



## Research Paper

## Effects of spatial scale on assessment of spatial equity of urban park provision



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## HIGHLIGHTS

- Spatial scale has large impact on park provision and equity assessment.
- Park provision indicators are prone to skewed distributions.
- Skewness increases with smaller spatial scale.
- Unequal distribution of parks according to wealth and income was observed.
- Park planning needs to focus on smaller spatial scale.

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## ABSTRACT

Urban parks are widely-recognized to provide multiple social and ecological benefits, but an increasingly number of studies show that such benefits are often inequitably distributed across socio-economic and ethnic groups. This has led to a growing interest in assessing the spatial distribution and access to parks and other green spaces as an aspect of environmental justice. Even though such spatial studies require assessment at multiple scales, how results may be influenced by scale has not received adequate attention. This study assessed the effects of scale on park provision and spatial equity in Singapore. A range of park provision indicators were used to evaluate how they are affected by scale and to explore their correlations with wealth, income and ethnicity. Scale effects were assessed using planning units adopted for national land use planning, namely, region, planning area and subzone. Scale significantly affected park provision indicators, particularly for indicators that incorporate population. Correlations at larger scale tend to be stronger than at smaller scales. There were higher park provision and lower potential for park congestion in planning units with higher wealth and income. Inequity also appears stronger when studied at smaller spatial scales. Results also showed that park provision indicators are prone to skewed frequency distributions, especially at smaller scales. The implications of the results were discussed in relation to spatial equity assessment and possible causes of the disparities. We also highlight the need to direct park planning at smaller scale of neighbourhoods rather than at the town or regions levels.

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## 1. Introduction

A high degree of social stratification is a defining feature of many cities (Boone, 2013). This characteristic can also manifest as inequality among social groups which has existed long over the development of human settlements (Pringle, 2014). Of particular interest to urban planners and designers is that social stratification of cities also has strong spatial associations. These can be observed

as environmental disparities arising from uneven geographic clustering of socio-economic groups in the city. For instance, over the past three decades, scholars have studied these disparities under the rubrics of “environmental justice” and “spatial equity” (Lucy, 1981; Schlosberg, 2013; Truelove, 1993), focusing initially on the association of race and income to disproportionate exposure to environmental disamenities, and in more recent years, expanding the focus to unequal access to environmental amenities such as transportation, green spaces, and other recreational facilities, etc. (Schlosberg, 2013). In this paper, we focus on the distributional pattern of public parks in Singapore as one type of environmental amenities to understand its association with wealth, income and ethnicity arising from its distribution in the city-state.

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The focus of parks in spatial equity studies has emerged strongly over the last two decades, as seen in the number of published papers on this issue in different regions of the world (see [Appendix A](#)). These studies point to varying degrees of correlations between accessibility to parks with socio-economic status and ethnicity. The attention on parks as a public good is not surprising, given that parks and other forms of urban green spaces are widely recognized to be important elements of cities that can provide multiple benefits for urban living ([Jennings, Larson, & Yun, 2016](#); [Wolch, Byrne, & Newell, 2014](#)). Accessibility to parks and green open spaces for instance, can be associated with physical activity level, and in turn influences individual health and well-being ([Coombes, Jones, & Hillsdon, 2010](#)). Parks also foster community network and social capital ([Baur & Tynon, 2010](#)), generate economic value for communities and cities ([Boone, Buckley, Grove, & Sister, 2009](#); [Crompton, 2007](#)) and moderate the urban climate ([Chen & Wong, 2006](#)).

However, there are still inconsistencies and uncertainties in how geographic access to such benefits are correlated to race and socio-economic status (SES) (used here to refer to the combined effects of wealth, income, education, and occupation on social standing), which weakens the evidence base for effective policy interventions to address equity issues. For instance, [Sister et al. \(2010\)](#) highlighted examples of inconsistencies in the results of various studies, and suggested that these inconsistencies could be attributed to several methodological differences and limitations. These include the inability of areal unit to represent service area of an amenity, aggregation errors arising from the modifiable areal unit problem (MAUP), and limitations arising from choice of distance measurements.

