Poverty and environmental justice: a GIS analysis of urban greenspace accessibility for different economic groups

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ABSTRACT

Access to greenspace in urban areas is important because of the contributing role of the areas in the quality of life and improving human health and wellbeing. This paper describes GIS-based network analysis of greenspace accessibility for different economic groups. Mosaic plots used to illustrate how access to green space varies across different sectors of society. The results show 85% of Leicester population fail to meet the recommendation that people should live no further than 300m from their nearest green space. The results also reveal that the most deprived groups have significantly "more access" to greenspace than expected. Whilst the other derived groups (average and least deprived) have "less access" than would expected under an assumption of equal physical accessibility. Further work will develop an integrative methodology combining qualitative information on perceptions of accessibility with physical measures of actual access.

Keywords: Accessibility, Greenspace, Deprivation

1- INTRODUCTION

The provision of access to urban greenspace is important for a number of reasons including: social interaction; physical benefits especially for children; psychological benefits and environmental services. A growing body of literature demonstrates that direct or indirect exposure to urban greenspace can make positive contributions to public health, wellbeing and quality of life (Pinder et al. 2009; Santos et al. 2009; Mitchell and Popham, 2008). "The Sixth Environment Action Programme (EAP) of the European Community 2002 – 2012, specifically addresses the importance of public greenspace for an improved quality of life as one of its four priority areas.

Urban Greenspace and Provided Accessibility

Under notions of environmental justice and social justice, equitable provision of and access to community goods and services are important. Other work considering greenspace noted that people who live in close proximity to greenspace have more chance to use areas frequently (Hoehner et al. 2005; Tyrväinen et al. 2004; Van Herzele and Wiedemann, 2003). In such studies accessibility refers to the distance or walking time from a resident's home to an urban greenspace with attention to the safety of pathway. Other studies however, address accessibility as the way people use and experience greenspace and called it people attitude toward greenspace (De Ridder, et al. 2004; Balram and Dragicevic, 2005; Ozguner and Kendle, 2006).

Studies of greenspace, consider the equality of spatial distribution of greenspace amongst minority and low-income population. Recently, using Geographical Information Systems (GIS) is used to explore the social and environmental justice aspects in relation to urban greenspace access. For example, Kessel et al. (2009) used GIS to characterise access to greenspace in distance terms, and how such access has changed between 1990 and 2003 based on people socio-economic status. Work by Comber et al. (2008) used network distances to analyse greenspace accessibility for different ethnic and religious groups. Barbosa et al. (2007) measured accessibility to public greenspace to

households in Sheffield, and examined how this varies across different sectors of society. Heynen et al. (2006) analysed the spatial distribution of urban greenspace against income. Omer and Or (2004) used "coverage approach" to examine the differential access to urban greenspace among Arab and Jewish population in two mixed Israeli cities. Neuvonen et al. (2007) studied the relationship between access to greenspace and the frequency of visits in Helsinki. Oh and Jeong (2007) used the network analysis method of GIS, to analyse pedestrian accessibility to urban parks in Seoul and the subsequent serviceability of the parks. This paper aims to develop earlier work by Comber et al (2008) and seeks to determine how greenspace access varies with economic deprivation.

2- METHOD

Study area

The city of Leicester with total population of 280,000 is the most populous city in the East Midlands and the 10th largest in England. The total area of the city (18,060 acres), supporting almost 10% (2,000 acres) parks and open spaces, 6% (1100 acres) nature reserves and approximately 27% (4500 acres) as gardens.

Definition

In this study urban greenspace, accessibility and people socio-economic status are defined as bellow:

"Urban greenspace": publicly owned and publicly accessible open space in urban context where are covered by high degree of vegetation, e.g. urban parks, woodlands, spinney, meadows and other type of greenspace.

"Accessibility": physical distance or walking time from a residential home to an urban greenspace.

"Socio-economic status": is addressed according to the deprivation. Deprivation is a measure of poverty based on a number of criteria such as economic circumstances, health, crime, housing, educational achievement, skills and the environment. This study uses Townsend Index devised by Townsend et al. (1988) to quantify deprivation relating to public census data (i.e. unemployment, overcrowding, non car ownership, and non home ownership).

Data collection and Quantitative Method (Physical access)

The greenspace data of Leicester was provided by Leicester City Council. The output areas polygons (OAs) data and road network data, was extracted from UKBOURDERS and Ordnance Survey Meridian 2 (1:50,000), Edina. Census data for each OAs was obtained for the 2001 census from CASWEB service. Townsend Index was calculated according to unemployment, overcrowding, non car ownership, and non home ownership. The spatial distribution of deprivation was identified according to the 5 % threshold from the top and bottom levels of Townsend Index values.

Physical access was analysed in terms of shortest distance line from each residential output areas to the nearest greenspace access point in the urban context. The underlying premise was that shorter distances are associated with greater and more frequently use of the areas (Hoehner et al., 2005; Tyrväinen et al., 2004; Van Herzele and Wiedemann 2003). Accordingly, the closest facility option in network analysis extension was applied to quantify different physical access points within 5 minutes (equal to the 300 metres), between 5 and 10 minutes (almost equal to the 1000 meters) and more than 15 minutes (distance more than 1000 meters).

