on human activity at different levels: metropolitan area, city, or neighborhood. Bhatta (2010), Taubenböck *et al.* (2009) and Sudhira *et al.* (2004, 2007) examine sprawl using remote sensing data and GIS methods; Torrens (2008) presents varying characterizations and develops a toolkit to measure and simulate sprawl.

Originally a North American phenomenon, urban sprawl is now recognized around the world. Siedentop (2005), for example, describes indicators of sprawl on a macro and micro level (land use patterns vs. land use changes) for the Eastern part of Germany. Among several EU-funded investigations (Champion, 2011) is *ESPON* which identifies four profiles of sprawl (Bengs and Schmidt-Thomé, 2006): sprawl as emergent polycentric region with secondary urban centers, as scattered suburb with infill of low-density housing between urban centers or transport corridors, as peripheral fringes inhabited by lower-income population (old housing peripheries or new speculative developments), and as commercial strips and business centers (generating more traffic and further unplanned development). Angel (2012) warns that lessons learned from sprawl in the USA and Europe should not necessarily be applied to developing countries.

2.2.3 Conurbation/city region, urban agglomeration, metropolitan area

Conurbations, *urban agglomerations* and *metropolitan areas* denote similar constructs; they are merely used by different institutions or countries (GBHGISP, 2004): the United Nations use the term *urban agglomeration* (UN-DESA, 2011); the USA refers to *metropolitan areas* and the UK to *conurbations*.

To describe regions such as Greater London, Lancashire ("Lancastonia") or the Midlands ("Midlantonia"), Geddes (1915) coined the term *conurbation* or *city region*. Neighboring towns in these conurbations are linked by tramways and streets (Figure 4), while open spaces in between are disappearing. Population patterns are changing with a tendency towards social grouping, and new forms of political governance are developing. According to Geddes (1915), towns can be very different from a social, historical and structural point of view but still be part of the same conurbation if they are within an hour's travel from each other, like Glasgow and Edinburgh ("Clyde-Forth"). Thus, conurbations are usually polycentric but interlinked (transportation, labor). Fawcett (1932), who identifies 37 conurbations, defines them—in a more general sense but spatially more delineated—as continuous built-up areas and urban parks ("dwellings, factories and other buildings, harbor and docks") which are not separated by rural land. According to Castells (2002), a conurbation is no longer defined by physical proximity of places but has become a global concept based on on- and off-line networks. Soja and Kanai (2007) define city regions as areas with more than one million people. UN-DESA (2011b) describe urban agglomerations as cities with a sub-urban fringe not necessarily within the administrative city boundaries.

In the USA, *metropolitan statistical areas (MSAs)* are high-density urbanized areas with strong economic ties, a minimum population of 50,000 and a high level of in- and out-commuting. In 2013, new standards were released to classify *metropolitan*, *micropolitan* and *combined statistical areas (MSA, μ SA, CSA)* and the terms *standard metropolitan statistical area (SMSA)* and *primary metropolitan statistical area (PMSA)* were dropped (OMB, 2013).

In a stricter sense, *conurbations* are continuous urban forms, while *metropolitan areas*

may contain non-urban zones. According to this, Geddes' Glasgow-Edinburgh conurbation would have to be re-labeled *metropolitan area*. *Agglomerations*, for Dijkstra (2009), "by definition include the commuter belt around a city".

2.2.4 Functional urban region/area (FUR/FUA), urban field, city system, urban network, larger urban zone (LUZ)

A *Functional Urban Region (FUR)* (Hall, 2009a), while not universally defined, is a "travel-to-work area" with one or more municipalities at the core plus the surrounding fringe areas (Antikainen, 2005). The OECD (2012) describes *Functional Urban Areas* as one or several cities and their commuting zones. The commuter threshold varies between 10%–20% in Europe (Eurostat, 2013) and 15%–25% in the USA and Canada (OECD, 2012).

