



More Urban Constructions for Whom? Drivers of Urban Built-Up Expansion Across the World from 1990 to 2015

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Abstract	<p>Since the 1990s, the conversion of land for urban use has never been more intense. Occurring under all latitudes, transcending the economic disparities as well as the political regimes, urban built-up expansion appears very much articulated to the global financial turn, which occurred after the progressive destatization of the money creation, which accelerated and globalized after the debt crisis of the 1980s. Using the Global Human Settlement Layer dataset on the degree of urbanization, we can assess that, worldwide, the built-up surface expanded by 243,000 km² between 1990 and 2015 and the average urban density has declined slightly from 2775 inhabitants per km² to 2756. After describing the national level dataset used and our methodology, we expose the regional nuances in the global built-up spreading and their relations to population growth. Then in a third section, we correlate those national trends with a set of significant economic indicators. We articulate it also to the individualization and progress of housing condition. Population growth remains the dominant factor determining urban built-up spread, but countries differ. Built-up growth did not respond linearly to the final demand for housing and therefore to demographic pressure. Building is a material good whose value is also interdependent with economic growth. The universal relationship between size and density specific to scaling laws is verified once again in the case of cities. However, economic density or concentration of wealth tends to take precedence over population mass to explain urban built-up expansion.</p>	

Chapter 13

More Urban Constructions for Whom?

Drivers of Urban Built-Up Expansion Across the World from 1990 to 2015



Eric Denis

Abstract Since the 1990s, the conversion of land for urban use has never been more intense. Occurring under all latitudes, transcending the economic disparities as well as the political regimes, urban built-up expansion appears very much articulated to the global financial turn, which occurred after the progressive destatization of the money creation, which accelerated and globalized after the debt crisis of the 1980s. Using the Global Human Settlement Layer dataset on the degree of urbanization, we can assess that, worldwide, the built-up surface expanded by 243,000 km² between 1990 and 2015 and the average urban density has declined slightly from 2775 inhabitants per km² to 2756. After describing the national level dataset used and our methodology, we expose the regional nuances in the global built-up spreading and their relations to population growth. Then in a third section, we correlate those national trends with a set of significant economic indicators. We articulate it also to the individualization and progress of housing condition. Population growth remains the dominant factor determining urban built-up spread, but countries differ. Built-up growth did not respond linearly to the final demand for housing and therefore to demographic pressure. Building is a material good whose value is also interdependent with economic growth. The universal relationship between size and density specific to scaling laws is verified once again in the case of cities. However, economic density or concentration of wealth tends to take precedence over population mass to explain urban built-up expansion.

13.1 Introduction/Facts and Hypothesis

The conversion of land for urban use has never been more intense than it has been since the 1990s. Occurring under all the latitude, transcending the economic disparities as well the political regimes, urban built-up expansion appears very much articulated to the global financial turn, which occurred after the progressive destatization of the money creation, which accelerates and globalized after the debt crisis of

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the 1980. Deregulation lead to a tremendous expansion of credit but also to a chronic financial instability. Land and real estate becomes, in that context, a banking asset supporting a speculative rise of money creation widely disconnected of the productive machine needs. Hence, land driven development becomes a major motor engine of growth in many countries, in particular for the transitional economies. With gold, land constitutes one of the last warranties for the money creation. Land at the edge of cities represents also a frontier of non-fungible value to conquer and to introduce to the urban market and convert to private and fungible wealth. Conversion of land to urban uses is not the simple support of economic growth, it constitutes a major component of it, including the response to the need of productive spaces (for industries, offices, trades and logistic platforms) as well for housing and for, an expanding part, as a financial asset.

The de-densification and sprawl, is also the complex product of two structural changes: the parental de-cohabitation and the increase of standard of living. Children no longer stay in their parents' home at the time of marriage and houses and apartments tend globally to become larger. In other words, the structural and accelerated decline of density has to do with the dynamic of individualization, nuclearisation of families, as well the aspiration to individual bedrooms for kids. The habitation households claim to settle in tend to enlarge and the desire for individual housing becomes more and more a shared dream. The economy founds new opportunities in these personalizing trends when people are less bound in local solidarity group. They become more dependent of services to assist and eventually stimulate and create their growing individual aspirations.

Sprawl is a multidimensional phenomenon that could not be precisely evaluated using the set of data aggregated at the level of country we use.¹ Only the relation between density and growth of the built-up gives us here an indication of the urban trend. In our chapter, sprawl is viewed as the combination of the intensity of the relation between population density decline and increase of construction footprint.

Two global dependent indicators highlight our assumption: first-of-all, worldwide, the built-up surface expanded by 243,000 km² between 1990 and 2015, almost the full area of the United Kingdom; secondly, the average urban density (cities, suburbs and urban clusters) has declined slightly from 2775 inhabitants by km² to 2756. The Global Human Settlement Layer (GHSL) Degree of Urbanization 2018 geodatabase analysis confirms what Seto et al. (2011) or Angel et al. (2015) highlighted using a vast sample of cities across the world.

¹Thanks to Thomas Kemper and Michele Melchiorri for pointing to me, reading this paper draft that it is difficult to assess precisely in what extend the urban built-up expansion contributes to the densification of existing urban perimeters and what is related to sprawl (expansion of the urban perimeters with low density). A key publication on sprawl (Tikoudis et al. 2018) points to the complex apprehension of sprawl that we cannot assess precisely with the summary country tables. A paper to come will precise further the extent of the sprawl using the detailed data per city and the gridded data. It requests to mobilize data to quantify the fragmentation vs. compactness of urban perimeters, the number of population centres (high density and polycentricity) and the share of urban population in low-density area.

The built up annual growth is globally faster than the demographic one, by a factor of 1.17 between 1990 and 2000 and 1.13 between 2000 and 2015. The built up annual growth was established at 1.69% during the first phase and 1.39% during the second.

In the same time, between 1995 and 2014, global wealth grew by 66%, when the GDP at constant price of 2010 almost doubles, from 44.9 to 77.6 trillion. This global enrichment is materializing in the extension of the urban footprint. Furthermore, this capitalization in land and building assets is a major driver of the global wealth expansion. The total population grew only by 28% during the same period.

Our analysis confirms the strong correlation between urban built-up footprint distribution (log) by country and population (log); established at 0.88 in 2015.² They are definitively intricate grandeurs as are logs of GDP and built-up ($R = 0.55$). Richest countries have a more extended urban footprint. After Henderson (2003), it confirms the canonical and strong relation between logs of GDP per capita and share of urban population ($R = 0.85$) but population demand matters.

Based on the Degree of Urbanisation Model (DEGURBA) developed in the frame of the “Global Human Settlement Layer” (GHSL) project of the European Commission’s Joint Research Centre, in 2015, 84% of the world population live in areas covered of continuous built-up at 50%, or cities plus suburbs and urban clusters. In other words, in densely inhabited areas and intermediate density areas, using a 1 square kilometre grid to articulate built-up footprint and population, as we will detail it in the following methodological section.

