Disentangling public urban green space satisfaction: Exploring individual and contextual factors across European cities

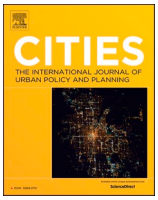
Thomas Coisnon, Anne Musson, Serigne Daouda Pene, Damien Rousselière

Cities 152 (2024) 105154

Contents lists available at ScienceDirect

Cities

journal homepage: www.elsevier.com/locate/cities



Disentangling public urban green space satisfaction: Exploring individual and contextual factors across European cities

Thomas Coisnon [a,d], Anne Musson [b,d], Serigne Daouda Pene [c], Damien Rousselière [a,d,*]

[a] Institut Agro, INRAE, SMART, 49000 Angers, France
[b] ESSCA School of Management, SMART, 49000 Angers, France
[c] LAPLACE, ENSEEIHT, 31000 Toulouse, France
[d] Institut de Recherche en Sciences et Techniques de la Ville, CNRS, 44000 Nantes, France

ARTICLE INFO

JEL classification:
I31
Q57
Q58
R52

Keywords:
European cities
Mixed effects ordered logistic regression
Satisfaction
Urban green spaces

ABSTRACT

Public urban green spaces generate positive externalities regarding the quality of the environment, health and the attractiveness of cities. In this article, we analyse the satisfaction of Europeans with public urban green spaces. Our analysis is original as it is the first international quantitative comparative analysis with a multi-level model that allows us to disentangle individual dimensions (specific to each inhabitant) and contextual dimensions (specific to the policy or structure of the city). Using pseudo-panel data from a series of Eurobarometer surveys conducted in 2006, 2009, 2012 and 2015, and CORINE Land Cover land use data for 75 European cities, we study the individual and contextual factors influencing population satisfaction with green spaces in their city. We estimate mixed effects ordered logistic regression models. Our results show that population characteristics influence the satisfaction with public urban green spaces and highlight heterogeneity between European cities. Our study also shows differences in satisfaction according to the type of green space. Our results are important regarding public policies, since the public decision-maker must take into account a more detailed analysis of the city's population in order to initiate the right green space policy.

1. Introduction

In line with the questioning of wealth and development indicators in the political and academic fields (Stiglitz et al., 2009), and in connection with the emergence of societal expectations related to the sustainable development of territories, local authorities have progressively adopted new political objectives that place greater emphasis on improving and maintaining the well-being of their citizens, reconnecting with previous academic and political concerns that had been left aside during the middle of the 20th century (Frijters et al., 2020). The identification and estimation of the components of well-being have been the subject of extensive work by the OECD (2020) which seeks to document the evolution of well-being outcomes over time and across countries. Among the components of well-being, the OECD identifies a number of key dimensions such as income, work or health status, but also the quality of the living environment or social connections. A better understanding of the importance of these different factors, including their subjective dimension, is of particular interest in the context of urban planning policies in order to attain the goal of a liveable city (Pacione, 2003).

To enhance the quality of life and satisfaction of city dwellers, local authorities can rely on a certain number of mechanisms such as transport policies, the design of public spaces or the provision of cultural and educational services. In this context, the strategy of Urban Green Spaces (hereinafter referred to as UGS) planning is often used to address transversal issues related to the social, environmental and economic performance of territories. The landscape quality of the city, particularly with regard to vegetation, structures the living environment and its influence is felt on a daily basis by the territory's users (Long & Tonini, 2012). Nowadays, UGS are among the main ingredients of territorial attractiveness, as shown by the many "green city" rankings and the inclusion of environmental variables in quality of life rankings. Garcia-Lamarca et al. (2021) explain how the green rhetoric is linked to the attractiveness of the city, creating rental income for municipalities, investors and residents. According to the 2013 UNEP-IPSOS survey, >90 % of French people express the need for daily contact with vegetation and 70 % of Europeans consider proximity to a green space to be

* Corresponding author.
E-mail addresses: thomas.coisnon@institut-agro.fr (T. Coisnon), anne.musson@essca.fr (A. Musson), serignedaoudapene@gmail.com (S.D. Pene), damien.rousseliere@institut-agro.fr (D. Rousselière).

https://doi.org/10.1016/j.cities.2024.105154
Received 17 September 2023; Received in revised form 1 April 2024; Accepted 24 May 2024
Available online 8 June 2024

important when it comes to choosing their residential location. A survey conducted in 2012 showed that nature is a vital need for 55.7 % of respondents in the French city of Lyon (Bourdeau-Lepage, 2015). While the scientific literature has focused on demonstrating the positive impacts of UGS in terms of health, residential choices and the environment, these spaces have also become an important topic for local urban public policy.

In light of this background, the aim of our work is to understand the determinants of the satisfaction of European cities inhabitants with UGS. Our analysis is original as it is the first international quantitative comparative analysis whereas previous research was essentially based on specific case study. Moreover our multi-level model allows us to disentangle individual dimensions (specific to each inhabitant) and contextual dimensions (specific to the policy or structure of the city).

Using Flash Eurobarometers and land-use data, we highlight the factors that make Europeans satisfied with their urban green spaces. Our contribution to the literature is twofold: (1) our results show the importance of considering the diversity of UGS and (2) our data allow us to compare European cities enabling us to show that the dynamics at work are heterogeneous. We highlight several empirical findings: the preferences of inhabitants are linked to local characteristics and specificities, whether geographical, political or cultural, which were not observed; there are important intragroup and individual-specific characteristics that the public decision-maker must take into account in order to initiate the right green space policy; finally there is huge difference in satisfaction according to the type of green space considered, distinguishing between landscaped areas, forests, sports facilities and agricultural areas; for example the perceived satisfaction of residents of dense cities is sensitive to the wooded and natural character of green spaces.

Our results are important regarding public policies, since the policymaker must understand what ensures that residents have a certain level of satisfaction with UGS – this influencing well-being and the sustainable dynamics of the city. The diversity of UGS is a predominant political element in the current context where cities are redesigning themselves and giving a central place to “green” considerations (Garcia-Lamarca et al., 2021).