A *FUR* roughly matches Friedmann and Miller's (1965) definition of an *Urban Field*: an interdependent area centered around one core (minimum population: 300,000) and extending out into the periphery up to two hours' (about 100 miles) driving away (Figure 4)—Friedmann and Miller's maximum for a daily commute. This dimension corresponds to Davoudi's (2003, 2006) inter-regional scale (see above). The idea is similar to Gottmann's *megalopolis* (see below) and was developed as a contrast to Christaller's 1933 central places theory. It was subsequently expanded into two further concepts: *City Systems*, which emphasize the interdependency of cities in a region, and *Urban Networks* (Van Houtum and Lagendijk, 2001) which are a cooperation of cities that used to be independent and even complementary. Two essential elements of urban networks are a connecting transport corridor and ICT infrastructure (Van Houtum and Lagendijk, 2001)—elements which are also essential for Castells (1989, 2002).

The OECD (Piacentini and Rosina, 2012) develop a method to define functional urban areas in 29 OECD countries by identifying urban cores, connecting non-contiguous areas and identifying hinterlands using economic, demographic and environmental data from different sources; a method the authors themselves recognize as arbitrary (OECD, 2012). The result is a list of 1179 mono- and polycentric functional urban areas as diverse as Vienna, Paris, Santiago de Chile, Vancouver, Seoul or Los Angeles. According to this OECD definition, *metropolitan areas* have a population between 500,000 and 1.5 million, *large metropolitan areas* more than 1.5 million. However, as shown above, on a global scale, the use of *metropolitan area* is not homogeneous.

For cities throughout Europe, the European Union's *Eurostat* agency has carried out several Urban Audits since 2003 to collect harmonized, comparable statistics and indicators (EC, 2004). The Urban Audit uses administrative units, NUTS 3 regions (ESPON, 2011; Dijkstra, 2009). Based on these data, an Urban Atlas was put together showing comparable land use and land cover data for *Larger Urban Zones (LUZs)*. The information on population figures is inconclusive depending on the source: EEA (2013) specifies areas with over 100,000 inhabitants as LUAs, while the EC (2004) and Dijkstra (2009) indicate 250,000. The LUZ is an approximation of the *Functional Urban Area*.

2.2.5 Metropolitan agglomeration, metropolitan region, metroplex

Bronger and Trettin (2011) identify *Metropolitan Agglomeration (MA)* as core plus the surrounding urbanized area, and *Metropolitan Region (MR)* as MA plus the less urbanized fringe. Castells (2002) provisionally uses *MR* for massive, functionally interrelated urban

constellations (e.g., Randstad, Pearl River Delta). *MRs* are not necessarily continuous but rather a combination of built-up (core as well as periphery) and rural and include models such as Edge Cities and conurbations. An essential feature is their connectedness through high-speed links on both physical (especially rail; Figure 4) and virtual level (telecommunications). Metropolitan areas are important from an economic, cultural, institutional and political point of view and are challenging to govern because of they transgress administrative boundaries.

In Germany, 11 *MRs* have been defined by the Conference of Ministers for Spatial Planning (*Ministerkonferenz für Raumordnung*) as driving forces for economic, social and cultural development (IKM, 2010). Their delimitation, however, does not follow a uniform method and thus, differences in population, density, distance and share of rural areas can be observed. Selection criteria are mainly based on metropolitan functions. With RhineRuhr as an exception, the regions are relatively sparsely populated compared to national and international averages.

The term *Metroplex* was originally applied to the Dallas-Fort Worth area in Texas and describes a big, extended metropolitan region with two (or more) spatially distinct key anchor urban cores (Lang and Nelson, 2007). It has since been used for Germany's Ruhr area, Randstad, Detroit-Windsor (USA/Canada), or Guangzhou-Shenzhen-Hong Kong-Macau.

Although a number of examples describe these "metropolitan" concepts, there is no delimitation in terms of their spatial dimension.

2.2.6 Mega-city region (MCR), megalopolis, megaregion, megapolitan, mega-urban region, mega-metropolitan region

According to Hall and Pain (2006), a *Mega-City Region* (MCR) consists of 10–50 separate but networked cities with one or more main city and thriving on an economic division of labor. Halbert *et al.* (2006) also describe global MCRs as "a cluster of towns and cities that is increasingly functionally interconnected across geographical space through virtual communications and travel". Although they resemble other polycentric concepts such as megalopolis (Hall and Pain, 2006), megapolitan areas (Lang and Dhavale, 2005) or Functional Urban Regions (Hall, 2009a), the fact that a megacity has to be part of an MCR sets them apart (Figure 4). Soja and Kanai (2007) set the minimum population threshold for a MCR to ten million and observe a trend towards an "extended regional urbanization". None of the descriptions of MCRs give a dimension that can be expressed in time or distance.