We should here relativize the pace of the built-up sprawl, in the sense that the urban agglomeration remains the most efficient way to use the terrestrial surfaces and to accommodate more than 7 billion inhabitants and most of their productive activities and daily commuting. All the negative externalities associated to agglomeration, notably congestion and pollution can be deeply mitigated using the present technologies and implementing appropriate rule of law. In fact, the total built-up spreads only on 0.6% of the terrestrial surfaces. The agglomeration process is not negative in itself. Even if we consider only the ecumene out of the land mass belonging to countries, it did not reach 1%. It occupies 1.7% of the land mass and 2.7% of the ecumene, if we consider the 1 km² grid where population and built-up information are merged in the “Degree of urbanisation” (DEGURBA) model and dataset (Dijkstra et al. 2018). Nevertheless, de-densification of urban environment characterizes the current trend. It leads to an extensive soil conversion.

In order to expose in detail and correlate precisely the global trend of built-up expansion we are highlighting here, in a first section we describe the national level dataset used and our methodology. Then, in a second section, we expose the regional nuances in the global built-up spreading and their relations to population growth. In a third section, we correlate those national trends with a set of significant economic indicators, such as the share of fix capital and labour, FDI, cement production, share

²We should consider here that the two variables, built-up and population are not fully independent. The estimated population within agglomerate is evaluated in relation with the density of built-up in 1 by 1 km² grid.

of construction sector in GDP. We articulate it also to the individualization and progress of housing condition. In conclusion, we expose some element related to the multiplication of localities and its consequence on urban hierarchies showing that, beside the expansion of urban units and mega urban region formation, we have to consider the less visible process of small towns' emergence.

13.2 A New Information Source on Global Urbanization

Measuring urbanization at the world scale was until recently almost impossible. We were comparing very much different objects defined as urban units. There was no harmonised dataset overpassing the various national definitions of the urban sector. The measurement of urbanization taking into account individual settlements and morphological agglomerations was until recently very rough and their spatial coverage was limited. Up to now, the most used datasets such as the UN-Habitat city population series are incomplete and biased by extremely heterogeneous definitions managed by independent administration of some 260 countries. François Moriconi-Ebrard (1993) demonstrated clearly the limitation of such series for a comparative study of urbanisation, generating major distortions. The international efforts of harmonization are yet very limited. Nevertheless, after Quito Habitat III Conference in 2016 and the New Urban Agenda commitment, World Bank, OCDE and EU agreed to promote standard to generate harmonized geographical datasets. One of the major output is the development of an open source complete and multisource dataset supported by Eurostat. Its fundamental concept is based on a three folds' definition recognising: (i) city, (ii) urban clusters and suburbs, and (iii) rural areas, villages or dispersed population. It distinguishes densely populated area, from intermediate and thinly populated areas³ (Dijkstra and Poelman 2014).

The dataset we use The Degree of Urbanisation from 1975 to 2015 last release 2018 (DEGURBA 2018) appropriates this threefold definition. It constitutes a fundamental output of The Global Human Settlement Layer project supported by the European Commission through the GEO Human Planet Initiative who generates it. It provides by countries and by morphological agglomerations multiple metrics described in Florczyk et al. (2018). It delineates precisely 10,322 urban centres (agglomerate units) between 50,000 inhabitants and 46 million in 2015 (Guangzhou in China). It is a unique source correlating population and build-up footprint. The Global Human Settlement built-up areas (GHS-BU) provides the concrete evidence of the presence of human concentration and their activities as demonstrated by Melchiorri et al (2018). The fundamental is to gather the tangible traces or observations of material transformation of the human environment—in other words, to detect and

³The only alternate yet promoted by EU and the OCDE after Quito Habitat is the Functional Urban Area (FUA) method. Previously known as larger urban zone (LUZ), it cumulates two major limitations that renders it inappropriate to conduct worldwide comparison: it details only the largest or metropolitan urban areas and it implies to gather harmonised data on daily commuting which are not available for many countries.

qualify the existence of built-up or building.⁴ A pure fact (the materiality of construction) grounds this approach of the urban. It is not in first instance supported by an institutional fact (administrative limit of city depending of human/social agreement).

The starting point is to consider, in order to achieve a unique instrument to measure the dynamic of settlement across the world, that only one approach can be used, based on the location of tangible footprint of human presence. It gathers two complementary gridded geographical layers: in one hand, the morphological spread of settlements using satellite imagery at 40 m resolution.⁵ The built-up grid gives a gradient of construction from zero to 98% based on the detection of constructions at 40 m. In a second hand, a population grid at 250 m resolution is generated using local population at municipal and district levels provided by censuses. Overlaying the two layers generalized in a 1 km² grid, it becomes possible to provide a harmonised and dynamic vision of the distribution of population articulated to the settlements they live in. The dataset is available for different dates: 1975, 1990, 2000, and 2015. This approach, based on mapping the territory through a grid, avoids distortions caused by using LAU2 or communes/municipalities varying tremendously in size and/or shape. Currently the GHSL-DEGURBA approach is certainly overestimating the urban population as it uses too aggregated data for population (mainly at district level) that are then too highly incorporated in urban.⁶

The 1975 GHSL assessment underestimates the existing built-up areas because of two main factors: (i) worse sensor characteristics, and (ii) the presence of large data gaps (no data available) in the 1975 collection. Mud and disperse type constructions are difficult to detect using 1975 satellite imageries. The underestimation is around 20% globally, but it becomes extremely precise and comparable from 1990, with standardized observation and dataset in 2000 and 2016. Technical papers appreciate how the GHS-BU as well its one km² gridded overlaying generalization are consistent. GHS appears always equivalent or more precise than any other sources. It has

⁴The concept of “buildings” formalized by the GHSL are enclosed constructions above ground which are intended or used for the shelter of humans, animals, things or for the production of economic goods and that refer to any structure constructed or erected on its site (Pesaresi et al. 2013). For the GHSL concept, refugee camps, informal settlements, slums and other temporary settlements and shelters are included in the notion of built-up area.

⁵An open source automated processing workflow analyses an exhaustive global Landsat mosaic to provide a continuous built-up mosaic at 40 m resolution. It uses advanced automated machine learning and quality control comparing the results with existing open source layers such as MODIS, DMS/OLS night time lights, (Smith 2017) as well OpenStreet Map. Several researches assessed also the quality through comparison of various sources (Leyk et al. 2018; Lu et al. 2014). They validate that is the most advanced model of detection of built-up—errors are very limited. It is an open source in constant development, incorporating more and more advanced imageries, Sentinel in particular, and automated processes.

⁶Geopolis global database (<http://e-geopolis.org/>) is by far the most precise sources for a count of urban population by unit. Its unique methodology is taking into account the smallest census units, but the acquisition of built up footprints is dependent of human interpretation and scarcely updated. They cannot be used to conduct a precise work on built-up changes. In Geopolis, all the morphological agglomerations with more than 10,000 inhabitants are considered as urban. A morphological agglomeration is a built-up patch with less than 200 m between constructions (following UN recommendations). It uses open sources Google earth imagery.

been compared to the Gridded Population of the World, version 4.10 (GPWv4.10)², the Global Urban Footprint (GUF) initiative (Esch et al. 2017), DMPS/OLS night light imagery (Li and Zhou 2017), as well the 30 m resolution global land cover (GlobeLand30) generated by Chun et al. (2014). Because of its multi-temporal availability, it is achieving more than the Human Built-up and Settlement Extent at 30 m resolution too, but limited to a 2010 unique layer (HBASE; NASA-SEDAC).