In the following section, we provide a review of the literature on the social and environmental benefits associated with UGS and their link to inhabitants' well-being, which invite us to identify more precisely the different types of UGS. We then describe our original data collection based on a matching between a spatial land-use database and a pseudo-panel database with successive waves of a European Survey. We present the econometric strategy that consider both individual and contextual dimensions before developing the results on individual levers on the one hand and on the heterogeneity of UGS on the other hand. Finally, we offer a discussion of the results and their public policies implications.

2. Literature review

Urban Green Spaces (UGS) have significant direct impacts on those who live near them. Bourdeau-Lepage et al. (2018) point out that the literature is abundant in demonstrating the positive impact of natural spaces on health. They reduce stress, mental fatigue and anxiety (De Vries et al., 2003; Kaplan & Kaplan, 1989; Rubin et al., 2003; Sheets & Manzer, 1991), with some landscapes having therapeutic virtues (Gesler, 1992; Kuo & Faber Taylor, 2004; Ulrich, 1984). More recently, Seo et al. (2019), in a study of seven Korean metropolitan areas, showed that living in an area with green spaces reduces the risk of cardiovascular disease. Regarding health and wellbeing, Zhang et al. (2020) show the effects of park size, shape and density on walking behaviors in London. UGS also have positive effects on the environment, notably through cooling effects (Aram et al., 2019; Masoudi & Tan, 2019), on air quality or water flow (Aerts et al., 2020). Moreover, the location and design of green spaces have an impact on the development of biodiversity, potentially improving ecological connectivity in urban areas (Avon et al., 2014). Both public and private green spaces may contribute to environmental benefits, with the role of private gardens depending on their size, tree and shrubs cover or species composition (Irvine et al., 2010).

Use of UGS is often linked to positive feelings (being with friends, enjoying nature and scenery, attending a concert, playing sports or exercising) but can also be associated with fear or anger (Roberts et al., 2019). The literature shows that the presence of green spaces is conducive to better life satisfaction. Zhang et al. (2017), focusing on the Netherlands, highlight the impact of accessible and usable green spaces on neighborhood satisfaction and the importance of perceived quality of UGS. Ma et al. (2019) looked at Beijing and showed how well-being is linked to resident participation with green spaces. However, a nonlinear relationship between residents' well-being and their distance from a park or public green space is apparent. Regarding German cities, Krekel et al. (2016) show the positive impact of access to green urban areas, such as gardens and parks, on life satisfaction. Olsen et al. (2019) identify specific land covers associated with greater life satisfaction, such as open farmland, whereas herbaceous vegetation and green urban areas (following the definition of the European Urban Atlas) were negatively associated. Studying the case of Guangzhou (China), Su et al. (2022) provided evidence that daily exposure to green spaces has significant positive impact on people's momentary happiness.

While the literature shows that UGS have a positive impact on health, and more generally on the quality of life, on the attractiveness of the territory and on the environment, these results should be better clarified, in particular by improving the understanding of the satisfaction of inhabitants and users in relation to these green spaces. Indeed, satisfaction with UGS also seems to have an impact on wellbeing, perhaps even more than the quantity of green space available (McEachan et al., 2018). For example, the immediate proximity to the green space may be important for the inhabitant (Gueymard, 2006).

Ostoić et al. (2017) note that several elements may impact people's perception and satisfaction with urban forest and green spaces, namely: physical attributes of these spaces, the presence and quality of facilities, the presence and quality of management or maintenance structures, the behaviour of other users, and socioeconomic factors. In their study regarding seven Southeast European cities, they highlight the dissatisfaction regarding the current states of UGS and the heterogeneous results between cities (Ostoić et al., 2017). The calm provided by green space is also evoked, in line with the results of Gozalo et al. (2018) stating that noise is the most influential factor in the evaluation of an UGS.

The findings illustrated in our literature review invite us to identify more precisely the different types of UGS. Indeed, the literature shows a wide variety of UGS based on different criteria. Several studies distinguish between formal and informal green spaces. Formal spaces designate well-recognized, clearly demarcated and managed vegetated areas such as parks or forests while informal spaces refer to more neglected areas with an uncertain use, legal or ecological status such as vacant lots or interstitial spots (Pietrzyk-Kaszyńska et al., 2017; Sikorska et al., 2020). Another way of classifying UGS is to differentiate between their aesthetic or productive character and their associated use. Indeed, Coisnon et al. (2022) show that UGS in European cities are not just restricted to the provision of public parks and gardens, and can instead build on agricultural or forestry activities. In this respect, several European cities stand out for their more forested profile (such as Oslo, Reykjavik or Bordeaux) while in other cities, agricultural areas make a significant contribution to providing urban vegetation (e.g., Rennes, Bologna). A third group of cities (including Paris, Manchester or Geneva) is distinguished by a more artificial and developed UGS profile. The results are consistent with the multiple case studies on green space accessibility in five European cities made by Buckland and Pojani (2022) and with the comparison analysis of land use datasets proposed by Feltynowski et al. (2018). Other studies classify UGS according to their shape (Park et al., 2017), their ecosystem services potential (Vidal et al.,

2022) or their public versus private ownership (Irvine et al., 2010). Finally, a number of studies have sought to design UGS typologies on the basis of a multi-criteria grid including the above-mentioned determinants crossed with the type of stakeholders (Biernacka & Kronenberg, 2018) or with the nature of the landscapes generated (Ignatieva & Mofrad, 2023).