In the EU-funded project *POLYNET*, functional relations and information flows were analyzed for eight polycentric mega-city regions in North-West Europe (e.g., RhineRuhr, South-East England, Randstad). In their project summary, Hall and Pain (2006) describe MCRs as building on Castell's "space of flows" and on Scott's (2001) global city region while at the same time more interconnected and complex than Gottmann's *megalopolis*.

Although *megalopolis* is commonly attributed to Gottmann (1957; 1961), the term has been in use since the 1820s and also appears in essays from Geddes and Mumford (Baigent, 2004). A megalopolis has at least 25 million people, is polynuclear with each city as an individual urban system but at the same time cohesive from a communication and transport perspective (Gottmann, 1976; Pacione, 2009). Gottmann's example is the area now known as Bos-Wash (with a population of some 30 million in 1950). He describes the Great Lakes Megalopolis from Quebec to Milwaukee (via Toronto, Detroit, Chicago) in a similar way

and acknowledges the existence of a further four such areas (Gottmann, 1976). He emphasizes that a megalopolis has to be separated from other large urban networks by enough less urbanized space that is substantially different from the metropolitan region. Florida (2006) prepared a draft mapping of what he calls the “New Megalopolises” and names them the most significant territorial connected units of today’s global economy. On a macro-regional level he defines North-East Asia, Western Europe and North America. 29 Sub-regions form these zones (Florida, 2006, Soja and Kanai, 2007).

Based on Gottmann’s model region, the Regional Plan Association (2006) elaborates the *Megaregions* concept by specifying five relationship groups: environment, infrastructure, economy, settlement patterns and land use, and culture/history. The more of these relationships apply, the more cohesive a megaregion is.

Virginia Tech’s Metropolitan Institute defines a new urban unit, *Megapolitan*, as “two or more metropolitan areas with anchor principal cities between 50 and 200 miles apart” (MI, 2008). Their size is larger than a metropolitan area but smaller than a megaregion (Lang and Nelson, 2007) and only regions with a projected population of at least five million by 2040 are considered. Criteria are compactness (they “can easily be traversed by car in a day, round-trip”; Lang and Nelson, 2007), connectedness (high percentage of commuters, goods and service flows, cultural entity, functional networks), complexity (megapolitans are formed of metropolitan and micropolitan areas and themselves, together with other metros, form megaregions), and corridors (often linear and polycentric) (Lang and Dhavale, 2005; MI, 2008).

In the Institute’s report (Lang and Dhavale, 2005), ten megapolitan areas are identified which, although different approaches are used (Ross, 2008), roughly equal the Regional Plan Association (RPA)’s megaregions. For the RPA, megaregions are “large, connected networks of metropolitan areas that maintain environmental, cultural, and functional linkages (Lang and Nelson, 2007). With around 200 million people, they account for over two thirds of the USA population (Lang and Dhavale, 2005). A later article (Lang and Nelson, 2007) refines the definition to (subsets of) megaregions: 20 (emerging) megapolitans form the ten megaregions in the USA. Between one and four megapolitan areas make up a megaregion; their total population is assessed at close to 300 million. The form of these megapolitans ranges from linear “corridor” to “galactic” (Lang and Dhavale, 2005). This draws upon an earlier definition of a *galactic metropolis* by Lewis (1983) as fragmented, multi-nodal and with urban centers, sub-centers and satellites of varying sizes and densities. The linear shape is also recognized by Neuman (2000) who describes Gottmann’s megalopolis as a “linear corridor multi-metropolitan region”. Banerjee (2009) arranges the RPA’s ten megaregions along two axes: galaxy/corridor and mosaic/network (the latter of which are not mutually exclusive). Of the more corridor-like megaregions, Northern California and the Gulf Coast are mosaicked while the Arizona Sun Corridor, Cascadia and the Texas Triangle show well-developed networks.