13.3 Urban Expansion and Population

If urban morphological expansion is a global phenomenon, regional, national and local difference exists. They can be apprehended, first of all, in assessing the materialization of new constructions using the 30 m resolution data, and secondly in appreciating the de-densification using the one km² gridded dataset.

In 2015, the urban built-up footprint occupies some 570,000 km² worldwide (Table 13.1). With 175,000 km² of constructions added since 1990, it expanded by some 44%. This spread equals the urban built-up of the whole Northern America in 2015! The African continent experiment the most important expansion: there, the urban built-up almost doubled. In contrary, Europe experiment the slower built-up spread. Here appears that, at the macroscale, the physical expansion of the urban world is, in first instance, correlated to the demographic pressure (44% vs. 42). Nevertheless, the relation is not uniform; it differs from region to region. For instance, the European built-up expansion is, in fact, important vis-à-vis its population stagnation (18.5% vs. 1.6). Here it should be make clear that the built-up layer capture only the constructions. It ignore street networks and open spaces. It did not represent the entire urban perimeters. By coupling built-up and gridded population, as explained above, DEGURBA's approach provides a measure of functional urban perimeters. The urban built-up footprint is precisely the measure we are interested to study as

Table 13.1 Distribution of the urban built-up in square kilometres in 1990 and 2015, and changes

	Urban built-up			Variation 1990 to 2015		Urban population change
	1990	2000	2015	in km ²	in %	
World	394,842	465,745	569,942	175,099	44.3	42.2
Africa	32,826	43,230	62,138	29,312	89.3	101.7
Asia	138,813	171,802	226,471	87,658	63.1	39.5
Europe	100,075	108,485	118,627	18,552	18.5	1.6
Latin America and Car.	34,113	40,269	45,739	11,626	34.1	47.2
Northern America	81,555	93,809	107,888	26,333	32.3	35.8
Oceania	7470	8165	9097	1628	21.8	52.8

Source GHSL

a unique indicator of the dynamic of construction and investments driven towards buildings.

Among 166 countries we consider here, twenty only contribute 74% of the built-up expansion between 1990 and 2015 (Table 13.2 and Fig. 13.1). The variability between them is tremendous: China built-up growth is two times higher than its urban population progression and USA 4.2 times higher, but India, even it is the third country in absolute terms for urban morphological expansion, it is much below its urban demographic growth; 8.2% versus 19%. China alone concentrates about one quarter of the world urban built up expansion. USA constitutes also a marker of the variability with its 25,000 km² of added built-up associated to an extremely limited demographic urban growth: 3.3% compared to 14.2% for the built-up imprint. Urban Europe and Japan experiment also conversions of land use at a much higher rate than their demographic stagnation would request.

Table 13.2 The 20th largest contributing countries to world's urban built-up expansion from 1990 to 2015

Rank	Country	Built-up		Urban population		Ratio B.U. Gro./Pop. growth
		Growth	Weight	Growth	Weight	
1	China	23.61	16.30	11.53	19.59	2.05
2	United States	14.23	17.69	3.35	3.80	4.25
3	India	8.24	5.17	22.28	19.33	0.37
4	Indonesia	4.60	3.44	3.73	3.75	1.23
5	Nigeria	3.44	1.89	4.23	2.56	0.81
6	Brazil	2.05	2.90	2.83	2.68	0.73
7	South Africa	1.88	1.61	0.94	0.68	2.01
8	Mexico	1.83	1.71	2.03	1.65	0.90
9	Japan	1.62	4.34	0.21	1.88	7.83
10	Italy	1.36	2.01	0.13	0.74	10.09
11	Germany	1.33	3.03	0.08	0.95	17.07
12	France	1.31	2.07	0.21	0.66	6.18
13	Russia	1.23	3.16	-0.37	1.85	
14	Turkey	1.16	1.01	1.23	1.04	0.94
15	RDC	1.15	0.60	1.83	0.92	0.63
16	Ghana	1.07	0.59	0.60	0.35	1.78
17	Vietnam	0.95	0.64	1.27	1.39	0.75
18	Malaysia	0.91	0.81	0.59	0.40	1.54
19	Pakistan	0.90	0.65	4.27	2.79	0.21
20	Thailand	0.90	0.78	0.56	0.77	1.60
	Sum	73.77	70.39	61.54	67.78	1.20
	World	100.00	100.00	100.00	100.00	

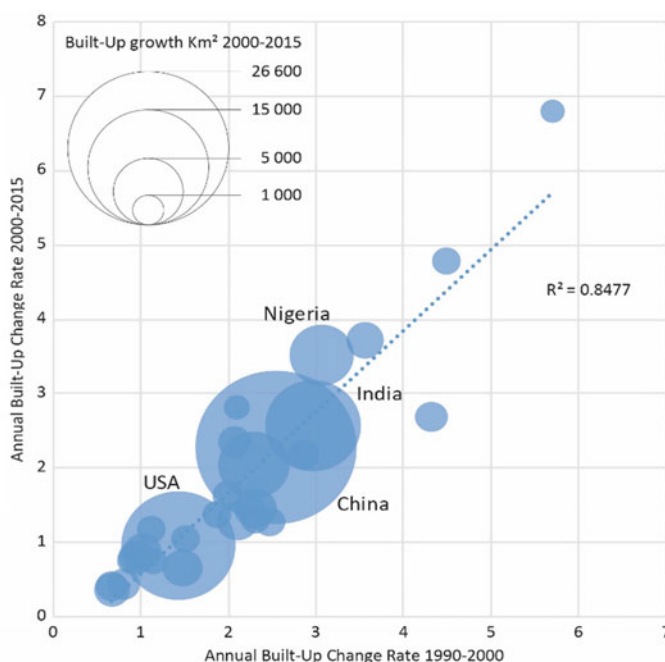


Fig. 13.1 Built-up annual growth rate during 1990–2000 and 2000–2015 for the 30 largest contributors to change (>80% of the total)

Regarding global regional differentiation, Asia experiments the fastest increase of its share of urban built-up followed by the African continent (Table 13.3). Nevertheless, their share of built-up is not yet proportional to their high population weight. Density their remains necessarily higher, but it tends to decline. The share of all the other regions declines. Remarkably, the trajectory of North America and Europe are diverging. Europe urban built-up continues to expand more rapidly than its urban population growth while, in Northern America, this difference tends to reduce.

