

## The Urban Sprawl in Megacities, it is an Unsustainable Model?

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### Abstract:

The present paper has as goal the analysis of the urban sprawl phenomenon, from a planetary scale, assuming the hypothesis that this is an unsustainable process. It aims to demonstrate that what were initially a way of human settlement characteristic of many civilizations (northern and eastern Europe, nomadic tribes of America and Africa, etc.) and that represented in the early twentieth century a vernacular urbanism design, has become, particularly in the 70's of the last century, an International Style, a general trend in global scale. A model as a result of the widespread American Dream, based on the extensive land consumption, the car as basic transportation, and oil as primal energy. For this purpose the paper analyses in a first step, the urban sprawl in ten selected metropolitan areas: New York, Los Angeles, Chicago, Mexico, Sao Paulo, Tokio, Shanghai, Moscow, London, Madrid and Barcelona.

### 1. Introduction

The second half of the twentieth century was undoubtedly the time when there has been a faster urban growth worldwide. The urban population has grown from 750 million in 1950 to 2860 million in 2000, and now represents over 50% of world population. The expansion of the cities had its origin in the model of suburban life began with the generalized use of the car. A lifestyle based on the "American Dream: one single family-home, and one (or more) car (s)", that means mobility and homeownership. However it has been since the late 70s when it has had a more dramatic development, as a consequence of the crisis of metropolitan areas linked to what is called Post-Fordism economy and some authors have characterized as counter-urbanization (Berry, 1976) desurbanization (Berg, 1981), edge-cities (Garreau, 1991), , peri-urbanization (Dezert & alt., 1991), metapolis (Asher, 1995) or diffuse city (Indovina, 1990). Despite the diversity of urban development, the increasing consumption of land, the excessive use of land as a scarce resource, it is a constant in the urbanization process in the early twenty-first century.

In this sense, the urban sprawl, the process of gradual spread out of urbanization has become a worldwide phenomenon, especially in the developed world and its environs. The growing consumption of land, as a result of the extension of highway networks in urban areas, seems to have become unstoppable and affects virtually all the contemporary metropolis worldwide.

The literature has discussed deeply the concept of sprawl. Some of these concepts are:

*"Sprawl is the spreading out of a city and its suburbs over more and more rural land at the periphery of an urban area. This involves the conversion of open space (rural land) into built-up, developed land over time"* (SprawlCity.org);

*"Our method of defining sprawl is to characterize it simply in terms of land resources consumed to accommodate new urbanization. If land is being consumed at a faster rate than population growth, then a metropolitan area can be characterized as "sprawling." If population is growing more rapidly than land is being consumed for urbanization, then a metropolitan area can be characterized as "densifying"."* (Fulton et al., 2001);

*"The literature on urban sprawl confuses causes, consequences, and conditions. This article presents a conceptual definition of sprawl based on eight distinct dimensions of*

*land use patterns: density, continuity, concentration, clustering, centrality, nuclearity, mixed uses, and proximity. Sprawl is defined as a condition of land use that is represented by low values on one or more of these dimensions.” (Galster et. al., 2001).*

*“Urban sprawl is commonly used to describe physically expanding urban areas. The European Environment Agency (EEA) has described sprawl as the physical pattern of low-density expansion of large urban areas, under market conditions, mainly into the surrounding agricultural areas. Sprawl is the leading edge of urban growth and implies little planning control of land subdivision. Development is patchy, scattered and strung out, with a tendency for discontinuity. It leap-frogs over areas, leaving agricultural enclaves. Sprawling cities are the opposite of compact cities — full of empty spaces that indicate the inefficiencies in development and highlight the consequences of uncontrolled growth.” (EEA, 2006).*

However there is no consensus in defining urban sprawl, because of its complexity and multidimensional character.

Another perspective of the research is to approach the genesis of this kind of urbanization. Dematteis (1998) has shown how this phenomenon corresponds to the further development of one of the two major human settlement patterns developed throughout the story, a model of low density, especially linked to northern Europe and to the Germanic law or British common law. Faced with this model of land occupation, the Latin countries have developed a compact settlement, in which Roman law, linked to the *urbs* or the *civitas* and inherited from the Greek polis, would have had an important role. In Mediterranean Europe the city would have been characterized by its compactness and the clear separation between urban and rural landscapes. The cities, walled, would have later in the Middle Age additional reasons as to defend, to remain "closed" to the outside, but would have remained the spatial occupation characterized by the concentration of population in cities and towns.