In the following, we will use the official French definition stating UGS as "all green urban projects such as woods, parks, gardens" as well as "suburban green areas (…) that may include forests, agricultural areas or natural areas" (French Circular of 8 February 1973 on Green spaces policy). In line with this definition and with the Corine Land Cover nomenclature, we therefore chose to draw a distinction between the characteristics of UGS through their nature (artificially vegetated areas, sports and leisure facilities, agricultural areas and forests and vegetated seminatural areas). The actual quantity of UGS is taken into account, but, as shown in the literature, their quality must also be studied (Buckland & Pojani, 2022). Although our study does not precisely explore the way in which the different spaces are maintained, nor their amenities, we assume that these characteristics are different according to the nature of the UGS whether we are dealing with an area such as a stadium, a park, a forest or a pasture.

Roberts et al. (2019) distinguish two approaches for making the link between well-being and UGS, namely: observational studies and experimental studies. Observational studies associate well-being in its broadest sense with environmental characteristics. Regarding satisfaction with UGS, this is in keeping with needs-based visitor satisfaction, concerning how visitors' demands are met (Sun & Shao, 2020). Recent work has used data from social networks to measure satisfaction with UGS. For example, Sun and Shao (2020) used Sina Weibo in China, while Roberts et al. (2019) used posts on Twitter in the UK. Experimental studies consider components of well-being, including level of happiness. To measure subjective satisfaction or associated moods, the most common method employed is surveys. Face-to-face semi-structured interviews can be used (Gozalo et al., 2018; Ostoić et al., 2017; Žabkar et al., 2010) as well as online surveys (Bertram & Rehdanz, 2015). Another possibility is to work with larger questionnaire surveys using telephone-based interviews such as the European Urban Audit Survey (Olsen et al., 2019) or the Flash Eurobarometer (Moeinaddini et al., 2020).

For the purposes of our study, we have chosen this last option, using Eurobarometer surveys conducted in 2006, 2009, 2012 and 2015. The 2015 Flash Eurobarometer, "Quality of life in European cities" (No 419), was conducted at the request of the Directorate-General for Regional and Urban Policy to get a snapshot of people's opinions on a range of urban issues, with earlier surveys conducted in 2004, 2006, 2009 and 2012.[1] We use in particular the following Eurobarometer question: "*Generally speaking, please tell me if you are very satisfied, rather satisfied, rather unsatisfied or not at all satisfied with each of the following issues in [CITY NAME]? - Green spaces such as parks and gardens*". The survey data is presented in the following section.

3. Methodology

3.1. Data and variables

The data used in our study was put together in an original manner by matching data from a variety of sources. The first set of data comes from a series of Eurobarometer surveys that were conducted respectively in 2006,[2] 2009,[3] 2012[4] and 2015[5] across a number of European cities. They gathered information on the sociodemographic characteristics of individuals (gender, age, etc.) and on the quality of life in the cities concerned, particularly on satisfaction with UGS.

Initially, the database contains 157,884 individuals, but several cities and variables are missing from some survey segments. Removing these observations, as well as the missing values for the variables of interest, we end up with a sample of 141,132 individuals in 75 European cities.[6] The list of cities covered by our study is given in Fig. 1. The Eurobarometer survey's sample includes all capital cities of the countries concerned (except for Switzerland), together with between one and six more cities in the larger countries. To ensure comparability between units, our spatial analysis was then carried out for each city in a standardized way, based on Eurostat's official definition of cities as "local administrative units where a majority of the population lives in an urban centre of at least 50 000 inhabitants".

We also used the Corine Land Cover (CLC) spatial land-use database.[7] These data cover the entire European territory. For each city in the sample, they give the proportions of areas dedicated to artificial vegetated areas (AV) such as parks and public gardens; sports and leisure facilities (SF) such as stadiums; agricultural areas (AG); and forests and vegetated seminatural areas (FN). CLC data have the advantage of being easily mobilized by field workers and researchers alike, and have been available for the whole of Europe at regular time intervals since 1990. However, the data description threshold is 25 ha, a relatively low level of precision that does not allow us to include in our analysis informal spaces such as avenue trees and interstitial vegetation.

Our sources also provide information at the city level, including the population aged 15 and over (Eurobarometer) and the total surface area (CLC). The perimeter of each city is the one defined by Eurostat according to density criteria of population and continuity of the built environment. As such, it is not limited to municipal administrative boundaries. Finally, we used the Human Development Index (HDI)[8] for each country of the 75 different cities as a control variable. The descriptive statistics presented in appendix (Fig. A.1. and tables A.1 to A.3) show that there are important various according the year of the study, the age and the gender of the respondents but also at the international level, suggesting the need for a methodological strategy that take into account both individual and collective levers. This methodology is explained in the next section.

3.2. Econometric strategy

In this study, we analyse the individual and contextual determinants of satisfaction with UGS. The variable we aim to explain is an ordered qualitative one. The variable takes the following modalities: not at all satisfied, rather not satisfied, rather satisfied, very satisfied. In addition, our data was composed of 75 distinct groups, namely cities. We therefore estimated a mixed effects ordered logistic regression model, combining both fixed and random effects. The latter were estimated at the city level.

Our model is specified as follows:

$$logit\left(Pr\left(Y_{ij} \leq k | X_{ij}, U_j\right)\right) = \beta X_{ij} + \gamma V_j + U_j, \; 0 \leq k \leq K-1 \quad (1)$$

K is the total number of modalities of the output variable, $j = 1, \ldots, 75$.

[1] https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/urban/survey2015_en.pdf.

[2] Flash Eurobarometer 194 (European Commission, 2011).

[3] Flash Eurobarometer 277 (European Commission, 2009).

[4] Flash Eurobarometer 366 (European Commission, 2017).

[5] Flash Eurobarometer 419 (European Commission, 2016).

[6] Note that all statistics (descriptive statistics and estimated parameters coming from econometric models) are given using post-stratification weights controlling for both sampling design and non-response.

[7] https://land.copernicus.eu/pan-european/corine-land-cover.

[8] http://hdr.undp.org/en/content/human-development-index-hdi.