The urban sector captured with the Global Human Settlement methodology distinguishes two complementary territorial configurations in reference to the 1 km^2 gridded approach: (i) densely populated areas or cities and their immediate peripheries and (ii) intermediate density areas composed of towns and diffuse suburban milieus (Pesaresi et al. 2016b). The first category called Urban Centre regroups more than 13,000 morphological agglomerations defined as contiguous spatial units of the 1-km^2 grid cells (four-connectivity gap filling)⁷ with more than 50% of build-up and/or a minimum threshold of 1500 inhabitants per cell. Urban Centre should

⁷The goal for the high-density clusters is to identify urban centres without any gaps. Therefore, enclaves needed to be filled. If the central square is not part of a high-density cluster, it will be added to a high-density cluster if five or more of the eight surrounding cells belong to a single high-density cluster. This rule is applied iteratively until no more cells can be added.

Table 13.3 Regional repartition of urban built-up and population from 1990 to 2015

	Share urban built-up (%)			Share urban population (%)			Built-up/Pop. ratio		
	1990	2000	2015	1990	2000	2015	1990	2000	2015
World	100.0	100.0	100.0	100.0	100.0	100.0	1.00	1.00	1.00
Africa	8.31	9.28	10.90	10.9	12.4	15.5	0.76	0.75	0.70
Asia	35.16	36.89	39.74	64.0	64.1	62.8	0.55	0.58	0.63
Europe	25.35	23.29	20.81	12.2	10.5	8.7	2.07	2.22	2.38
Latin America and Car.	8.64	8.65	8.03	8.0	8.2	8.3	1.08	1.06	0.97
Northern America	20.66	20.14	18.93	4.4	4.4	4.2	4.66	4.63	4.47
Oceania	1.89	1.75	1.60	0.4	0.4	0.5	4.33	4.05	3.40

(Built-up/Pop ratio = built-up share divided by population share)

have a minimum of 50,000 inhabitants. The second category named Urban Cluster includes some 300,000 peri-urban territories and towns composed of contiguous one-km² grid cells having more than 300 inhabitants per square kilometre and a minimum of 5000 inhabitants by agglomerate unit (8 connectivity). Through this dichotomy of urban perimeters, we are able to better qualify what is belonging to the sprawl. It will occur in the lesser dense urban areas bellow 1500 inhabitants per kilometres. Nevertheless, using here only the country summary tables, we are not able to qualify precisely the amplitude of the sprawl, as some of the urban clusters are not contiguous peripheries of urban centres. Some of them constitute forms of diffuse or disperse urbanization rather than sprawl per say.

The density (inhabitants per square kilometre) is globally stagnating but this average is made of contrary trends (Table 13.4a, b). It declines continuously in Asia as well in Europe, in denser cores as well as in their peripheries. Other drivers than population accommodation are at stake in this trend. The deconcentrating trend concerns first-of-all the cities, their cores and immediate peripheries but it expands at a slower pace on the diffuse urban sector. Conversely, densification of high-density areas characterizes Africa, Oceania and Latin America. At a slower pace, the North

Table 13.4 a Inhabitants per square kilometre (1-km² grid—DEGURBA), **b** annual variation of density (inhabitants per square kilometre)

a						
	High density area			Low density area		
	1990	2000	2015	1990	2000	2015
World	5422	5338	5345	1676	1633	1551
Africa	5516	5547	6063	1988	1943	1852
Asia	7095	6792	6431	1974	1868	1695
Europe	3702	3615	3575	1169	1110	1056
Latin America	5404	5447	5823	1643	1637	1638
Northern America	1749	1763	1825	760	774	797
Oceania	1681	1843	2211	1130	1188	1329
b						
	High density area		Low density area			
	1990–2000	2000–2015	1990–2000	2000–2015		
World	3	1	−4	1		
Africa	3	34	−4	−6		
Asia	−30	−24	−11	−12		
Europe	−9	−3	−6	−4		
Latin America and Car.	4	25	−1	0		
Northern America	1	4	1	2		
Oceania	16	25	6	9		

Table 13.5 Square meters added per year and per inhabitant

	Urban area		High density area		Low density area	
	1990–2000	2000–2015	1990–2000	2000–2015	1990–2000	2000–2015
World	1.39	1.12	2.57	1.77	1.21	1.05
Africa	1.64	1.31	2.33	1.46	0.95	1.12
Asia	1.01	0.94	1.08	0.94	0.90	0.92
Europe	1.58	1.25	0.90	0.81	2.38	1.80
Latin America and Car.	1.48	0.71	1.66	0.82	1.15	0.48
Northern America	5.53	3.58	6.80	4.57	3.54	1.76
Oceania	3.15	2.14	4.79	2.64	0.80	1.33

Source Built-up GHSL; reference Population 2000 and 2015

America’s paradigmatic sprawl seems to decelerate too and, eventually, agglomerates re-densify there.

With the number of meters added per inhabitant and per year, we appreciate more precisely how the expansion process slowed down vis-à-vis the population whatever the urban sector, dense or less dense (Table 13.5). The trend is much contrasted from region to region: the densification in Africa, Oceania and Latin America diverges with de-densification in Asia and Europe, especially for the dense areas. Northern America tends to stagnate. In this last region, the sprawl has not stopped but only decelerated, and yet Northern America experiments the highest increase in square meters added per inhabitant 3.6. Nevertheless, the subprime crisis reflects in the way the annual built-up footprint growth is slowing down, compared to the respective population growth (Table 13.6).

Convergence of built-up growth in densest and lesser-inhabited urban sectors characterizes the global trend apprehended at the macro-region level (Table 13.6). A gradual decrease of the physical expansion drives this conjunction of trends.

Everywhere, annual built-up rate of growth declines except in Africa low-density areas. It has certainly to do with a deficiency in land governance and physical planning leading to an extensive dynamic of sprawl by juxtaposition of individual houses.

Table 13.6 Annual growth rate of population and built-up for the two urban sectors (%)

	High density area				Low density area			
	Population		Built-up		Population		Built-up	
	1990–2000	2000–2015	1990–2000	2000–2015	1990–2000	2000–2015	1990–2000	2000–2015
World	2.30	1.81	1.86	1.47	1.23	0.88	1.40	1.18
Africa	3.80	3.50	3.32	2.44	2.32	2.12	2.00	2.45
Asia	2.44	1.79	2.22	1.87	1.29	0.75	2.05	1.85
Europe	0.44	0.10	0.56	0.49	−0.10	−0.08	1.01	0.68
Latin America & Car.	2.70	1.99	1.90	1.01	1.43	0.83	1.27	0.54
Northern America	2.46	2.00	1.80	1.26	0.48	0.47	0.85	0.42
Oceania	3.29	2.07	1.24	0.83	0.70	1.41	0.26	0.52

13.4 Beyond the Relationship Between Population Growth and the Built Environment: A Diverse World

If the decrease in population growth goes together with the decelerating of built-up densification⁸ and expansion, the relation is far from being uniform. In fact, for the entire urban footprint of the 156 countries with significant figures, the correlation coefficient (Pearson) between the annual population change and the annual built-up growth for the 2000–2015 is solid, established at 0.507. It is sensibly higher than the previous period of observation (1990–2000) when it was at 0.470. Population dynamics still matter in the way cities are expanding nevertheless the correlation between density and built-up growth tends to decline (0.367–0.224).