The same form of spatial occupation has characterized the original settlement patterns of America. Faced with the dispersion of the nomadic of North America there were the cultures of Mesoamerica (the *Mexicas*, so-called Aztecs) and South America (the Incas) that developed compact cities like Latins (or Asian). The emergence of a powerful State on the original common property (Vitale, 1997) probably led to these civilizations to adopt a model of human settlement concentrated, with cities like Tenochtitlan or Cusco as most prominent examples.

American colonization reproduced the compact model through the Laws of the Indies in Spanish America, this model was adapted without significant conflicts with the structure of cities Incas and Aztecs, but came into contradiction with indigenous forms of rural settlement, which produced irreversible effects.

The transition of dispersed settlement patterns in to urban sprawl occurs in the late nineteenth century, with improved communications. The trams and railways, and especially the metro systems allow to the cities with traditional dispersed pattern reconcile rural / urban opposition that industrialization had generated.

Real estate, mass transit system and low density development (the single family home) appears from the beginning the same model of urbanization. The model, until then with local consequences, is incorporated in the traditional lifestyles of the countries with low density development tradition, creating an urban pattern that could well be characterized as vernacular. With the E. Howard theory (Garden Cities of To-Morrow, 1898) of garden city, and the generalization of this model for social housing developments in the U.S. and UK (Crawford, 1995) as well as the proliferation of architectural movements, such as the Prairie School in Chicago, are an example.

However, what at first was but a manifestation of a vernacular urbanism, would become in International style with the coming of the automobile. The case of Los Angeles is in this sense, paradigmatic. The best public transportation system in the world becomes, since 1937, the greatest urban motorway network. And with it comes the trivialization of what has become to be called the American Dream: a single family home and a car. A model based on consumerism as a premise, predator of space and natural resources as a result, a way of life and a reference to follow, in the globalized world.

## 2. Objectives

- The first specific objective of the research is to delimitate, measure and understand the urban continuum inside and outside the administrative boundaries.
- The morphological analysis of conurbation will serve to identify the core city from the surrounding countryside and to compare the different structures of the studied megacities. The comparison between the different models of urbanization of the selected megacities allows making a first approach of the differences and similarities of these megacities on the phenomenon of urban sprawl and the interaction existing between land consumption and a number of urban sustainability indicators, such as mobility, energy consumption and the generation of CO<sub>2</sub>.
- In parallel, the degree of monocentrism or polycentrism of the study areas will be analyzed, in order to validate the hypothesis relating to the improved environmental performance of polycentric metropolitan systems over those characterized by the macrocephaly of a single center.

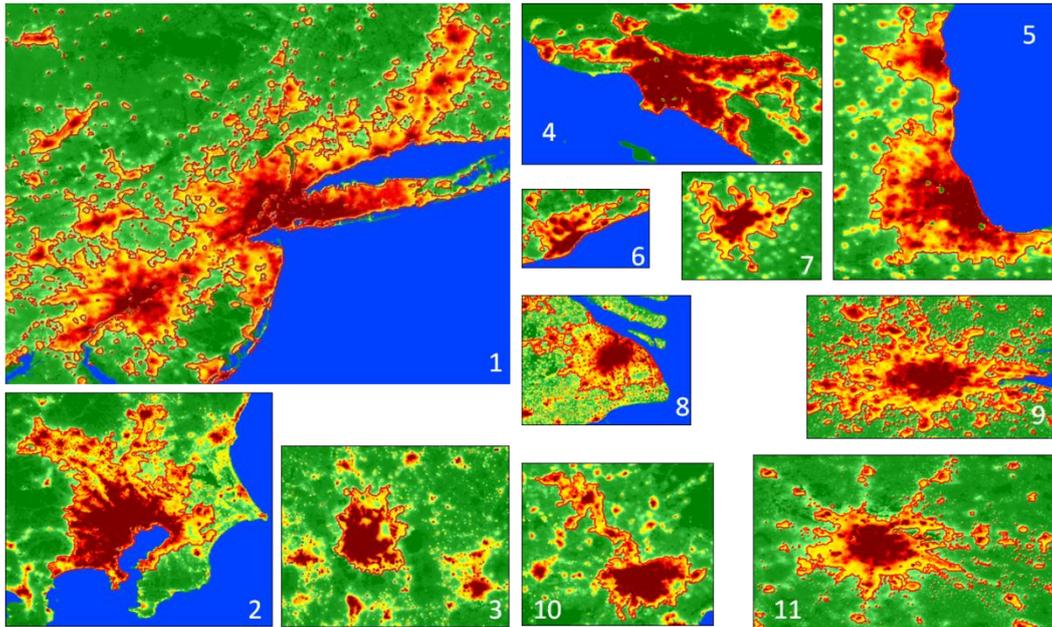
## 3. Land consumption and urban sprawl

In order to study the urban sprawl and land consumption in the selected megacities the research investigates and provides own quantifications from the available databases. The databases analyzed until now are: Demographia (2007 onwards), for the USA, the Urbanized Area (UA), as designated by the Census; Landsat worldwide, World Night nighttime images (DMSP-OLS Nighttime Lights Time Series ) of NOAA's National Geophysical Data Center (NGDC), ISA (Constructed Impervious surface area), which identifies the sealed area.