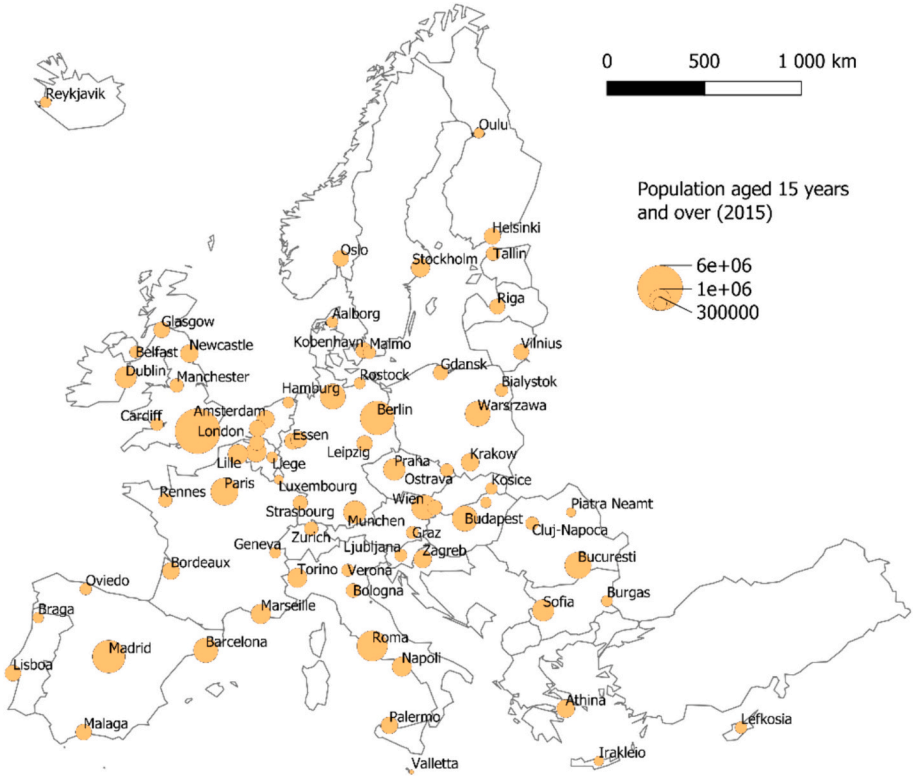


Fig. 1. Spatial distribution of the 75 cities included in the study.
(Source: Authors from Eurostat and European Commission data (2016).)

For each group j we observe $i = 1, \ldots, n_j$ individuals. Y_{ij} represents the variable to be explained, i.e. satisfaction with UGS, X_{ij} includes individual socio-demographic variables (age, gender, age upon leaving school, professional activity) and the year when the data was collected. V_j represents the variables providing information at the city level (geographical area, density calculated on the population aged 15 and over, log area (km^2), AV, SF, AG, FN, HDI). U_j corresponds to the random city effect upon the assumption it follows a centred normal law of unknown variance τ^2.

In order to control for the set of unobserved individual effects, we estimated a hybrid model initially proposed by Allison (2009) for linear models and applicable to all non-linear models, such as ours (Rousselière, 2019; Schunck & Perales, 2017). This involved introducing into (1) the average per city of the sociodemographic variables and subtracting the calculated average from each X_{ij}. In this way, we were able to estimate intragroup and intergroup effects.

The hybrid model (Allison, 2009) is given as follows:

$$logit\left(Pr\left(Y_{ij} \leq k | X_{ij}, U_j\right)\right) = \beta_w\left(X_{ij} - \overline{X}_j\right) + \beta_B \overline{X}_j + V_j\beta_v + U_j \quad (2)$$

β_w gives the within effect (intragroup) and β_b gives the between effect (intergroup) (Mundlak, 1978; Neuhaus & Kalbfleisch, 1998). The idea of breaking down intra and intergroup variation and estimating the respective effects in a single model is not new (Neuhaus & Kalbfleisch, 1998) but it seems to have become increasingly popular in multilevel analysis (Bryan & Jenkins, 2016; Rousselière, 2019).

The city effect can be assessed by calculating the residual Intraclass Correlation Coefficient (ICC). This coefficient corresponds to the share of the variance explained by the group and is given by:

$$ICC = \frac{\tau^2}{\sigma^2 + \tau^2} \quad (3)$$

where τ^2 is the intergroup variance, σ^2 the intragroup variance (in the case of a multilevel logit $\sigma^2 = \frac{\pi^2}{3}$). If the correlation is close to zero, it means that observations within the same group are no more similar to each other than observations from different groups, and therefore using multilevel modelling provides neither more information nor more robustness similar, and are very different from those in other groups. However, its value is very small in non-linear models (Diya et al., 2014; Grilli & Rampichini, 2007; Paveglio et al., 2016; Rousselière & Rousselière, 2017), the consensus being that for a multilevel categorical model, a value of 5 % is unanimously considered to justify this type of modelling.

Alternatively, the Median Odds ratio can be used (Larsen et al., 2000). In our case, this ratio measures the impact of moving from one city to another on the probability of being more satisfied with UGS when comparing two individuals randomly selected from the population.

$$MOR = OR_{median} = exp\left(\sqrt{2\tau^2}.\Phi^{-1}\left(\frac{3}{4}\right)\right)$$

where $\tau^2$is the intergroup variance at the city level and $\Phi^{-1}$the inverse of the normal law distribution function.

To test the existence of non-linear relationships, we introduced interaction effects between city level variables. Seven models were estimated:

- M1: the explanatory variables are age, gender, school-leaving age, professional activity, and year.
- M2: in addition to the M1 variables, it includes the geographical area, density, surface area, the proportion of area dedicated to artificial vegetated areas (AV), sports and leisure facilities (SF), agriculture (AG) and forests and other natural areas (FN) as well as the HDI;
- M3: in addition to the M2 variables, it includes city averages for each modality of the socio-demographic variables.