In the dense urban sector also, globally, the independence of trajectories tends to increase during the last period of observation ($R = 0.683$ against $R = 0.528$ for the previous decade). It is high and stable in less dense areas ($R = 0.560$ and 0.552).

The relation varies from region to region and tends also to consolidate or stays stable. For instance, in Africa for the last period the correlation is 0.421 (0.310 previously). In Latin and Central America, it declines very little from 0.410 to 0.384. Asia, excluding the Middle East countries, exposes a strong and increasing relation passing from 0.734 to 0.797. In Europe, it goes up very significantly to reach 0.832, from 0.568 previously. In this last, slow population change, even decline sometime, goes hand-to-hand with a limited built-up expansion.

The heterogeneity of the relation (only $\frac{1}{4}$ of the variance of one growth variable can be statistically explained by the other) can be appreciated when mapping residuals of the linear relation between built-up and population growth for the last fifteen years observed (2000–2015). The map opposes a major part of Africa and Asia to Europe and America including Latin America (Fig. 13.3).

This is not a simple economic and wealth dichotomy nor a demographic regime that drive the contrast we observe on the residuals mapping at the world scale (Figs. 13.2 and 13.3). The relationship is not linear ($R^2 = 0.25$), nor even polynomial ($R^2 = 0.27$) but appears as almost random (Fig. 13.2) reflecting a complex, various, contextual and multifactorial explanation of built-up expansion. The maximum contrast opposes, in one hand, countries with high population growth articulated to an extremely great built-up increase to, in the other hand, countries where urban land conversion and construction is very limited and sometime extreme population growth but more often a sluggish population growth. Globally it reflects a dichotomy between countries characterized by a rapid urban transition combining physical expansion and demographic growth and nations with a limited urban development.

An accelerated urban sprawl affects East Africa from Ethiopia (4.7% per year compared to 2.7 for urban population) to Malawi including Burundi and Rwanda (5.9% vs. 2.7). South Sudan appears here too as a post war speculative (re)construction

⁸By densification, we understand here more continuous urbanization measured at 38 m. The approach did not provide direct information about vertical densification and the transition from detached houses landscape to apartments. Nevertheless, increases of density are indicators of more people in some areas more often linked to building having more floors and apartments.

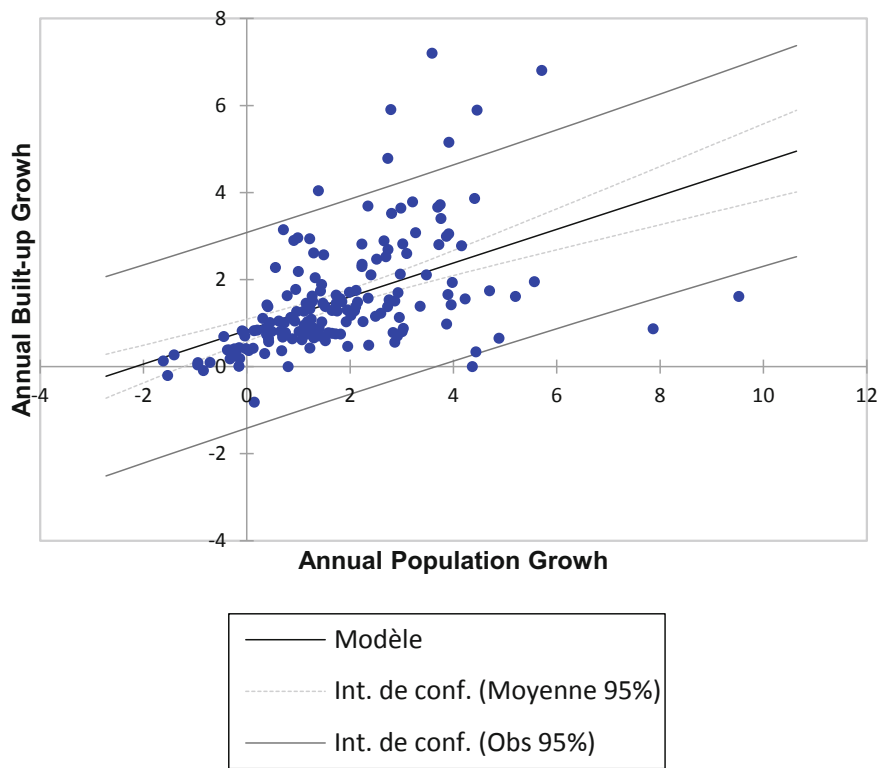


Fig. 13.2 Regression of annual built-up growth 2000 to 2015 by annual population growth ($R = 0.507$; $R^2 = 0.257$)

and quest to fix capital (5.8 vs. 4.4). There, surplus pour massively into plots and construction at a rhythm much higher than their population growth demand. Western Africa, notably Burkina Faso (3.7%/y for built-up) and Nigeria (3.5%) are other significant cases of rapid urban landscape metamorphosis, less extreme but yet very high. They are characteristic of a public governance of land that induces a selective redistribution of the public domain toward civil servants, army officers and supporters as a path to preserve the stability of the regime.

Houses, apartments and plots constitute as many tangible and irremovable assets, which protect their owners in the context of high inflation and against the poor return and lack of security of financial wealth. In those configurations, we found a majority of lower-income countries with a limited banking system poorly inclusive.

In such situation, we found also most of the Asian countries. Cambodia, Bangladesh and Myanmar represent extreme cases. The sustained pace of 2.2% per year of China physical expansion of cities is of particular significance as it represents almost of quarter of all the physical urban expansion of the world between 2000 and 2015. There, despite a lacklustre demographic growth limited to 0.5%, the built-up

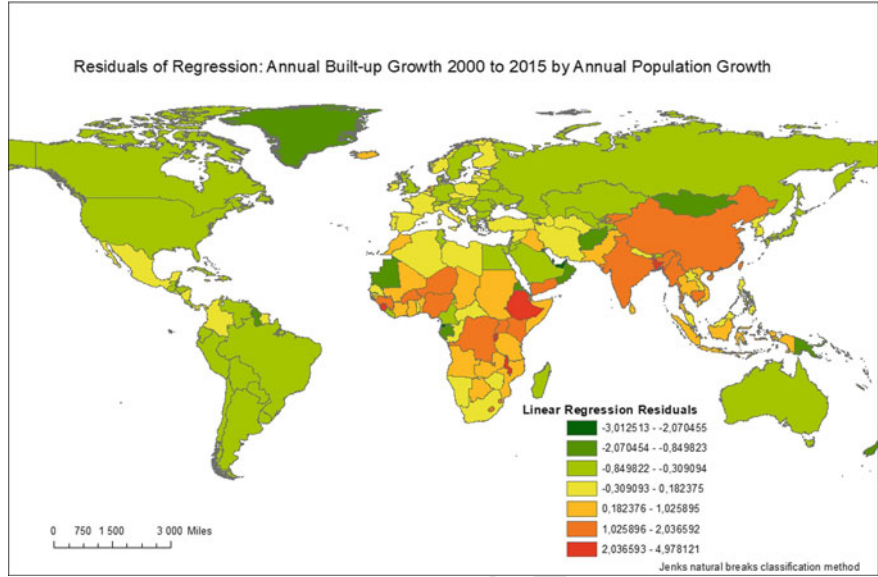


Fig. 13.3 Regression residuals: annual built-up growth by annual population growth (2000–2015)

footprint continues to expand fast at 3.8% per year since 2000. In 15 years, almost 14 m have been added per urban 2015 inhabitant.