In a first review and working with the database ISA (Constructed Impervious Surface Area) we obtain an image of the selected mega regions: New York-Philadelphia area has 24.483 sq km and 24.521.188 inhabitants, Tokyo mega region has 9.823 sq km and 36.994.235 inhabitants, Mexico City Metropolitan Area has 3.300,11 sq km and 19.073.825 inhabitants, Los Angeles Metropolitan Area has 7.962,38 sq km and 15.292.539 inhabitants, Chicago 10.093,20 sq km and 10.121.359 inhabitants, Barcelona 1.429 sq km and 4.330.321 inhabitants, Madrid 2.451,58 sq km and 6.086.016 inhab., Seoul 4.904,30 sq km and 23.086.147 inhab., London 5.680,53 sq km and 12.100.655 inhab., Sao Paulo 4.663,33 sq km and 22.026.935 inhab. And finally Moscow has 3.323,73 sq km and 13.195.799 inhabitants.

Megacity	Urban Land	Population	Density
Barcelona	1.429,00	4.330.321	3.030
Chicago	10.093,20	10.121.359	1.003
London	5.680,53	12.100.655	2.130
Los Angeles	7.962,38	15.292.539	1.921
Madrid	2.451,58	6.086.016	2.482
Mexico City	3.300,11	19.073.825	5.780
Moscow	3.323,73	13.195.799	3.970
New York - Philadelphia	24.483,00	24.521.188	1.002
Sao Paulo	4.663,33	22.026.935	4.723
Shanghai	4.904,30	23.086.147	4.707
Tokyo	9.823,00	36.994.235	3.766

**Table 1, Mega Cities Densities (From ISA)**



**Fig. 1, 1: New York-Philadelphia, 2: Tokyo, 3: Mexico, 4: Los Angeles, 5: Chicago, 6: Barcelona, 7: Madrid, 8: Shanghai, 9: London, 10: Sao Paulo, 11: Moscow**

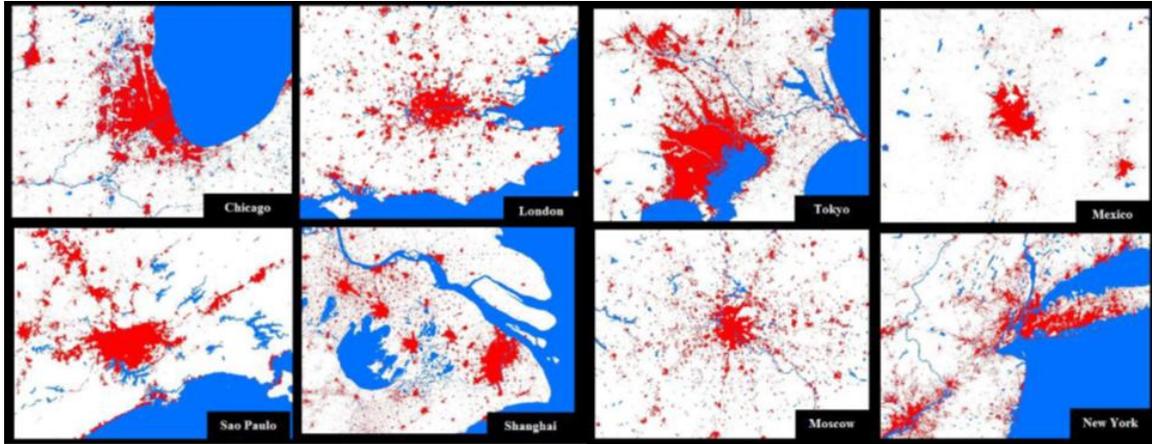
In this analysis we can see that in Latin-speaking America and Asia have less urban sprawl or have bigger densities than in Europe, but some mega regions of the USA, like Chicago and New York have a very marked sprawl process with densities of one thousand inhabitants per square kilometre.

Another source of analysis was the world night-time images (DMSP-OLS Nighttime Lights Time Series) and again we can see a different process of urban sprawl in the United States than in Europe, Latin-speaking America or Asia.