In a worldwide rather than North American context, the term *mega-region* is used in a slightly different way. We therefore adopt a hyphenated spelling to mark this difference. UN-Habitat (2008a) identify mega-regions as one of three types of new urban configurations, along with urban corridors and city-regions, and characterize them as having larger populations than any mega- or meta-city, with an “enormous” economic output. Examples are

China's Pearl River Delta (around 120 million people), Japan's Tokyo-Nagoya-Osaka-Kyoto-Kobe mega-region (a prospected 60 million people by 2015), Brazil's São Paulo to Rio de Janeiro stretch (43 million people). The UN report states that mega-regions are most common in North America and Europe but emphasizes that Asia and other parts of the world are growing quickly; including African regional urban systems such as the Nile valley or Ibadan-Lagos-Accra which all have several cities of over a million people (UN-Habitat, 2008b).

Florida *et al.* (2007), who use night-time lights for a global study of mega-regions, consequently describe them as contiguously lighted areas in those datasets, or, more pragmatically, as "very large area across which one could walk, carrying only money, without getting hungry". From an economical point of view, mega-regions amass talent, productivity, innovation and markets and allow labor and capital to be redistributed at low cost (Florida *et al.*, 2007). Similarly, Yusuf (2007) points out economic advantages such as scale, talented workforce, or lower resource utilization of mega-regions, while acknowledging downsides such as congestion, living expenses, environmental pollution and fiscal, juridical or governmental challenges. Castells (2002) recognizes the existence of *mega-metropolitan regions* which, for him, are "without a name, without a culture, and without institutions" (Castells, 2002). Taubenböck and Wiesner (2015) measure the increasing settlement continuity between cities within megaregions and compare spatial patterns across the globe.

Several authors have observed a distinct mega-urban development pattern in Asia. This is mainly due to the much faster population growth and expansion of urban areas compared to Europe and North America. Laquian (2011), for example, specifies three types:

- a) *Urban corridors* (e.g., Tokyo-Kyoto, Beijing-Qinhuangdao, Mumbai-Pune) (see 2.2.7).
- b) *Mega-city dominated city regions* (Metro Manila, Jabotabek, Greater Bangkok, Dhaka).
- c) *Sub-national city clusters* (Guangzhou-Shenzhen-Hong Kong; the Surabaya-Surakarta-Semarang-Yogyakarta-Malang region in Indonesia; or Daegu-Ulsan-Busan-Guangjiu in South Korea).

McGee (1991) introduces the term *desakota* to describe the rural-urban transition where metropolises expand in the form of ribbon development but traditional farmland is left standing (Kraas and Nitschke, 2008). McGee (1991) divides *desakota* regions into three types: *desakota type I* regions are a mix of small farm plots, industrial and residential areas with a mainly non-agricultural economy (Japan, South Korea). *Type II* regions show a dynamic economic growth with improved transport facilities and infrastructure (Nanjing-Shanghai-Hangzhou, Jabotabek). Jogjakarta or Kerala belong to the *desakota type III* regions with slow economic growth and low productivity.

2.2.7 Urban corridor

Whebell (1969) first introduced the concept of *urban corridors* using Southern Ontario (Canada)—Windsor, London, Toronto to North Bay/Ottawa respectively (about 700–800 km in length)—as phenotype region. However, the concept has received very little scientific attention. In Whebell's view, a corridor is a "linear pattern of major towns joined by highly developed 'bundles' of transport routes". Development happens in continuous, cumulative stages from initial occupancy to metropolitanism through transport improvements (rail, early automobile, rapid transit). Surface characteristics, settlement behavior, time, direction and

distance are important elements of the model (Whebell, 1969).

The most distinguishing element of a corridor, in Trip's (2003) view, is its linear structure. Batten (1995) illustrates corridor cities as linearly linked main nodes with further branches and nodes of different size and connectedness (Figure 3).

Figure 3 Corridor city (after Batten, 1995)

Li and Cao (2005) identify some basic aspects of corridors such as a high population density, existence of large cities or city clusters, high land use heterogeneity and a well-developed transport infrastructure. A critical feature of any corridor, according to Chapman *et al.* (2003) is that of “connection”, i.e. the “free and easy flow or transmission of people, goods or information” (Chapman *et al.*, 2003). Continuous settlement is not necessarily essential along corridors, rather it is a possible result of their growth (UN-Habitat, 2010). Several authors compare urban corridors to Gottmann's Bos-Wash megalopolis (e.g., Neuman, 2000; Laquian, 2011). Other massive urban corridors include the “Blue Banana” (Hospers, 2002; Brunet, 1989 in Hall, 2009b), a highly urbanized and densely populated area that reaches right across Western Europe from Birmingham to Milan, covering around 2000 km in length, and BESETO, stretching 1500 km from Beijing to Tokyo via Pyongyang and Seoul (Choe, 1996 and 1998; Lo and Marcotullio, 2001).