This trend exemplifies a group of countries that a Chinese colleague Hsing (2010) called “land-driven development machine”. A variant would be the “property state” as coined by Haila (2016) looking at Singapore public management of urban land rent. There, the commodification of land supports the economic growth. It backs money creation and credit development. It is important to understand at the global scale this process has a complex decision game not simply driven by market forces but mediated by state policies vis-à-vis land supply and rate of credit as well by various “cultural ethics” determining the conception of home ownership for household and institutional in their management of assets and embeddedness. Consequently, it leads to an extreme consumption of space. Hence, housing oversupply characterizes today Chinese urban landscape. In 2014, the China Household finance Survey underlined that 40% of the annual housing supply would be enough to meet the additional housing demand. This year (2018), the vacation rate has reached 22%, it was already of 20% in 2011 (Li 2018). This represents some 50 million units!

India is not far, with an urban built-up growth at 2.6% per year but associated to a much higher demographic growth (1.6 per year). Beside this consequent land conversion to urban uses, due to market distortions and severe inequalities,⁹ the improvement of the urban housing condition remains very limited. Some 65 million

⁹Oxfam reports that in 2017, the richest 1% in India cornered 73% of the wealth generated. Official figures about urban inhabitants living below poverty line is 25.7% (Rangarajan Committee 2011). It represents today more than 100 million persons.

urban Indians or 17% of the urban citizen lives in slums and their number continue to increase. The real estate boom, which constitutes the major component of the new urban frontiers, generates an offer targeting the upper-middle class and the riches who are looking in real investment to fix cash.

It is particularly important to detail the Chinese and Indian cases because between them, they account for nearly a third of the global urban built-up expansion from 2000 to 2015.

Major post-industrial democracies could have also experimented faster built-up footprint spread vis-à-vis their population growth. USA is part of this trend with a built-up expanding at 0.95% per year when the urban population continues to grow at 1.11%. Nevertheless, because urban USA is paradigmatic of the extensive urban with its suburbs and yet represents the second share of the world built-up growth (14%), its trend is of a particular importance. Without the subprime crisis, it could have been even bigger. To some extent, it is comparable to several major Latin American countries and Canada as well: Brazil stands at 1.33 versus 1.03 and Argentina at 0.61 versus 1.07.

Europe is representing an average relation between urban built-up expansion and population growth: only could we distinguish a set Western and Southern Europe vis-à-vis Northern and Eastern Europe. The second exposes a slower built-up rate of change in view of their demographic growth. It is undoubtedly necessary to link this time lag to a process of catching up between the countries of the South and Northern Europe, but also to less control over land use—in other words, to regulations that are more flexible.

The most deficit-oriented countries in term of built-up growth vis-à-vis their population change are, for a part, rich petroleum monarchies (UAE, Qatar, Kuwait and Oman) with an extremely high demographic rate of growth (between 5 and 7% per year) and a built-up growth below one percent per year.¹⁰ In the same group are countries often poor or/and affected by conflict such as Afghanistan where demographic growth remains strong.

13.5 Economic Drivers of Land Conversion and Urban Built-Up Growth

If, globally, the recent urban physical expansion (2000–2015) did not respond linearly to the variability of demographic growth from country to country, the link to the distribution of income by country points to a dissimilarity in trend. There is not much difference between high-income (HIC) and low-income countries¹¹ (LIC): 0.475 versus 0.501, except that the relation is decreasing in HIC (0.596 previously)

¹⁰Here we could face a form of underestimation of the built-up change and of densification by verticalisation.

¹¹We use the UN income group classification: https://esa.un.org/unpd/wup/cd-rom/WUP2014_DOCUMENTATION/WUP2014_DEFINITION_OF_MAJOR_AREAS_AND_REGIONS.pdf.

and increasing in LIC (0.370). The tendency to a lower correlation of the urban built-up expansion and the population demand/pressure goes with an accomplished demographic transition, the stabilisation of rural to urban migration and an increase of wealth generated.

The population, its growth, did not explain totally and uniformly the intensity of the built-up imprint expansion. Nevertheless, it constitutes the best proxy expressing the demand for housing, productive activities and infrastructures. The artificialisation of soil and new constructions within and around cities answers to multiple goals that the demographic growth is not covering fully: (i) Buildings constitute also places for multiple economic functions which are not strictly proportional to population and (ii) housing is answering to very different segments of demand depending of wide spectrum of inequalities. Furthermore, edifices incorporate a financial value detached of their use value. Fixation of richness in plots and built assets tends to generate a dynamic of construction more and more de-correlated of the population demand. It certainly reflects in the degree of financialisation of economies, wealth formation and inequalities.

Before going further in the macro-economic analysis, we should notice that the family size weight and change by country considered as a proxy of the level of nuclearisation that should affect the housing demand is not correlated to built-up weight nor its change (Table 13.7). Correlations are also non-existent with proxies related to construction, whether it is the share in world concrete production or the weight of fixed capital in GDPs. The weight of the real estate and financial sector in the GDP could perhaps give a better result, but it is not easy to gathers for all the countries of the world a proper harmonized and updated indicator.

Significant correlation between economic and urban built-up indicators opposes urbanized land “stock” world distribution by country and its evolution to growth rate of change and densities of urban built-up by country. It means that, when the GDP per capita is negatively correlated with the annual growth rate of the built-up ($R = -0.317$) as well to the average urban density per country, it is positively correlated with the distribution of the world built-up by country ($R = 0.456$); in other words, with the largest and richest nations. A reverse dichotomy characterizes the link between annual GDP growth by country from 2000 to 2015 and built-up share ($R = -0.343$) versus annual growth rate of built-up ($R = 0.336$) and density ($R = 0.420$). Here we have a first indication of how the growth of housing by country is localized, in an inversely proportional way, to the various national economic weight; built-up growth responds in priority to a demand linked to strong demographic pressure, hence the link with densities also. It should be noticed here that the relationship is not very simple since the weight of countries in the world GDP in 2015 is very weakly correlated to their share in the global urban built-up growth ($R = 0.180$), nor to the share of wealth ($R = 0.128$), but their growths are correlated.