**Fig. 2, Megacities urban land**

In other hand, working with the Landsat images and delimitating a window of 45.000 sq km for all regions, the built-up area overcomes the 5,000 sq. km in New York, Tokyo and Chicago. In London, Sao Paulo and Shanghai is between 4,000 and 5,000 sq. km. Finally, Moscow and overall Mexico City has a lower built-up area, 3,000 and 2,000 sq. km respectively (see fig. 3).



**Fig. 2, Megacities Built-up area**

The above results suggest, if they are correlated with information on population and economic structure of those metropolises, a higher level of urban sprawl in the USA and Japan than in Europe and Latin-speaking America.

#### **4. Polycentrism and urban sprawl**

More polycentrism means less urban sprawl? *“Polycentric spatial development is the main concept underpinning the aims of territorial cohesion. The concept can be described as a bridging mechanism between economic growth and balanced development. Accordingly, polycentric development can bridge the divergent interests of the Member States by encouraging more balanced and coordinated competitiveness. Interest in polycentric development is also fuelled by the hypotheses put forward in the ESDP that polycentric urban systems are more efficient, more sustainable and more equitable than either monocentric urban systems or dispersed small settlements.”*(EEA Report , 2006).

In order to understand the function of the “urban artifacts” of our century have been chosen four cities of the research, two of them in the USA and other two in Spain (Los Angeles, Chicago, Barcelona and Madrid) to apply the methodology of the Interaction Value (Roca et al., 2005) as examples of different types of urban structure, the efficiency of their metropolitan systems will be evaluated from the dual perspective of land consumption and sustainable mobility.

Given the commuter flow matrix home / work of local base (places or cities), calculate the matrix origin / destination, i / j, of “interaction values” through equation:

$$VI_{ij} = \frac{F_{ij}^2}{POR_i \cdot LTL_j} + \frac{F_{ji}^2}{POR_j \cdot LTL_i}$$

Where  $VI_{ij}$  is the interaction value between entities i and j, and  $F_{ij}$   $F_{ji}$ , the flows from I to j, and j to I, respectively,  $POR_i$  and  $POR_j$  the employed population resident in both entities, and  $LTL_j$  and  $LTL_i$  the workplaces located in these entities.

The equation includes not only the outflow but also the inflow, and considers their own mass (resident workers) and the destination. This methodology allows defining the internal structure of the metropolis and evaluating the degree of polycentrism of the system.

After using the methodology of the Interaction Value it has been shown the monocentrism of Chicago (8 sub-centers) and Madrid (8 sub-centers) and the polycentricism of Los Angeles (13 sub-centers) and Barcelona (24 sub), so we can say that Los Angeles metropolitan area consumes less land, have a more sustainable mobility and is more polycentric and dense over Chicago, the same apply to Barcelona and Madrid respectively, but Madrid has a real compact central area and very dispersed periphery (Roca et al., 2011). It is remarkable that contrary to the image of city of sprawl, Los Angeles is not so much compared to other American cities and according to databases.

	<b>Los Angeles</b>	<b>Chicago</b>	<b>Madrid</b>	<b>Barcelona</b>
Artificialized land (sq km)	7.033,70	5.281,82	774,00	667,37
Population (2000-2001)	16.005.014	8.911.577	5.439.588	4.530.254
LTL (employments)	6.409.654	4.041.382	2.428.364	1.903.795
Urban Density (Inhab./sq km Artif)	2.275,48	1.687,22	7027,89	6788,22
Employment Urban Density	911,28	765,15	3137,42	2852,68

**Table 2, Metropolitan Systems**

The sub-systems structured around subcenters can configure cities within the metropolitan city, making a real city of cities (Nel.lo, 1998).

## 5. Conclusions

The land consumption as quantification of sprawl, is an essential indicator of the sustainability of urban ecosystems, not only because it allows the evaluation of land consumption, an scarce resource, but also, as has highlighted the literature (see among others Arellano & Roca, 2010a and b, Arellano et. alt. 2010), as it allows an indirect evaluation of energy consumption, CO2 production, and thus the ecological footprint.

Although research is still in development, it has reached a first approach of the hypothesis regarding the degree of polycentricism involved positively in lower consumption of land, and consequently in a more efficient decentralized urban systems (ETA 1999).

Monitoring urban sprawl using remote sensing is fundamental to understand the contemporary process of urbanization on a global scale. As a result of this research, among others, our center of research on Land Policy and Valuations is developing a platform called GLOBUS to observe the global urban sprawl (<http://www-cpsv.upc.es/GLOBUS>), and its purpose is to continue studying and analysing the process of urban sprawl in a representative sample of most populated metropolitan areas, intermediate cities and singular small cities with the hypothesis that the process of urban sprawl is a phenomenon which is not limited to the developed world and it is a global scale process. The urban trend to sprawl brings negative effects on sustainability and social inclusion.

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