- M4: it excludes sociodemographic variables and includes differences from the calculated averages (2).
- M5: model M4 including interaction effects between density and AV, SF, AG and FN variables.
- M6: it includes interaction effects between the surface (in log) and the variables AV, SF, AG and FN by removing the interaction effects added to the M5 model.
- M7: it simultaneously includes the interaction effects between density and the variables AV, SF, AG and FN and those between area (in log) and the variables AV, SF, AG and FN.

M1 and M2 are simple random effects models, M3 is a correlated random effects model and M4 to M7 are hybrid models. Following a Bayesian approach to model selection (Burnham & Anderson, 2004; Raftery, 1995), we select the model using Akaike's (1974) Information Criterion (AIC).

4. Presentation of results

4.1. Main results

This section presents the results obtained after estimating the models described in the methodological approach. The estimated parameters for all models are provided in supplementary material (Table A.4). However, the results of only one model (M7) have been interpreted, since according to the AIC, it is the best model. Given that the difference between the different AIC values is sufficiently high (>10), the probability of making a mistake by selecting a model that is different from the DGP (data generation process) is close to zero (Burnham & Anderson, 2004). Following Burnham and Anderson (2004), we compute model probabilities. The model probabilities for models other than model 7 are close to 0: 0.63 % for model 5 and <0.001 % for model 6. Model 7 has a probability equal to 99.36 %. We estimate also model with full interaction between various UGS. With an AIC = 319,160.6, this model has essentially not support. Using alternative link such as probit (AIC = 319,456.9) or cloglog (AIC = 321,127.5) leads to models with an even worst fit.

Table 1 shows the estimated parameters of the M7 model. The interclass correlation coefficient is 0.06, meaning that 6 % of the variance is explained by the city effect. In this model, the median odds ratio is 1.56, which shows that in the median case, when comparing two randomly selected individuals in the population, one is 1.56 times more likely to be satisfied with UGS if he moves to a different city than another individual. In other words, the city effect is not negligible, even if we control by all of our population structure variables and UGS variables.

Because the UGS may not be completely accurately measured by Corine Land Cover, we conduct a sensitivity analysis following Blackwell et al. (2017). According to Aune-Lundberg and Strand (2021), the accuracy is about 85 %. Therefore, we test two scenarios with 10 % or 20 % of measurement errors for the variables describing UGS. As reported in the appendix table A.5 and table A.6, these scenarios lead to slightly the same results.

Fig. 2 illustrates the city effects, showing the effect of all the unobserved factors on the probability of being more satisfied with UGS. These factors may be political, social, cultural or geographic. In cities such as Bratislava, Nicosia and Lisbon, these factors have a negative effect on the likelihood of being more satisfied with UGS in relation to the average city. The opposite effect can be seen in cities such as Turin, Oviedo and Bialystok. However, the random effect at the city level is relatively less important in cities such as Paris and Stockholm, which occupy a median position.

4.2. Interpretation of individual effects

Because we have non linearity in the model, the direct interpretation of the coefficients is fundamentally ambiguous (Greene & Hensher,

Table 1
Estimated parameters of the M7 model.

	Variables	coef	s.e.
Between effects	Gender (ref. Female)		
	Male	0.027*	(0.015)
	Age (ref. 15 to 14 years)		
	25–34 years	−0.065*	(0.037)
	35–44 years	−0.055	(0.042)
	45–54 years	−0.011	(0.043)
	55–64 years	0.094*	(0.048)
	65 years and older	0.343***	(0.057)
	Education (ref. up to 15)		
	16–19 years	−0.070**	(0.031)
	20 years and older	−0.106**	(0.044)
	Still studying	−0.079	(0.052)
	Occupation (ref. employees)		
	Manual workers	0.018	(0.028)
	Self-employed	0.011	(0.024)
	Not working	0.023	(0.021)
	Year (ref. 2006)		
	2009	0.119**	(0.051)
	2012	0.082	(0.081)
	2015	0.203*	(0.123)
Within effects	Gender (ref. Female)		
	Male	5.395	(3.404)
	Age (ref. 15 to 14 years)		
	25–34 years	14.549**	(7.227)
	35–44 years	2.326	(5.415)
	45–54 years	20.225***	(7.639)
	55–64 years	−10.744**	(5.330)
	65 years and older	17.439***	(4.812)
	Education (ref. up to 15)		
	16–19 years	4.494**	(1.794)
	20 years and older	1.412	(1.204)
	Still studying	10.639**	(4.471)
	Occupation (ref. Employees)		
	Manual workers	4.544*	(2.538)
	Self-employed	−10.701***	(2.246)
	Not working	−8.151***	(1.733)
	Year (ref. 2006)		
	2009	−10.409***	(2.388)
	2012	6.656	(12.273)
	2015	−18.258	(12.338)
Contextual effects	HDI	4.722	(3.840)
	Density	−0.002	(0.006)
	Surface	0.765***	(0.255)
	AV	94.363***	(23.371)
	SF	3.891	(30.431)
	AG	15.535**	(6.365)
	FN	19.881***	(5.965)
Interaction effects	density#AV	0.089**	(0.037)
	density#SF	−0.223	(0.153)
	density#AG	−0.018***	(0.005)
	density#FN	0.102***	(0.027)
	surface#AV	−7.878***	(1.801)
	surface#SF	−0.408	(2.232)
	surface#AG	−1.230**	(0.490)
	surface#FN	−1.632***	(0.457)
Intercept	cut1	14.304**	(5.916)
	cut2	15.857***	(5.915)
	cut3	18.032***	(5.919)
var(cities)		0.219***	(0.043)
AIC		319,135.40	
ICC		0.06	
MOR		1.56	
Observations		141,132	
Number of groups		75	

Robust standard errors in parentheses.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$
(Source: Flash Eurobarometer 2006, 2009, 2012 and 2015.)