If there is no link with inequality indicators such as the repartition of millionaires or Gini indices, there are significant correlations with the distribution of wealth in general and by quantile. The relationship is more significant than with the global distribution of the GDP. Wealth reflects more the material capital encapsulated in the built-up footprint. The distribution of global urbanized territories by country is

Table 13.7 Correlation (Pearson) between urban change indicators and economic proxies

Variables	Annual growth rate urban population 2000–2015	Annual growth rate urban built-up 2000–2015	Urban density 2015	Urban density change 2000–2015	Urban built-up share 2015	Variation urban built-up share 2000–2015
^a Family size—2015	−0.033	−0.059	−0.025	0.062	0.082	0.088
^a Family size change 2000–2015	−0.076	0.013	−0.094	−0.160	0.012	0.006
^b Share of World GDP—2015	−0.143	−0.095	−0.137	−0.064	0.180	0.098
^b Annual growth rate GDP 2000–2015	0.359	0.336	0.420	0.101	−0.343	−0.231
^b GDP Per Capita—2015	−0.098	−0.317	−0.301	0.146	0.456	0.298
^b Annual growth rate per capita GDP 2000–2015	−0.281	0.029	0.068	−0.273	−0.189	−0.150
^c 2015 share immobilized capital in GDP	0.127	0.100	0.213	−0.047	−0.194	−0.166
^d Variation cement prod.—2000–2012	−0.085	−0.018	−0.113	0.062	0.020	−0.016
^d Share World cement prod.—2012	0.030	−0.012	0.037	0.027	−0.034	−0.034
^a Share World millionaire per country	−0.096	−0.090	−0.153	−0.028	0.149	0.070
^a Wealth to GDP per adult—2015	−0.265	−0.325	−0.235	−0.021	0.399	0.246
^a Share of adult under 10,000 wealth—2015 (USD)	0.111	0.402	0.228	−0.151	−0.383	−0.213
^a Share 10,000–100,000—2015	−0.234	−0.443	−0.222	0.176	0.254	0.122
^a Share 100,000–1 million—2015	−0.079	−0.247	−0.256	0.119	0.537	0.373
^a Share over 1 million—2015	−0.083	−0.190	−0.271	0.046	0.367	0.219
^a Gini per country—2015	0.006	0.127	−0.017	0.018	−0.038	0.025
^a By country share of total wealth 2015	−0.107	−0.081	−0.148	−0.044	0.131	0.060
^a Share change world total wealth 2010–2015	0.035	0.037	−0.049	0.002	−0.195	−0.128
^a Wealth per adult—2015	−0.102	−0.236	−0.274	0.077	0.458	0.297
^a Financial wealth per adult—2015	−0.084	−0.212	−0.284	0.075	0.478	0.354

(continued)

Table 13.7 (continued)

Variables	Annual growth rate urban population 2000–2015	Annual growth rate urban built-up 2000–2015	Urban density 2015	Urban density change 2000–2015	Urban built-up share 2015	Variation urban built-up share 2000–2015
^a Non-financial wealth per adult—2015	−0.098	−0.231	−0.259	0.087	0.320	0.188
^a Debt per adult 2015	−0.071	−0.189	−0.243	0.092	0.403	0.315
^a Var share of nonfinancial wealth 2010–15	0.089	−0.002	0.099	0.118	−0.067	−0.060
^a Debt to wealth in 2015	−0.128	−0.254	−0.186	0.137	0.211	0.175

The values in bold are different from 0 to a level of meaning $\alpha = 0.05$; *Sources* ^aWealth data Credit Suisse Wealth Report 2016; ^bThe World Bank, ^cOCDE, ^dU.S. Geological Survey, ^eGlobal Data Lab

strongly linked to the weight of the high income and capital in national economies: the weight of the upper middle classes (100,000 to 1 million wealth) and the richest (over 1 million) ($R = 0.537$).

Conversely, the rate of change of built-up imprint is correlated with the weight of the most modest adult populations, below 10,000 USD ($R = 0.402$). It exposes the materiality of a meta-trend of convergence. The least developed countries are experiencing an urban sprawl that corresponds to an expansion of popular housing and thus to an overall improvement in housing conditions. Multi-storey apartment buildings remain often extremely limited accenting the sprawl during the first cycle of land conversion.

The analysis of the same set of correlations between building growth and economic indicators by countries gathered by income groups confirms the contrast between countries whose building expansion is insufficient vis-à-vis the demographic pressure they experiment and advanced and rich countries where building expansion is more and more uncorrelated to the immediate final user demand (inhabitants). In this last, the demand is mediated by complex market rationalities. Land transformation and real estate fuel, both, the physical production of cities and the enlargement of the financial sector.

Lower-income countries (LIC) expose a significant link between the share of debt vis-à-vis the wealth and the built-up growth rate: $R = 0.465$ versus $R = 0.105$ for high-income countries (HIC), but the debt share per adult link to built-up growth is more a characteristic of HIC ($R = 0.308$). It contrasts the limited capital of LIC with HIC. In HIC, credit could expand individual wealth including built capital. In other words, the built-up growth in HIC is more dependent of the debt level.

In lower-income countries, the density in 2015 is inversely correlated to the degree of inequalities ($R = -0.434$) and positively to the weight in the world built-up ($R = 0.449$). Dedensification, notably in larger LIC countries, could have a link with increasing inequalities. The strong correlation between density and the share of adult below 10,000 USD in LIC confirms it ($R = 0.526$). There, physical expansion has to

do with the capture of the urban rent by the upper class. In LIC the growth of GDP per capita is significantly correlated to built-up growth ($R = 0.420$) while it is the opposite for HIC ($R = -0.329$).

We know after Piketty (Alvaredo et al. 2017) in particular for LIC and medium low-income countries including BRICS that the increase of GDP per capita goes with strong upsurge in inequalities. The capture of wealth including urban land and their rent by a very limited and rich minority is at stake. There, wealth grows at the rate of return to capital, a rate that normally exceeds the economic growth rate. The expansion of built-up environment encompasses the current tendency of fast growing economies to have ever-increasing ratios of wealth to income. The shaping of new peripheries involves a permanent reconversion of capital from financial (monetary) to nonfinancial (commodity) assets, and back again. Here we confirm the intuition of a growing disconnection between the production of new urban spaces and the final demand of users, inhabitants, productive activities, services and infrastructures. Nevertheless, in general ($R = 0.498$) it is indeed where the population growth more rapidly that the built-up is expanding faster but it is not meeting straightforward this rising demand.