With refer to the specified access criteria, Figure 1a shows the physical pattern of access to greenspace in Leicester categorising into "least access", "average" and "most access". The grey colour lines on the map show the boundary areas of each OAs. To show the spatial distribution of deprivation, the attribute table of Townsend Index values was joined to the attributes table of output areas polygons. Figure 1b shows distribution of deprivation in Leicester according to "5% least" and "5% most" values of Townsend Index. Rating colours from yellow to dark brown shows the characteristic of each OAs relating to the spatial deprivation as "least deprived", "average" and "most deprived".

3- RESULTS

Initial result:

Figure 1 shows the provision of accessibility according to the stated criteria. Leicester population is approximately 280,000 and its greenspace supports 640ha including public urban parks and local natural reserves. This produces a figure of 2.3 ha per 1000 population. Initial results show that only 15% of the population are within 300m of a greenspace area, whilst 40% are between 300and 1000m and 45% live more than 1000m from their nearest green areas.

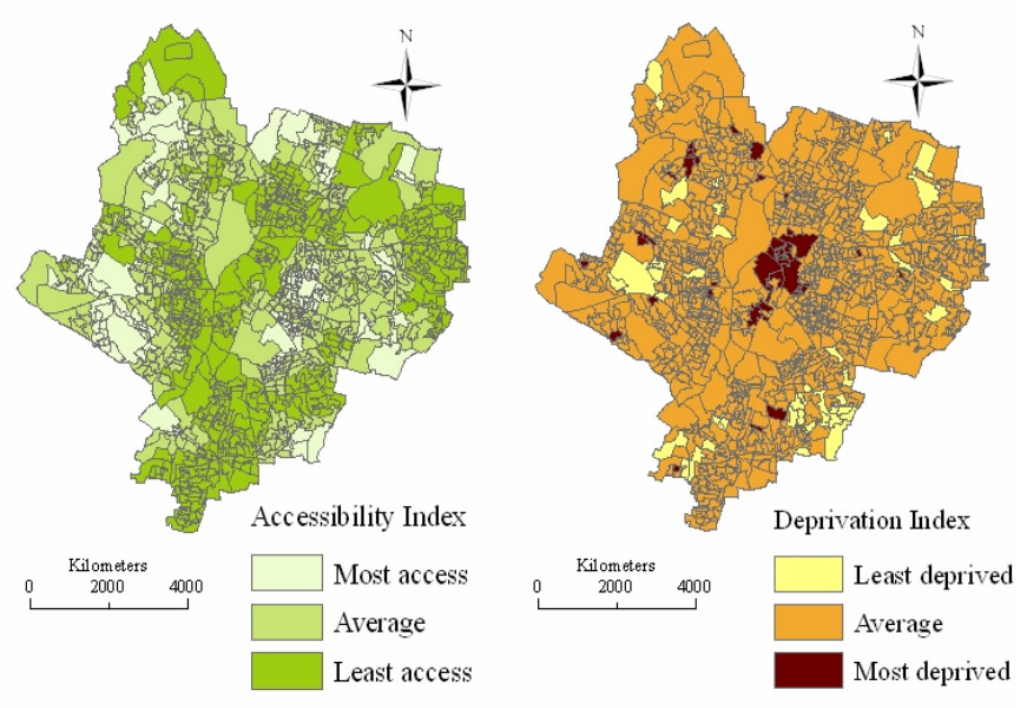

Figure 1: The spatial distribution of a) access to urban greenspace in Leicester and b) the most (top 5%) and least (bottom 5%) deprived

Main results: Analysis by deprivation

On the base of total population, the results of overlaying accessibility against deprivation characterise Leicester's OAs into one of the nine following categories (Table 1).

Table 1 Provision of physical access against deprivation in Leicester (Sotoudehnia, 2010)

Deprivation	Most access	Average	Least access	Total Grand
Least deprived	2635	40821	988	44444
Average	6586	99855	4147	110588
Most deprived	5175	113103	6611	124889
Total	14396	253779	11746	279921

The Mosaic plots method – first proposed by Hartigan and Kleiner (1981) and extended later on by Friendly (1994) – was used to assess the relative equity of physical access to greenspace amongst different social groups. The deprivation scores were used to determine the set of "5% most deprived" and "5% least deprived". The numbers of people with and without access greenspace (i.e. <300m) in each census output area were summed for the different deprived groups. Figure 3 visualises the results of mosaic plot.