3 Main results: combination of concepts

In section 1 we described concepts describing large urban areas, from single (mega-) cities to massive polycentric regions. We showed that for a number of these, there is no universal acceptance of indicators for a classification and delimitation. A consistent global classification for most concepts is therefore not possible. Table 1 summarizes these concepts and their characteristics for a better overview.

While these areas differ in many ways, especially in their functional characteristics, we maintain that from a spatial point of view, several constellations show considerable overlap. We therefore sketched the physical layouts with the parameters identified as defining features in the literature review (Figure 4).

These parameters can basically be narrowed down to two main aspects:

- spatial clustering of settlements, with a larger, spatially distinct central settlement and smaller fringe settlements, separated by varying degrees of open space
- infrastructure lines in the form of surface transport (road or rail).

The clustered settlement pattern can be derived from the following features defined in the literature review: “scattered” and “leapfrog” (see urban sprawl), “open space” (metropolitan areas), “core/fringe” (e.g., FUR, metropolitan agglomeration, Metroplex). A certain “continuity” (conurbation), however, is also important since it delimits the extent of a large urban area. The only definition which gives a range of the number of cities included in a region is Hall and Pain's (2006) MCR with 10–50 cities.

As becomes obvious, the general patterns show great similarity with regard to the distribution of places. The infrastructure network, too, is similar. Only ribbon development and

Table 1 Summary of concepts, their characteristics, examples and key literature

Concept	Examples from literature	Definition criteria identified in literature (only where applicable)					Key literature used in this review
		Population	Typical size	Number of cities or centrality	Physical parameters	Functional features	
Megacity	Los Angeles, Moscow, London, Istanbul, Rio de Janeiro, Paris	> 10 million		1			Kraas & Mertins, 2008; Fuchs et al., 1994; Gilbert, 1998
Metacity	Greater Tokyo, Delhi, New York-Newark, Shanghai	> 20 million		1			UN-Habitat, 2006; McGrath & Pickett, 2011
World/Global City	New York, Tokyo, Frankfurt, Zurich			1		Company headquarters, financial institutions, cultural and political status	Sassen, 1991; Hall, 1966 & Friedmann, 1986; GaWC, 2010
Informational/Network City	Randstad, San Francisco			1		ICT infrastructure	Castells, 1989 & 2002; Batten, 1995
World City Region	London, Istanbul, Randstad, RhineRuhr	(> 1 million)		Mono- or polycentric		Similar to World City but with internal connections	Kunzmann, 1998; Scott, 2000; Bronger & Trettin, 2011
Ribbon development	Bangkok, Hangzhou		Up to 100 km away from center	1	Settlements along infrastructure line	Multifunctional settlement pattern (residential, industrial, trade)	Kraas, 2010; Douglass, 2000
Urban sprawl	Atlanta, Houston, Melbourne			1	Scattered and leapfrog development on urban fringe		Tsai, 2005; Siedentop, 2005; Glaeser & Kahn, 2003
Conurbation/City region	Greater London, Lancashire, Midlands, Greater Paris	> 1 million	One hour travel time	Polycentric	Transport infrastructure, few open spaces between cities	Commuting patterns	Geddes, 1915; Fawcett, 1932; Soja & Kanai, 2007
Metropolitan area (MA)	Calgary, Helsinki, Rome, Phoenix	> 500,000					OECD, 2012
Functional Urban Region/Area (FUR/FUA)	Vancouver, Vienna, Paris, Dublin, Madrid		Commuting distance	Mono- or polycentric	Core plus smaller fringe towns	Interdependency, commuting patterns	Hall, 2009; OECD, 2012; Piacentini & Rosina, 2012
Urban Field	Miami, San Francisco, Denver, Chicago, Boston	Core population: > 300,000	Commuting distance	Mono- or polycentric		Interdependency, commuting patterns	Friedmann & Miller, 1965
City systems, urban networks	Randstad, Kansai				Transport infrastructure	Interdependency; ICT infrastructure	Van Houtum & Lagendijk, 2001
Metropolitan/Urban agglomeration	Ho Chi Minh City, Mumbai, Buenos Aires, Istanbul, New York, London				Core plus urbanized fringe		Bronger & Trettin, 2011
Metropolitan region	Randstad, Pearl River Delta, RhineRuhr			Polycentric	Core plus less urbanized fringe; transport infrastructure	ICT infrastructure	Bronger & Trettin, 2011; Castells, 2002

