Title: Building Volume per Capita (BVPC) – a simple metric for understanding crowding and housing inequity in cities

U20 2025 Theme: Digital Transformation and Innovation

Technologies and innovations arising from the Fourth Industrial Revolution (4IR) have given city managers and planners a new set of tools to improve governance and service delivery in cities around the world. Such innovations include the incorporation of Artificial Intelligence (AI), Internet of Things (IoT), smart automation and cloud computing and processing in the everyday lives of citizens as well as within the urban governance structures running the cities. Complex machine learning predictive modelling and the assimilation of a variety of formats of 'big data' can aid the management of a city at a highly granular level but simpler applications utilising novel datasets can also reveal trends across large city regions such as the Gauteng province in South Africa.

The housing landscape in Gauteng (and South Africa) has been inextricably moulded by historic injustices such as apartheid (1948-1994) and by the current inadequate responses towards addressing these injustices. Compositionally, housing in Gauteng comprises of formal types such as stand-alone houses, apartments, duplexes and security estates and informal types such as informal settlements, townships and backyard shack dwellings, which either occur in designated areas or are intertwined in a heterogeneous mixture across the rural-urban divide. Given the fact that demand for housing has long outstripped supply, governing structures need to understand the current state of crowding within the province, with the most vulnerable in mind. This U20 contribution describes how the leveraging of a simple metric, Building Volume per Capita (BVPC), derived from Earth Observation and population data, can be used to understand crowding within the formal and informal housing sectors of a heterogeneous urban conurbation. The focus of this article revolves around the Gauteng province of South Africa, one of the most densely populated and largest contributor to the country's overall economy. The article encompasses the findings from the Naidoo et al. (2025) academic article published in SAGE's Environment and Planning B: Urban Analytics and City Science.

Methodologically, the BVPC metric was calculated by simply dividing a building volume (m^3) dataset by a population count dataset to derive the amount of volume available per citizen across Gauteng. For building volume, a detailed 90m resolution dataset derived from the German Aerospace Center's World Settlement Footprint 3D (WSF3D; Esch et al., 2022) was used for the numerator, while a proprietary population count hexagonal (400m sided) GIS dataset, obtained from GeoTerraImage (GTI), was used as the denominator. This BVPC metric was mapped over the province of Gauteng, whilst being limited to residential land use classes, and intersected with building height, building count, building type and population income classes. In addition, using the South African housing codes and standards of what is regulated as an adequate housing height, area and the statistical number of occupants, the metric was used to ascertain the percentage of households across Gauteng, which were deemed inadequate given the level of crowding and available living space.

The results of the article found that the derived BVPC map illustrated that overcrowding is concentrated in parts of the province. BVPC is lowest in established Central Business Districts (e.g.

Johannesburg), apartheid-era townships (e.g. Soweto), post-apartheid housing projects and informal settlements. On the other hand, higher BVPC values were found in higher-income areas such as newer CBDs (e.g. Midrand) and affluent suburbs (e.g. Sandton). Compositionally, overcrowding was more likely for particular housing types, specifically shacks in informal settlements and backyard dwellings. Some formal housing also experienced overcrowding due to the intensive use of formal apartheid-era housing, formal welfare housing provided by the post-apartheid state and high-rise apartments occupied by lower-income groups. Overcrowding can also be found in multi-storey residential buildings, but since most residents of the province live in single-storey buildings, overcrowding is concentrated horizontally rather than vertically across the Gauteng urban landscape. Overcrowding was also found to be the burden of low-income classes, as 59% of Gauteng's total number of households, who earn less than R64,620 ($3925) a year, live in only 13% of Gauteng's total BVPC. Based on the South African housing codes and standards (see the article for exact measures of adequate housing), 51% of residential areas within Gauteng were deemed to be inadequate in terms of adequate liveable space. When benchmarked against other US cities, such as California and Baltimore, it was found that Gauteng has much lower BVPC ranges comparatively. In conclusion, this article outlines the usefulness of integrating novel Earth Observation and demographic datasets to produce a rapid and independent measure of housing inequality for urban planners and governing bodies to leverage for much-needed action. This was also the first study to implement this metric in a city-region in the Global South.

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