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Research Paper

Access to urban green space and environmental inequalities in Germany

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ABSTRACT

Although sufficient and equitable access to urban green represents a key aspect for adequate living conditions and a healthy environment in urban areas, national studies investigating the provision of urban green on household and individual level are scarce. We present a study investigating access to urban green space and environmental inequalities in German major cities by merging geo-coded household data from the German Socio-Economic Panel (GSOEP) and Census Population Data with land use data from the European Urban Atlas (EUA). The results indicate that 92.8% of the German population has access to green space within a 500 m around the place of residence. On average an individual in German major cities lives in a distance of 183 m to the nearest green space and has access to 4.4 ha urban green within a 500 m buffer and the average green space provision per capita amounts to 8.1 m^2. We also identify strong disparities in green space provision on city level ranging from 2.5 m^2 per capita (city of Schwerin) to 36.3 m^2 (city of Bergisch Gladbach) within 500 m buffer around the place of residence. We further identify inequalities in green space provision across German major cities by applying the Gini coefficient. Statistical analysis of the socio-economic background of households and individuals shows differences in urban green provision related to income, age, education and children in household. The findings provide helpful information for policy and planning to ensure an adequate green space provision and to eliminate environmental inequalities in Germany.

1. Introduction

Sufficient access to urban green represents a key aspect for adequate living conditions and a healthy environment in urban areas. Previous studies suggest that urban green contributes to climate regulation by improving air quality (Kroeger et al., 2014; Nowak, Crane, & Stevens, 2006) and heat stress reduction (Bowler, Buyung-Ali, Knight, & Pullin, 2010; Middel, Chhetri, & Quay, 2015). Moreover, a large body of literature highlights the positive effects of urban green for mental and physical health (Maas, Verheij, Groenewegen, de Vries, & Spreeuwenberg, 2006; Mitchell and Popham, 2007; Ulrich et al., 1991) as well as residential well-being (Krekel, Kolbe, & Wüstemann, 2016; White, Alcock, Wheeler, & Depledge, 2013). Urban green have been found to improve social well-being by raising social interaction and integration (Coley, Kuo, & Sullivan, 1997; Kweon, Sullivan, & Wiley, 1998; Peschardt, Schipperijn, & Stigsdotte, 2012). Interestingly enough, the literature provides evidence that the effects of exposure to urban green can differ across particular population groups (Krekel et al., 2016) and that greener environments can contribute to reduce socio-economic health inequalities (Mitchell and Popham, 2008). The provision of urban green is therefore increasingly recognized as an environmental justice issue (Wolch, Byrne, & Newell, 2014).

The relevance of urban green for human well-being and sustainable development of urban areas has led to the development of targets and thresholds for urban green provision at European, national and subnational levels. The European Environment Agency (EEA) mentions that people should have access to urban green within 15 min walking distance, which is approximately 900–1000 m (Stanners and Bourdeau, 1995). The Netherlands set the target of a minimum green provision of 60 m^2 per-capita within a 500 m radius around households (Roo, 2011) while in the UK urban dwellers should have access to 2 ha of urban green within a 300 m distance to the place of residence (Handley et al., 2003). The National Strategy on Biological Diversity in Germany (BMUB, 2007) sets the target that every household in Germany should have access to urban green within a walking distance without clearly defining the term “walking distance”. So far, neither a clear indicator nor a regular monitoring system for urban green provision exists at national level in Germany.

In response to the relevance of urban green, a considerable amount of literature investigates general access to urban green space on national and city level (Barbosa et al., 2007; Fuller and Gaston, 2009;

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Kabisch, Strohbach, Haase, & Kronenberg, 2016; Sotoudehnia and Comber, 2011; Van Herzele and Wiedemann, 2003). Given the link between urban green and residential well-being, one key question is whether urban green is equitably distributed in relation to race, ethnicity and social status (Wolch et al., 2014). As a consequence, a second strand of literature focuses on environmental justice and inequalities in urban green space provision (e.g. Astell-Burt, Feng, Mavoa, Badland, & Giles-Corti, 2014; Byrne, Wolch, & Zhang, 2009; Germann-Chiari and Seeland, 2004; McConnachie and Shackleton, 2010; Pham, Apparicio, Séguin, Landry, & Gagnon, 2012; Shanahan, Lin, Gaston, Bush, & Fuller, 2014). This literature shows, among others, differences in urban green space distribution related to income, ethno and racial characteristics, age, visible minorities, migration background and gender (Byrne et al., 2009; Comber, Brunsdon, & Green, 2008; Hekert, 2013; Kabisch and Haase, 2014; McConnachie and Shackleton, 2010; Pham et al., 2012).

However, most of the available investigations on access to urban green space restrict their analysis either to particular cities (e.g. Heckert, 2013; Heynen 2003; Kabisch and Haase, 2014; Pham et al., 2012) or − in the case of studies analysing urban green space provision on national level − they do not control for the socio-economic background of households and individuals (e.g. Fuller and Gaston, 2009; Kabisch et al., 2016; Stanners and Bourdeau, 1995). This paper contributes to the existing literature and analyses disparities in urban green space provision on household and individual level in German major cities. We make three core contributions: First, we quantify the general urban green space provision in Germany. Second, we analyse urban green space provision on city level and analyse disparities in green space provision across major cities in Germany and investigate whether urban green is equally distributed within city areas. Third, we control for the socio-economic background of households and individuals to identify environmental inequalities in the provision of urban green space.