The multifactorial unsupervised clustering provides a typology of urban growth articulated to the distribution of wealth (Fig. 13.4). Its mapping clearly contrasts advanced and rich economies in majority slowing down in term of population growth as well built-up footprint change (type 3) and developing and poor nations where urban population and built-up rate of growth are the highest (type 5). It consists

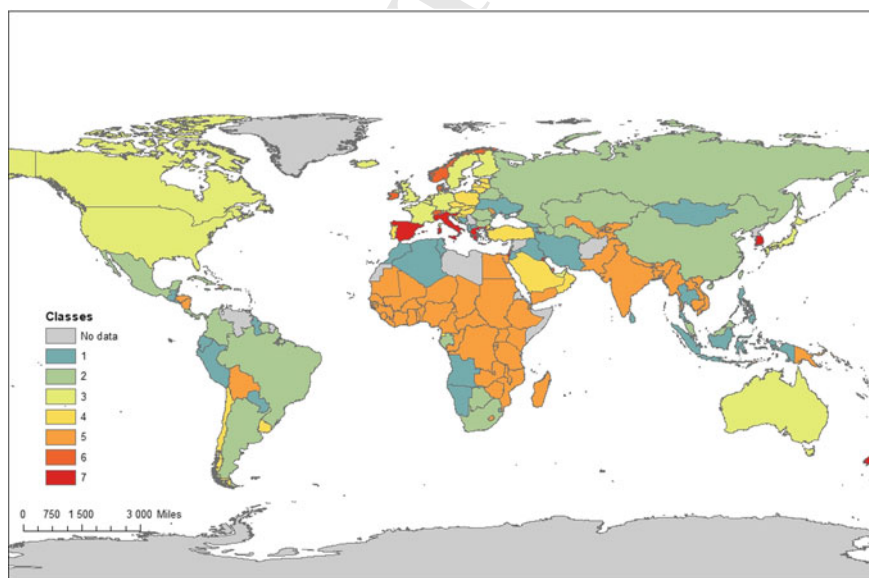


Fig. 13.4 City growth and economic factors: k-means unsupervised clustering

mainly of sub-Saharan and South-Asian countries that are experimenting the fastest expansion of their urban footprint (Table 13.8).

The other classes represent various intensity of built-up growth articulated to GDP per capita and wealth's quartile distribution. The class 1, for instance, gathers transitional countries relatively poor but with a significant middle class and medium-rich. There, the urban population pressure is less intense than in poorest countries (class 5) but built growth is high as well the GDP growth. The class two is more gathering BRICS type of countries.

The typology suggested by this K-Means clustering confirms a trend towards convergence through the catching-up effect of the poorest countries and a slowdown in built-up growth in the richest countries, due to the densification and structural slowdown in economic growth. In the poorest countries, the high intensity of urban built-up expansion reflects both continuing high population pressure and a structural trend towards housing improvement. Built-up intensity of construction is often all the stronger because buildings constitute a safe haven for fixing their economies or accessing mortgage credit. In these often fast-growing economies, the construction and ownership of buildings is also the driving force behind growing inequality.

13.6 Conclusion: The Urban Built-Up Expansion Tends to Diverge from Population Growth

This first exploration of the dynamics of building expansion by country using a harmonised geodatabase for the entire world reveals very contrasting trends. It is clear that population growth in cities remains the most important factor determining urban built-up spread, but countries differ. In particular, China, where urban built-up expansion continues at a sustained pace despite the significant decline in population growth. The extent of built-up growth in and around Chinese cities accounted for a quarter of the world's urban built-up increase between 2000 and 2015.

Americans are the world's second largest contributors to the global urban built-up expansion. It remains disproportionate to the low population growth within urban areas. However, the pace has slowed. The trend would even be towards a re-densification of urban areas and in any case a decline in construction, which must be linked to the 2008 subprime crisis.

Here we understand that the built-up growth is not simply a reflection of the final demand for housing and therefore of demographic pressure or even driven by the nuclearisation of families. Building is a material good whose value is also interdependent with economic growth. The universal relationship between size and density specific to laws of scale is certainly verified once again in the case of cities. However, economic density or concentration of wealth tends to take precedence over population mass to explain urban built-up expansion. As such, soil conversion is increasingly associated with economic trends and wealth distribution. We show here that there is a significant correlation between urban built-up expansion and

Table 13.8 Detailed legend of map 2 classes with value of variables for each class barycentre and weight of classes

Classes	Density	Population	Built-up	GDP Constant	GDP Per Capita 2015	Under 10,000 USD/Y	10,000–100,000	100,000–1 million	Over 1 million	Weight	Intra-class variance
	2015	Annual growth rate 2000–2015				2015 (wealth)					
1	2538	1.26	1.13	4.16	4334	65.2	17.7	9.7	0.9	31	2,024,606
2	2499	1.09	0.95	4.79	8481	66.4	18.7	5.8	0.4	23	3,842,214
3	2003	1.27	0.84	1.82	47,445	61.1	29.4	9.1	0.4	14	24,864,587
4	2263	0.88	0.72	3.54	16,758	67.7	16.5	8.2	1.4	16	10,160,750
5	3303	2.66	2.56	4.97	1188	68.1	19.9	7.9	0.5	56	1,967,539
6	2037	2.90	1.20	3.91	72,370	75.7	3.9	0.3	0.0	5	133,594,953
7	2560	1.31	0.80	2.14	29,999	59.9	26.4	12.9	0.8	8	31,444,633

Intra-class variance: 3.16%; Inter-classes: 96.84%

the weight of the upper middle classes, particularly in South Asia. In intermediate economies, increasing inequalities boosts extremely intense activity of construction. The capture of the global manufacturing activities and many IT services by these countries stimulates also there a gigantic dynamic of plant construction.

This first study remains at the global level of countries and compares them with each other. Further study is needed to examine the extent to which the intensity of urban expansion is correlated with the size of cities. Are the largest metropolitan areas expanding faster? Does the size and shape of city systems influence how and where land is converted to urban use? What is the precise share of the sprawl in the built-up growth?

This should lead us to question how to infer populations with measured built-up physical extension and thus how to generalize urban areas as DEGURBA does—today the DEGURBA urban population is overestimated. Other groupings are possible and likely to bring out more small towns at the expense of the extension of large urban areas as well as the extent of rural areas. In the immediate future, the approach tends to underestimate the emergence from below and thus the weight of rural localities that become small towns (see Russo et al. 2017). Nevertheless, the overall measurement of urban changes remains valid and robust, especially the harmonized built-up detection. The analyses and interpretations that we are receiving undoubtedly open up new avenues for qualifying and understanding, and even predicting, the spread of cities.

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Chapter 13

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Insert in text the matter indicated in the margin	⋏	New matter followed by ⋏ or ⋏ [Ⓢ]
Delete	/ through single character, rule or underline or ⌞ through all characters to be deleted	Ⓞ or Ⓞ [Ⓢ]
Substitute character or substitute part of one or more word(s)	/ through letter or ⌞ through characters	new character / or new characters /
Change to italics	— under matter to be changed	↵
Change to capitals	≡ under matter to be changed	≡
Change to small capitals	≡ under matter to be changed	≡
Change to bold type	~ under matter to be changed	~
Change to bold italic	≈ under matter to be changed	≈
Change to lower case	Encircle matter to be changed	≡
Change italic to upright type	(As above)	⋏
Change bold to non-bold type	(As above)	⋏
Insert 'superior' character	/ through character or ⋏ where required	Y or Y under character e.g. Y or Y
Insert 'inferior' character	(As above)	⋏ over character e.g. ⋏
Insert full stop	(As above)	⊙
Insert comma	(As above)	,
Insert single quotation marks	(As above)	Y or Y and/or Y or Y
Insert double quotation marks	(As above)	Y or Y and/or Y or Y
Insert hyphen	(As above)	⌞
Start new paragraph	⌞	⌞
No new paragraph	⌞	⌞
Transpose	⌞	⌞
Close up	linking ○ characters	○
Insert or substitute space between characters or words	/ through character or ⋏ where required	Y
Reduce space between characters or words		↑