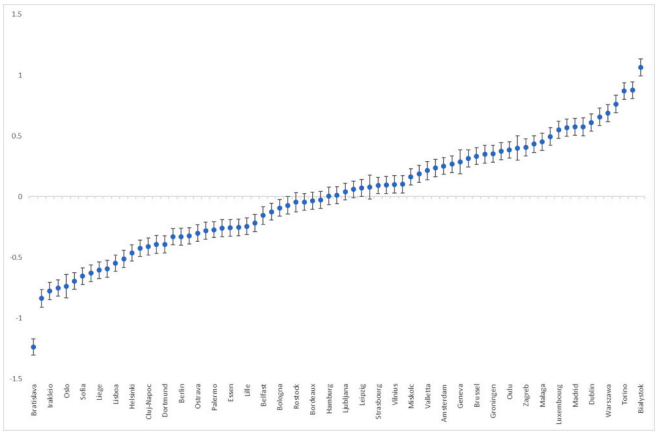


Fig. 2. Random effects at the city level.
(Source: Flash Eurobarometer 2006, 2009, 2012 and 2015. 90 % confidence interval.)

2010). We have to estimate the various marginal effects (see Figs. 3 and 4). Looking at within effects (Fig. 3), we see that, for a given city, being male rather than female makes it more likely to be very satisfied with UGS. Similarly, other things being equal, being over 55 years of age rather than between 15 and 24 years of age has a very significant effect on the likelihood of being more satisfied with UGS. On the other hand, belonging to the 25–34 age group (relative to the 15–24 age group) has a negative effect on satisfaction. The within-effects of professional activity are not significant. The year effect does not appear significantly either, which suggests that the finding in our descriptive statistics of an increase in satisfaction over time is rather due to structural changes (demography or UGS provision for example).

Regarding between effects, some structural effects related to population can be highlighted. It appears that cities with more students on average have a population that is more satisfied with UGS. Occupational activity also appears to play a role, since cities characterized by a higher presence of entrepreneurs or a higher share of non-active population are likely to be significantly less satisfied with their UGS (relative to the manual workers and employee occupational profiles).

4.3. Interpretation of contextual effects

Coefficients of the contextual variables at the city level are reported in Table 1. However, since share of the surface areas, population density and city area were introduced as interaction variables, it is necessary to look at marginal effects in order to comment on them. As reported in the supplementary material (Fig. A.2), the average marginal effects are insignificant.

As we may suspect heterogeneous effects (Sharifi et al., 2021), by crossing the density and the share of surface area dedicated to forests and vegetated seminatural areas (FN), we find that the more these two variables increase in the same direction, the more the increase in satisfaction with UGS is likely to increase as well. By making a representation of the marginal effect of the share of the surface area dedicated to FN conditionally to density (Fig. 5), it emerges that the denser the city, the greater the proportion devoted to FN increases the likelihood of being very satisfied with UGS. Interestingly this interaction effect is significant only in the case of the FN area, suggesting that other land uses such as agriculture or artificial green areas don't contribute to satisfaction as density increases.

The effect of a variation of 1 % in the proportion of area dedicated to artificial vegetated areas (AV) to the city surface area is negative on the probability of being very satisfied with UGS. The more the surface area increases, the more this effect decreases (Fig. 6). Accessibility mays explain this result. Indeed, even if the portion dedicated to landscaped vegetation is increasing, the importance of the size of the city means that city residents do not have easy access to UGS.

Madureira et al. (2015), in their work on French and Portuguese cities, explain that the effect of city size on the perceived benefits of UGS is unclear. Our contribution suggests that to study this link, we need to differentiate between different types of UGS and, in particular, between artificial spaces and natural spaces such as forests.

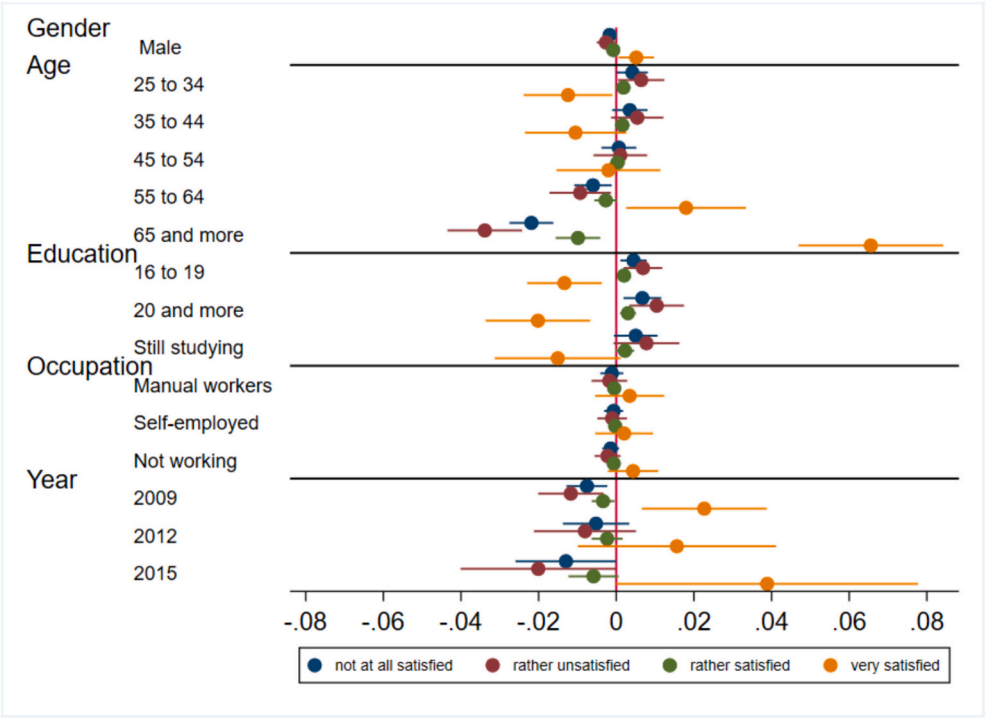


Fig. 3. Within effects.
(Source: Flash Eurobarometer 2006, 2009, 2012 and 2015, 90 % confidence interval.)

