

# A spatially-explicit sensitivity analysis of urban definitions: uncovering implicit assumptions in the Degree of Urbanisation

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**63th Congress – ERSA 2024**

*Special Session 6: A New Toolbox for Novel Research in Regional,  
Urban and Spatial Studies*

## **Introduction**

In recent years, there has been a renewed interest in defining cities and classifying locations into urban categories. However, there is no broadly shared agreement on how to define a city, neither in terms of methods nor in terms of thresholds to be used in these definitions, as it is challenging to develop conceptual justifications with universal validity (Cohen, 2004; Duranton, 2021). As a result, thresholds and other related criterion choices – such as how to operationalise spatial contiguity or how to cope with the presence of water bodies in urban areas – are at the root of considerable variability that is unaccounted for in the resultant urban delineations. This can have profound implications: different delineation approaches lead to varying numbers of cities and variable city boundaries, which in turn affect the quantitative analysis of issues as varied as economic development (Bosker et al., 2021; Wineman et al., 2020) and urban heat island effects (Yang et al., 2023). Variability in urban definitions also influences policies targeting ‘urban’ areas, as underestimating their presence or size may limit financial aid and political attention (Onda et al., 2019; Wineman et al., 2020).

More fundamentally, deciding on delineation criteria inevitably involves making explicit and implicit assumptions about the fundamental nature of ‘the urban’. These assumptions may – unwittingly – reproduce urban realities experienced and observed by those expressing them, potentially leading to spatially unequally distributed implications. For example, Statham et al. (2021) found that low-income countries are more sensitive to specific criteria in a delineation algorithm than high-income countries. This might point to implicit partiality towards urban patterns that are abundant in certain high-income countries, and gives rise to the question of whether consistent delineations are equally ‘fit’ to capture different types of urbanisation worldwide (Potts, 2018). It is key to understand how specific criterion choices shape our understanding of ‘the urban’ and assess how, why and – especially – *where* a definition leads to specific sensitivities. However, conventional sensitivity analyses typically lack insight into this spatial dimension; into which specific locations are most affected by variation in delineation criteria. There is a need for new methodological approaches to quantify sensitivities tied to urban delineations in a spatially-explicit manner, not just at the regional or country level, but at finer spatial granularities.

## **Methodological approach**

Against this backdrop, we introduce a methodological framework to conduct a spatially-explicit sensitivity analysis that quantifies the sensitivity of a location’s ‘urban’ classification across various

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criterion settings. Our methodological framework is *spatially explicit* in the sense that it does not rely on aggregate statistics such as the urban population or number of cities per country or region, but instead focuses on the sensitivity of the classification of *individual* spatial units at the finest possible resolution (e.g., grid cells or statistical units). It consists of three consecutive steps (see Figure 1). The first step involves the identification of all criteria that may induce variability in a specific urban definition. Next, a set of alternative realisations of the definition is constructed by simultaneously varying the values of these criteria. Finally, the sensitivity of each spatial unit is quantified based on the dispersion in the classification across the set of alternative realisations. Many urban delineations result in an ordinal outcome (e.g. city, town, rural area). A potential measure of dispersion of ordered categorical data is the inverse of the metric proposed by Blair & Lacy (2000).

The final output is a map with a sensitivity index calculated for each spatial unit. This map serves as a starting point for an in-depth examination and guides researchers to potentially interesting regions. By zooming in on these regions and reviewing a selection of alternative realisations, researchers can assess the link between the sensitivity and the underlying urbanisation pattern. In that way, they can gather a deeper understanding of the implications of certain criterion choices for specific types of urbanisation, and potentially uncover implicit assumptions tied to a delineation approach.

As an empirical example, we apply the framework to the definition of the Degree of Urbanisation (DEGURBA), proposed by Dijkstra et al. (2021). DEGURBA identifies cities, towns, and rural areas by clustering contiguous grid cells that meet a minimum population density, and collectively contain a minimum number of inhabitants. The definition was initially developed for urban settlements in the European Union, but was later applied to the rest of the world (Dorward et al., 2023). Since then, it is widely used in academic circles, policy reports, and analyses of Sustainable Development Goals. A handful of previous studies conducted sensitivity analyses of DEGURBA (Bosker et al., 2021; Dijkstra et al., 2021; Dorward et al., 2023). By applying our spatially-explicit sensitivity framework to DEGURBA, we expand on these existing analyses in three main ways. First, we explicitly focus on the sensitivity of spatial units at the finest spatial granularity – 1 km<sup>2</sup> grid cells – instead of relying on aggregate statistics per country or region. Second, our approach goes beyond the ‘obvious’ population density and size threshold criteria. We consider all implementation rules that may induce variability in the resulting delineations, including technical specifications in DEGURBA such as contiguity rules<sup>§</sup> and an additional built-up density threshold. Although these criteria may seem less relevant at first glance, they can have spatially unequally distributed implications that embody regional skewness in the definition. Third, our framework facilitates adopting a critical perspective on DEGURBA. Because the definition was initially calibrated on European settlements (Dorward et al., 2023), it cannot be ruled out that, say, a Eurocentric bias is inserted – even unwittingly. Our analysis of the impact of criteria tweaks in DEGURBA may help grasp whether and how the urban definitions are shaped by or reflect