(to be continued on the next page)

(Continued)

Concept	Examples from literature	Definition criteria identified in literature (only where applicable)				Key literature used in this review
		Population	Typical size	Number of cities or centrality	Physical parameters	Functional features
Metropolitan	Dallas-Fort Worth, Randstad, Detroit-Windsor			2 or more	Spatially distinct urban cores	
Mega-City Region (MCR)	RhineRuhr, Randstad, South-East England	Main city: > 10 million		10-50		ITC infrastructure, commuting patterns
Megalopolis	Bos-Wash, Great Lakes (Quebec-Milwaukee)	> 25 million		Polycentric	Transport infrastructure	
Megapolitan	Midwest/Great Lakes, Piedmont Atlantic, Southern California		Anchor cities: 50-200 miles apart	2 or more	Formed of metropolitan areas	ITC infrastructure, commuting patterns
Megaregion (USA)	Midwest/Great Lakes, Piedmont Atlantic, Southern California, Texas Triangle			Polycentric	Formed of megapolitans	
Mega-region	Pearl River Delta, Tokyo-Kobe, São Paulo-Rio de Janeiro; Nile Valley		Larger than mega- and metacities	Polycentric		
Urban corridor	Bos-Wash, Blue Banana, BESETO		Several 100 km long	Polycentric	Linear pattern, transport routes, city clusters	ICT infrastructure

metropolitan regions show a distinct road layout, while most of the others are connected in a similar way. Conurbations, in their original definition, are connected by tramways—presumably, FURs and MCRs have similar transport methods although these are not explicitly part of the definition. Likewise, metropolitan regions are defined by a fast transport network but basically all of today's large urban constellations have major highways and rail lines. For some of the constellations, travel time gives an indication of their extent but the definitions generally only give vague suggestions. Only for megapolitans and urban corridors, a rough distance in miles or kilometers is provided. The concepts are grouped as detailed in Table 2.

Where an extent is given in travel time, Geddes' (1915) and Friedmann and Miller's (1965) one- to two-hour maximum for a daily commute applies. This means that ribbon development, urban sprawl, and the concepts summarized under “conurbation” and “FUR” all have a more or less identical physical extent.

In a next step, we overlaid the concepts from Figure 4 with their different transportation networks (Figure 5, left). We then removed all infrastructure lines (Figure 5, right) and were left with a cluster of different-sized cities which could represent any of the concepts described above (with the exception of ribbon development which only covers part of the cluster). This shows the physical similarity of most of the concepts without fully taking into account their scale. The general clustering of a number of cities is the same for all concepts described.

Table 2 Grouping of the different concepts

Type	Shape	Extent in travel time	Extent in distance	Number of major cities	Infrastructure
Megacity	Point			1	Undefined
Metacity					
Metropolis					
Ribbon Development	Linear	Up to >1 hr		1	Undefined
Urban Sprawl	Galactic	<1 to >2 hr		1	Undefined
Conurbation	Galactic	1 hr		≥ 2	Road, tram
Metropolitan Area					
Urban Agglomeration					
Functional Urban Region (FUR)	Galactic	2 hr		≥ 1	Undefined
Urban Field					
City System					
Urban Network					
Larger Urban Zone (LUZ)					
Mega-City Region (MCR)	Galactic			≥ 2 and up to 50	Undefined
Megalopolis					
Mega-(Urban) Region					
Mega-Metropolitan Region					
Megapolitan	Galactic		50-200 mi	≥ 2	Undefined
Metropolitan Agglomeration	Galactic			≥ 2	High-speed road/rail
Metropolitan Region					
Metroplex					
Urban Corridor	Linear		>1500 km		High-speed road/rail

This overlay enables us to apply the physical parameters for any large urban area globally. A main limitation of the revised concepts is their lack of transferability: with some of them limited to case studies (e.g., megalopolis, Metroplex, conurbation), a global identification is hard to achieve. Our focus on the spatial pattern allows us to categorize large urban areas on a worldwide scale without having to consider administrative boundaries or functional criteria which are not measurable consistently.