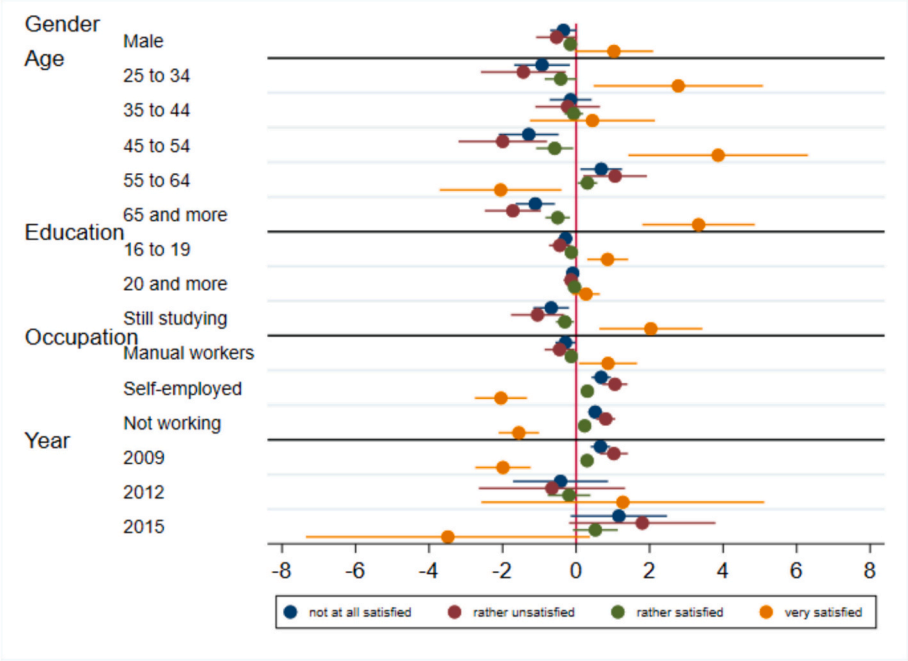


Fig. 4. Between effects.
(Source: Flash Eurobarometer 2006, 2009, 2012 and 2015, 90 % confidence interval.)

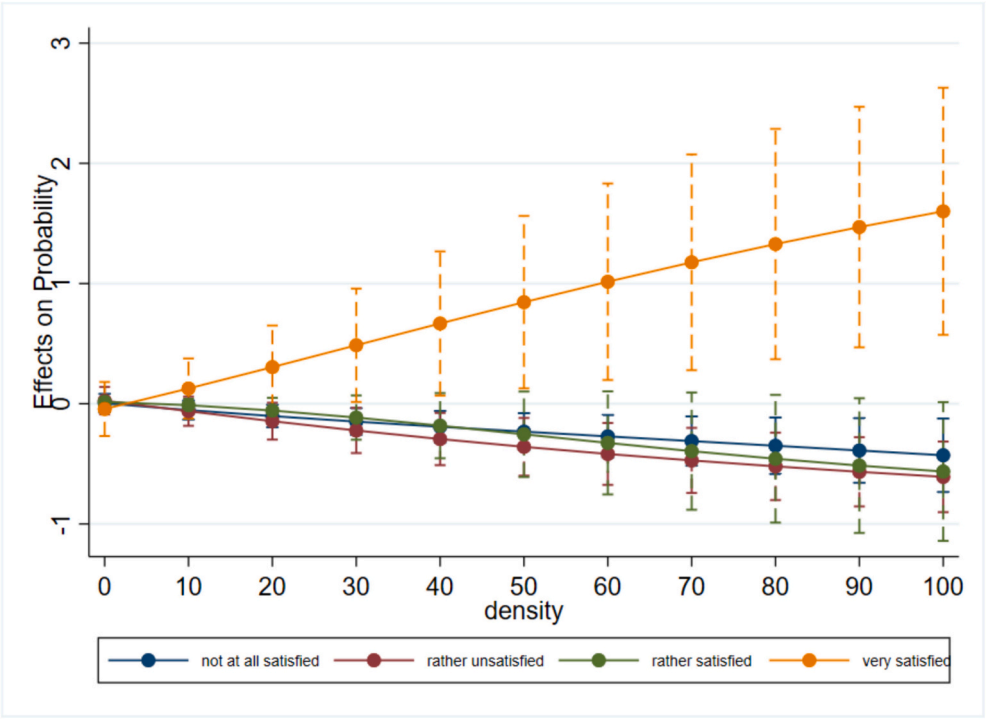


Fig. 5. Marginal effect of FN conditional on density (90 % CI).
(Source: Flash Eurobarometer 2006, 2009, 2012 and 2015, density in habitants per hectare, 90 % confidence interval.)

Overall, the higher the density of the city, the less space there is for UGS, but the trend towards greater density does not lead to the same results in terms of green spaces within European cities (Fuller & Gaston, 2009). The literature attributes these differences to accessibility, culture, North-South divergences (Kabisch et al., 2016) or West/East divergences (Boura & Caruso, 2020) or differences in budget and governance (Boulton et al., 2018) or the structure of these cities (Han et al., 2023). We suggest that the typology of UGS matters.

This finding also sheds light on the fact that the provision and accessibility of UGS matters to residents (see Bertram et al., 2017, for example). Our results add to this literature this statement: it is also the type of UGS that counts. City density and size will impact supply capacity regarding artificial and natural green spaces, but the impact on satisfaction will differ according to the type of UGS involved.