MAUP refers to how the choice of spatial scale (i.e., areal sizes of unit of study) used for analysis affects the strength of statistical associations between variables in a study ([Cutter, Holm, & Clark, 1996](#); [Openshaw, 1983](#)), which thereby influences the inferences drawn from the study, and those made between studies. MAUP is also concerned with “zoning effect”, in which alternative ways of aggregation of smaller units lead to variations in results ([Dark & Bram, 2007](#)). In spatial equity studies of parks and green spaces that we reviewed ([Appendix A](#)), MAUP was seldom addressed as an objective and its assessment was seldom incorporated as a methodological step. Of the 20 studies we reviewed, only two studies ([Boone et al., 2009](#); [Zhang, Lu, & Holt, 2011](#)) explicitly examined the effects of geographic scale on the assessment of equity. Comparability of studies is also made more complicated by the fact that there are large differences between studies in the geographical sizes and the populations represented within these spatial units used for analysis. For instance, studies in the US generally used census blocks, census block groups and sometimes census tracts (see [Abercrombie et al., 2008](#); [Nicholls, 2001](#); [Wolch, Wilson, & Fehrenbach, 2005](#)), whereas studies elsewhere used a range of administrative or planning boundaries. Populations represented within census block groups and census tracts range from 600 to 3000, and 1500 to 8000 people, respectively, and areal size of census blocks and tracts are also highly variable (<http://www.census.gov>). In contrast, studies in the United Kingdom tend to use “census output areas” ([Barbosa et al., 2007](#); [Comber, Brunson, & Green, 2008](#)) which have populations of around 300 (<http://www.ons.gov.uk/>). In the studies by [Oh & Jeong \(2007\)](#), “regions” in Seoul were used for comparison, and these have populations between 0.57 million and 3.4 million, and sizes between 56 sq km and 171 sq km. A similar study by [Park et al. \(2013\)](#) for Seoul used “boroughs”, which seemed to be of different administrative classification and size compared to “regions”. In Australia, [Shanahan et al. \(2014\)](#) studied access to green spaces in Brisbane using  $1 \times 1$  sq km grid, whereas [Timperio, Ball, Salmon, Roberts, & Crawford, 2007](#) studied Melbourne using postal districts which are between 5.5 to 29.7 sq km in area.

Scale effects on spatial equity assessment of parks within a city are thus not well-understood, and how they affect comparability of, and the ability to draw generalizations across studies are also unclear. Scale influences on spatial studies is in fact an already well-recognized phenomenon in spatial studies. For instance, MAUP was already described in the 1930s and has since then been recognized as an important issue in quantitative analyses in studies on human and physical geography ([Dark & Bram, 2007](#); [Zhang, Lin, Chen, Li, & Zeng, 2014](#)). In landscape ecology, scale has also emerged in more recent years as an important consideration for assessment of landscape heterogeneity on landscape processes and functions ([Jelinski & Wu, 1996](#); [Wu, 2004](#)). In spatial equity studies, [Bowen & Laroe \(2006\)](#) showed that the choice of spatial unit of analysis between census tract and county can lead to markedly contrasting correlations between toxic releases of chemicals and socioeconomic variables. For equity assessment of parks, [Boone \(2013\)](#) showed that results differ between analysis at the scale of City of Baltimore compared to Metropolitan Baltimore, and the authors concluded that scale effects need to be considered in spatial equity research. [Fotheringham & Wong \(1991\)](#) and [Wong \(2004\)](#) also suggested that studies should report results from use of different areal units to understand their effects on statistical analyses.

In this study, we examined the effects of scale on the assessment of park distribution and spatial equity of parks in the city-state of Singapore. As equity is a term that embeds several related concepts, such as distribution of a service in relation to equality of provision, as well as the need, demand and willingness to pay for a service ([Lucy, 1981](#)), its use in this paper has to be defined. We refer to spatial equity of parks in this study as the equality of opportunity to access to parks and benefit from its usage independent of socio-economic status and locality of residence. The focus on Singapore is motivated by several reasons. Firstly, Singapore as with many rapidly developing countries, has a recognized rising income inequality challenge to manage ([Tan, 2012](#)), but whether inequity issues also manifest spatially with respect to access to parks and other key urban amenities has yet to be widely understood. This might be expected as income disparities tend to be also associated with spatial segregation in housing and neighbourhood environmental quality ([Reardon & Bischoff, 2011](#)).

Secondly, Singapore has specific policies that tend to attenuate spatial disparities across ethnicity and income. For instance, one initiative is to simply provide more parks through land use planning. Over the last four to five decades, Singapore has placed considerable emphasis in the provision of parks and green spaces as part of its overall development approach ([Neo, Gwee, & Mak, 2012](#); [Tan, Wang, & Sia, 2013](#)). It is well-regarded as a city with a successful urban planning history ([Goldblum, 2008](#); [Yuen, 2011](#)), made possible by a strong land use framework which also considers the provision of parks and green spaces. The emphasis on park provision is reflected in the progressive increase in park provision ratio (PPR, the ratio of park area to population) as a national land use planning parameter used by the national land use planning authority. PPR has increased from 0.13 ha/1000 person in 1971, to 0.36 ha/1000 in 1977 and to the current 0.8 ha/1000 in 1989 ([Tan, 2016](#)). In addition, Singapore has a long-standing policy of preventing racial enclaves from forming in residential areas as a strategy to promote racial harmony and integration and Singapore’s multi-cultural identity ([Chua, 2003](#)). Through the “Ethnic Integration Policy” introduced in 1989 ([Chua, 1991](#); [Tan, 2005](#)), a racial mix quota in public housing estates is maintained to prevent any ethnic group from dominating the population of residential estates when compared to the overall ethnic composition in Singapore. This ensures a more homogeneous spread of the ethnic groups in public housing estates, which currently house 80% (<http://www.singstat.gov.sg/statistics/latest-data>) of the total population. If ethnic groups are spatially dispersed, this should logically reduce

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