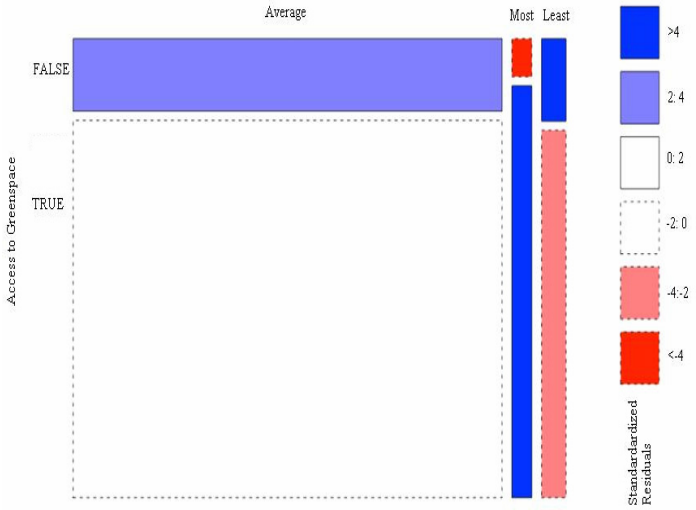

Figure 2**:** The Mosaic plot of access to greenspace by deprivation

The blue tiles show combinations of access and deprivation that are higher than average. The tiles shaded deep blue correspond combinations of access and deprivation whose residuals are greater than +4, when compared to a model of proportional equal levels of access for all deprived groups. This indicates a much greater frequency in those cells than would be found if this model were true. The tiles shaded deep red correspond to the residuals less than -4 indicating much lower frequencies than would be expected.

The most deprived group has significantly more greenspace access than expected and other derived groups (average and least deprived) have less access than would expected under an assumption of equal access. Generalised linear models were used to estimate likelihood of access as a function of deprivation. A table of counts was drawn up where the rows designated whether individuals had access to green space (i.e. within 300m) and the columns designated the deprivation. The count in column i and row j is denoted by cij. To test whether there is an association between the row and column effects, the Poisson regression model was applied:

$$E(cij) = \text{Log}(r + Ai + Fj) \qquad \text{Equation (1)}$$

Where cij has a Poisson distribution, r is an intercept term, Ai is a column effect and Fj is a row effect, is compared against the model:

$$E(cij) = \text{Log}(r + Ai + Fj + Iij) \qquad \text{Equation (2)}$$

where the extra term Iij is an interaction effect between rows and columns. If this is significantly different from zero, this suggests some degree of association between the row and column effects. In this study, it may be used to test for association between deprivation and access to green space. The counts as described above were cross-tabulated for the different deprived classes (Table 2).

Table 2:The number of people of diffrent social groups with and without access to greenspace

Access	Average	Most Deprived	Least Deprived
False	40821	988	2635
True	212958	10758	11761

Values of Iij were estimated by fitting Equation 2 to the data for deprivation using the R statistical software package. These coefficients were related to a comparative index of access for each of the row categories, using the formula:

$$\text{Access} = 100(\exp(Iij) - 1) \qquad \text{Equation (3)}$$

Due to the way the interaction terms are calibrated, this quantity compares each column category j against a 'reference' category. A value of 0 suggests the likelihood of access for category j is the same as for the reference category. A value of +50 for category j suggests access is one-and-a-half times as likely as the reference category, a value of -50 that it is half as likely, and so on. The reference categories for deprivation were the middle 50% of the deprived scores. For each of the coefficients, the access was calculated. The results are shown in Table 3.

Table 3: Percentage access to greenspace of different social groups

Deprivation	Access
Most 5%	+8.7%
Least 5%	-14.4%

* when compared to the Average deprived group

The results in that the more deprived (5%) parts of Leicester there is significantly more access to greenspace than 90% of the city and that the more affluent areas (5%) have less levels of greenspace access.

4- DISCUSSION and CONCLUSION

This study analysed physical access to urban greenspace against national access guidelines, which recommend no person should live further than 300m from a greenspace. "Network analysis" used as an equipped and powerful analytical tool to quantify physical accessibility. The Mosaic plot approach employed to visualise the provision of physical access to greenspace across different social groups.

In the light of the study's objective – quantifying accessibility against public socio-economic status relative to social and environmental justice – the results discolour the assumption of social justice in provision of and access to greenspace in Leicester. The results indicate the converse influence of deprivation on physical access by exploring that, in Leicester, people from the most deprived areas has significantly more accessibility to greenspace than expected and other derived groups (average and least deprived) have less access than would expected under an assumption of equal access. These results support the previous findings of Kessel, et al. (2009) indicated people from more deprived areas have better access to Thames Chase Community Forest (TCAF). In contrast to these findings, Omer and Or (2005), addressed people from more affluent areas have greater access to greenspace in Israeli cities (Omer and Or 2005).

Although this study determined accessibility by physical proximity, parameters such as size and people's experience of attractiveness and appropriateness of greenspace are likely to be important whilst as yet has received relatively little attention (Balram and Dragicevic, 2005; Dwyer and Childs, 2004). This raises the necessity of conducting further work in this area to study the influence of deprivation on the way greenspace use and perceived by public in the city of Leicester. Such integrated analyses are particularly important to planning process and to support social and environmental justice objectives.

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