Finally, we illustrate the spatial relationships of the reviewed concepts by comparing the dimensions provided in the definitions and using the spatial layout presented in Figure 4 (Figure 6). We did this in order to visualize physical overlap and dimensions of the different terms. For the sake of legibility, the legend only shows some terms out of each box in Figure 4. The result is a spatial impression of the concepts in relation to each other. It provides an estimate of a concept's scale relative to other concepts. The infrastructure network is not further classified.

Based on existing definitions, urban corridors form the largest constellations by far. Their dimension exceeds that of other large urban areas—all of them are surpassed in size in comparison (this is not to say though that *all* of them actually occur within an urban corridor).

Figure 4 Comparison of spatial footprints of different concepts

Figure 5 Concepts overlaid and with their infrastructure network removed

Figure 6 Spatial juxtaposition of different concepts for large urban areas

Figure 6 shows the approximate spatial relation of different concepts to each other while using the spatial clustering from Figures 4 and 5. The infrastructure network is not further differentiated but generally shows some form of fast connection (road or rail). Urban sprawl, ribbon development, conurbations and metropolitan areas have a similar extent in terms of travel time (roughly one hour from core to edge)—smaller than FURs and MCRs. Two or more of the previous concepts combined can form megapolitans, which are only exceeded in size by megaregions and urban corridors. Most of the concepts are rather compact in shape, only ribbon development and urban corridors show a linear layout.

We are aware that our juxtaposition can only be an approximation of the scale and extent of large urban areas but our results show the physical parallels between different concepts. The massive dimension of urban corridors reflects the current urbanization trend—growing urban population, changing physical shape of urban areas —, and if this trend continues, we expect the number of urban corridors and other large urban areas to increase.

These results are intended to serve as a guideline for delineating large urban areas using spatial parameters. This will contribute towards providing clear definitions for further analysis, and also towards a consistent understanding of what constitutes large urban areas from a spatial point of view.

4 Conclusions and outlook

In this paper, we examined the question whether we can turn the conglomeration of concepts for large urban areas into one spatially consistent approach. In order to answer this, we reviewed various urban concepts based on the existing literature. These included mega- and metacity, ribbon development, urban sprawl, conurbation, metropolitan area, megaregion, mega-urban region and urban corridor. Our aim was to consolidate them on the level of spatial features. Functional aspects, although fundamental to some concepts, have not been taken into account. While we are aware that functional issues are significant as well, we argue that the spatial dimension is the only measure which can be observed globally, consistently and temporally. It can thus provide valuable information on the shape of urban areas as well as changes in this shape at different points in time, however we acknowledge that in

order to understand dynamics and trends of large urban areas, other dimensions such as economic, population, etc. data are required: spatial patterns help to *describe* urban areas but they cannot *explain* them.

The concepts and related spatial features vary in size, shape and function. Some of them do not have a universal definition and show varying degrees of overlap. Cities or regions around the world therefore usually fit into several categories—a general rule of thumb is that the larger an area, the harder it is to describe accurately because of the growing number of factors involved.

The two main physical characteristics for any concept describing large urban areas are the settlement clustering and the connecting transport infrastructure. While this may seem an obvious result—after all, expansion of and connection between settlements are only possible through transport infrastructure lines –, the actual similarity is remarkable. While the physical layout of a large urban area is the most visible aspect, this layout is generally not further defined in the reviewed concepts.

Most of the concepts above do not have an explicit scale. Some rough guidelines, such as one or two hours' travel (Geddes, 1915; Friedmann and Miller, 1965) or “can [...] be traversed in one day, round-trip” (Lang and Nelson, 2007), give an indication of an area's size. The Morrison Institute (2008) provides one of the few absolute distance measures between cities: 50–200 miles apart. Some authors give figures on a minimum population size (e.g., Friedmann and Wolff, 1982; Bourdeau-Lepage and Huriot, 2006; UN-Habitat, 2006): thus, population seems to play a more important role in defining urban concepts than spatial extent. Our spatial juxtaposition (see Figure 6) allows us to group some of them according to their physical form in order to achieve one of the aims of our study, which is to reduce the complexity and multidimensionality of concepts and making them more clearly delimitable from a physical perspective.