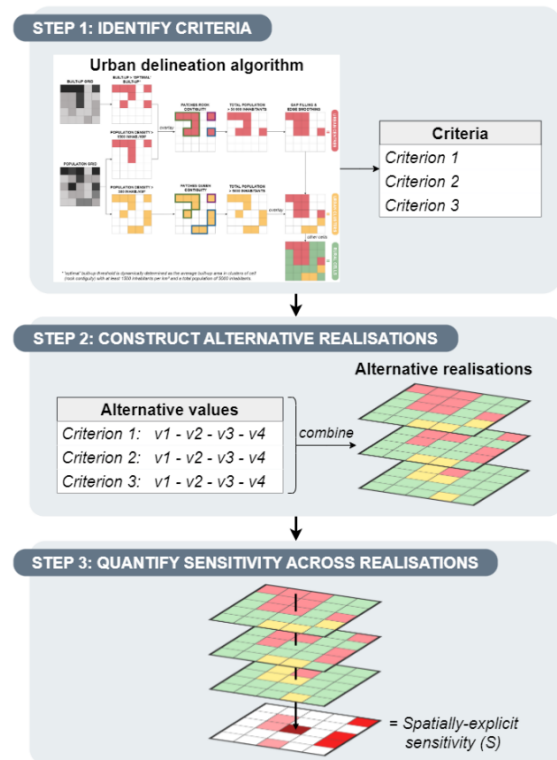


Figure 1: Schematic representation of methodological framework for a spatially-explicit sensitivity analysis

<sup>§</sup> The contiguity rule determines when two cells are ‘contiguous’. Queen’s contiguity identifies two cells as contiguous if they share a corner. With rook’s contiguity two cells are only considered contiguous if they share an edge.

policy frameworks and implicit theoretical biases.

### **Results and discussion**

Our results demonstrate that different regions in the world are in fact sensitive to small variations in criterion settings of DEGURBA, but interestingly, the distribution of the sensitivity is not equally distributed across the world. Certain regions and specific types of urbanisation exhibit higher sensitivity than others, pointing to potential skewness in the urban delineations of DEGURBA. For example, we found that changing a contiguity rule in DEGURBA disproportionately affects certain regions, specifically large delta regions, including the Ganges River Delta, Nile Delta, and Red River Delta. However, in other parts of the world – including Europe – the effect of changing the contiguity rule is rather limited. The developers of DEGURBA might not have been aware of the implications of this technical implementation criterion, precisely because the definition was developed in the European context where the choice of contiguity is less impactful. This, in a way, demonstrates that knowledge production about ‘the urban’ reflects and is shaped by specific urban realities.

The results also reveal that cities in North America are disproportionately influenced by changing an additional built-up density threshold in DEGURBA. According to DEGURBA’s documentation, the built-up threshold is introduced to reduce fragmentation and avoid generating multiple urban centres for a single ‘city’. The rule is established explicitly for “a few countries with relatively low-density urban development and a strong separation of land use functions” (European Commission, 2023, p. 51, footnote 30). It thus appears that DEGURBA incorporates the specific urbanisation pattern that is abundant in North American cities, as the definition contains a specific rule to ‘better’ delineate these types of urban agglomerations. However, no such targeted rules exist in other world-regions. This might point to an implicit bias of DEGURBA towards North American urbanisation patterns.

Our main point is not to criticise the definition of DEGURBA. Instead, DEGURBA serves as an example to illustrate that, because there is no generally accepted ‘true’ definition of urbanisation, every urban definition *inevitably* requires making specific assumptions about the outlook of ‘the urban’. Given the challenging task of developing globally consistent urban delineations, the DEGURBA method, in fact, is well-conceived and contributes significantly to the field of urban studies. Nevertheless, it is crucial to be aware of unequally distributed sensitivities when employing the specific definition. Our proposed methodological framework facilitates making the implications of sensitivities legible in a spatially-explicit manner.

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