2. Data and Method

2.1. Data

In order to investigate urban green space availability, we use urban green data from the European Urban Atlas (EUA) of the European Environment Agency (EEA) recorded in 2006. The EUA is a comprehensive and comparative cross-sectional study, which provides land cover data for European major cities (EEA, 2011). Major cities in Germany are defined as cities with more than 100,000 inhabitants which is currently true for 77 cities in Germany (DESTATIS, 2011). Based on the availability of geo-coded EUA data we had to restrict our analysis to 53 German major cities with more than 100,000 inhabitants.[1] The EUA provides geo-coded information on the geographical locations of urban green, allowing to merge data on urban green space with geo-coded information on the location of German households including their socio-economic background. In our analysis, we focus on the two most important land use categories related to urban green, namely "*green urban areas*" and "*forest*". According to the EUA, the class "*green urban areas*" contains public green areas for predominantly recreational use, such as gardens and parks. Not included in green urban areas are private gardens within housing areas and cemeteries. The "*forest*" class contains land that has a ground coverage by a tree canopy of more than 30% with tree heights of more than 5 m, including bushes and shrubs at the fringe of the forest. Forests within urban areas are included in class urban green areas (see Table 1). Since other green space categories such as private gardens, cemeteries and land mainly used for sports and leisure are often subject to a number of restrictions (entrance fees, opening hours etc.), we decided to exclude these categories from our analysis. In comparison to other geo-coded land use data potentially available for German major cities the EUA holds several advantages (Hoymann, 2013). First, the spatial resolution of the EUA (1:10,000) in urban areas with more than 100,000 inhabitants is higher than the spatial resolution of other land use data bases such as ATKIS and CORINE land cover (1:100,000) (Hoymann, 2013). Second, the use of the EUA is free of charge and is updated on a regular basis (every six years) potentially allowing to monitor the development of urban green space provision over time.

The analysis of access to urban green space on household and individual level in German major cities requires geo-coded information on (i) the location of the households and individuals and (ii) information on the socio-economic background of the households and individuals. To assess urban green space provision on household and individual level in German major cities we use grid cell population data from the German Census which are collected in a register-based procedure as part of the EU population and household census 2011 (Kleber, Malsonado, Scheuregger, & Ziprik, 2009; Statistisches Bundesamt, 2015). The German Census data (GCD) provides information on the number of residents in Germany based on a 100 × 100 m grid as a result of the National Census on May 9, 2011 (Statistische Ämter des Bundes und der Länder, Results of the Census, 2011). According to EU legislation (Regulation EC No 763/2008), the German Census is updated on a regular basis but only once every 10 years (the next Census will be conducted in 2021). The results show that Germany has 80.2 million inhabitants. In our investigation we applied the population data for 53 major cities with more than 100,000 inhabitants. This subset of the CGD includes around 18 million inhabitants of Germany. The Census allows for spatial analysis based on each grid cell and therefore offers the possibility to calculate the urban green space provision for the population of a particular grid cell. For the calculation itself, the centroids of each grid cell are merged with data on urban green from the EUA. The results of the computationally intensive calculations are (i) the distance between the centroid of the grid cell and the border of the nearest urban green space and (ii) the amount of urban green in a predefined 500 m buffer around the centroid of the grid cell. Data for grid cells with less than two residents are excluded from the data set and grid cells with two residents are treated as if having three, yielding a minimum population of three residents for all inhabited grid cell. The bias resulting from this falsification should be rather small in relation to the overall sample size. Grids cells with five or less than five inhabitants, for example, account for only 0.2% of the whole sample of more than 18 million residents. Table A.2 (see *Supplementary data*) provides a summary of grid cells and the population per grid cell for all 53 major cities in our study sample.

Due to the strict data protection policy in Germany, the Census data provide no information on the socio-economic background of the households. Therefore we employ a second data base − the German Socio-Economic Panel (GSOEP) for the year 2006 − to measure the provision of urban green with respect to the socio-economic background of households and individuals (GSOEP, 2015). The GSOEP is a comprehensive and representative panel study of randomly selected private households in Germany, including almost 11,000 households and 22,000 individuals every year. It provides information on all household members, covering Germans living in the old and new federal states, foreigners, and recent immigrants (Wagner, Frick, & Schupp, 2007; Wagner, Göbel, Krause, Pischner, & Sieber, 2008). Moreover, the GSOEP provides information on the geographical

[1] EUA data are available for 53 major German cities in 2006. The major German cities with more than 100,000 inhabitants include the city of Augsburg, Bergisch Gladbach, Berlin, Bielefeld, Bochum, Bonn, Bottrop, Bremen, Darmstadt, Dortmund, Dresden, Duisburg, Düsseldorf, Erfurt, Erlangen, Essen, Frankfurt am Main, Freiburg im Breisgau, Fürth, Gelsenkirchen, Göttingen, Hagen, Halle an der Saale, Hamburg, Hamm, Hannover, Herne, Karlsruhe, Kiel, Koblenz, Köln, Leipzig, Leverkusen, Magdeburg, Mainz, Moers, Mönchengladbach, Mülheim an der Ruhr, München, Neuss, Nürnberg, Oberhausen, Offenbach, Potsdam, Recklinghausen, Regensburg, Saarbrücken, Stuttgart, Trier, Wiesbaden and Wuppertal. Although the city of Schwerin and Frankfurt/Oder have only 92,000 and 60,000 inhabitants, we include these cities to increase the size of the final sample.