We conclude that there are two major problems which hinder a widely agreed nomenclature. Firstly, since most concepts disregard a clear scale definition, meaningful upper and lower bounds of scales are typically missing. Some of the consequences of scale have been demonstrated by Liu *et al.* (2014): For worldwide studies, the amount of ‘urban areas’ ranges from 0.45% to 3% depending on the definition of ‘urban’—from ‘impervious surface area’ (finest granularity used) to ‘built-up area’ to administrative boundaries definitions. This leads to a second conclusion: The interoperability is hampered by a lack of a commonly agreed ontology of urban areas. Commonly agreed land cover classes, taxonomies like for species and clear standards are needed. Feranec *et al.* (2014) establish that correct awareness of the similarity between classes from different nomenclatures is the prerequisite for their semantic interoperability. Therefore, many of the concepts reviewed in this article that have their origins in planning or social sciences may continue to lack interoperability and transferability as long as a common ontology—vulgo: a meta-language—is not achieved.

Despite of this lack of clearly identifiable and measurable features we maintain that spatially, urban concepts show great similarities: the general clustering of populated and less populated areas, evident through built-up and non-built-up land surface, is the key indicator. In Figure 6 we showed the (scale-independent) spatial footprint of selected types of urban areas as identified through existing definitions. By overlaying these concepts, we found that the general clustering of large urban areas is more or less the same, especially if the con-

necting transport infrastructure is taken out.

For a systematic classification of large urban areas, a consistent dataset needs to be globally available. For functional indicators, this is not given; a spatial approach for global delimitation, on the other hand, is feasible due to the availability of consistent datasets, particularly through satellite imagery. However, mapping of urban areas on a global scale is a challenging task: the areas of interest are relatively small compared to the total land surface, the land cover is everything but homogeneous, and the term “urban” is interpreted in different ways (Schneider *et al.*, 2010). The outcome of global urban maps is dependent on the input data: census data return the population distribution, while remote sensing-based night-time lights (used for example by Small *et al.*, 2005, 2011; Elvidge *et al.*, 2001) reflect population (Sutton *et al.*, 2001), built-up density and/or economic activity (Schneider *et al.*, 2010; Elvidge *et al.*, 2007; Doll *et al.*, 2006). Taking into account those limitations, Florida *et al.* (2007) use a global night-time dataset to estimate the population and, with additional estimates of national gross domestic product, the economic activity of mega-regions. In a series of papers, Potere and Schneider (2007, 2009) and Schneider *et al.* (2010) examine different maps of global urban areas for accuracy and disclosed a high degree of variance, unveiling a lack of a universal taxonomy and global assessment of urban areas (Potere and Schneider, 2007). Liu *et al.* (2014) propose a nested hierarchy of “impervious surface area”, “built-up area” and “urban area” to overcome some of the limitations of land use estimates.

Recent global urban mapping projects use geometric resolutions of 15m and less (compared to 300m and more for earlier studies such as Bontemps, 2009; Bartholomé and Belward, 2005; Loveland, 2000; Hansen, 2000). Examples include the global urban footprint product developed at the German Aerospace Center (DLR) from TerraSAR-X/TanDEM-X radar data (Esch *et al.*, 2012), the Joint Research Center (JRC)’s “Global Human Settlement Layer” (GHSL) (Pesaresi *et al.*, 2013), or maps based on ASTER satellite data combined with existing urban area maps (Miyazaki *et al.*, 2012).

The physical conceptualization of urban concepts examined in this paper allows us to analyze global datasets consistently, for which the above-mentioned remote sensing products provide a new geometric precision. Using both a consistent dataset with a worldwide coverage as well as consistent parameters contributes towards a global comparison with simple but objective indicators. Our literature review therefore serves as a step towards reducing the complexity of describing large urban areas and advancing our knowledge of their physical characteristics in order to assist informed decision making for planning and resource management.

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