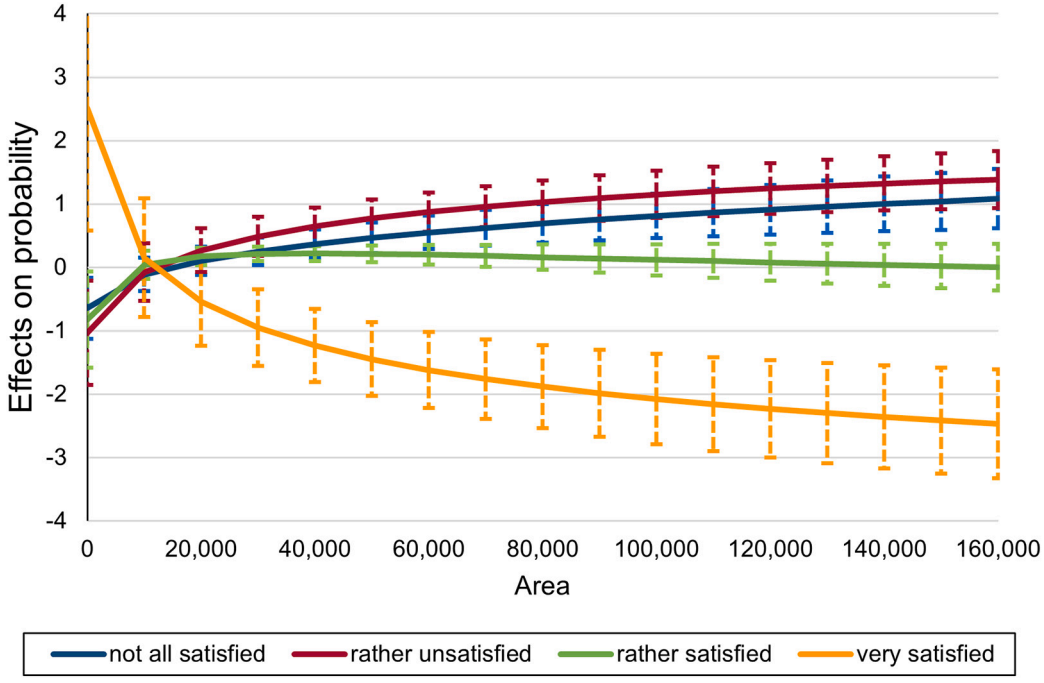


Fig. 6. Marginal effect of AV conditional on area (90 % CI).
(Source: Flash Eurobarometer 2006, 2009, 2012 and 2015, area in hectare, 90 % confidence interval.)

5. Discussion and conclusion

Our first finding highlights the heterogeneity between cities. The existence of a significant random effect justifies our multilevel modelling strategy. In our model, compared to an average European city, residing in Bratislava has a negative impact on the likelihood of being more satisfied, contrary to Bialystok which is associated with a higher likelihood of being more satisfied. These significant random effects at the city level suggest that the preferences of inhabitants are linked to local characteristics and specificities, whether geographical, political or cultural, which were not observed here. In line with other studies (e.g. Buckland & Pojani, 2022; Sharifi et al., 2021), this result therefore implies that the political decision-maker must first consider the specific characteristics of their city, in terms of habits and preferences of its inhabitants and of its urban and landscape profile.

We highlight intragroup and individual-specific characteristics. This constitutes our second finding. For example, being a male rather than a female makes it more likely to be satisfied with UGS, whereas older people (55 years+) are more likely to be satisfied with UGS. Ambrey and Fleming (2014) also showed differences in preferences between individuals in the case of Australia. For example, single parents tend to value green spaces more than others. We have distinguished the intergroup characteristics, which in turn highlight the effects of population structure. Individuals living in student-dominated cities are thus more likely to be satisfied with the supply of UGS. This result is in line with the study of Yang et al. (2019) on various university cities in China for which the provision of higher levels of urban green space has positive effects on the mental well-being of students. These same effects exist at the level of the age structure of the population as well as partly regarding professional activity. Nevertheless, the public decision-maker must take into account a more detailed analysis of the city's population in order to initiate the right green space policy. Focusing on the specific case of urban parks, Waitt and Knobel (2018) show how subjective the inhabitant's lived experience is and how it will be anchored in their life experience and culture, and they explain to what extent this will have an overall impact on the performance of urban policy. Barker et al. (2020) explain that it is necessary to imagine alternatives, to present scenarios for the development of UGS to the inhabitants, and with this objective in mind, differentiating the types of green spaces becomes an essential first step.

Our third finding is original regarding the literature, because it highlights the differences in satisfaction according to the type of green space considered, distinguishing between landscaped areas, forests, sports facilities and agricultural areas. Ambrey and Fleming (2014) showed that the proportion of public green spaces, as well as population density, both have an impact on the happiness felt by residents but did not distinguish between the different types of green spaces. Our work shows interesting insights regarding the nature of UGS in relation to the size of the city. Although the type of UGS doesn't seem to have a significant marginal effect on residents' satisfaction, we show that the effect of an increase in the proportion of surface area dedicated to forests and seminatural areas on the probability of being very satisfied with the UGS is greater as the city's density increases. This result suggests that the perceived satisfaction of residents of dense cities is sensitive to the wooded and natural character of green spaces. As this effect is not significant for agricultural or sports and leisure areas, we can deduce that the mechanisms linking landscape perception to satisfaction with UGS are of a different nature. In the case of agricultural areas, it is likely that the anthropized dimension is more strongly perceived, and probably also associated with negative externalities (pollution, standardisation of the landscape in connection with crop choices, greenhouse infrastructures in the immediate vicinity of the city). In the case of sports and leisure areas, this result can be explained by the fact that these are perceived in a more utilitarian way and not necessarily associated as part of UGS. Our work also shows that, as the total surface area of the city increases, the effect of an increase in the proportion of surface area dedicated to landscaped areas such as parks on the probability of being very satisfied with UGS tends to decrease. This result suggests that, in addition to a quantitative policy aiming at increasing the number of parks and other green areas, local authorities should also include a reflexion on their spatial distribution and accessibility to the residents. As highlighted by Badiu et al. (2016), UGS per capita is not a valuable target without considering other determinants and specific characteristics of the city's profile.

The policy implications are important. Indeed, Ma and Jin (2019) explained that while UGS have significant impacts in terms of land prices, labour market and transportation, these impacts would not be the same for greenbelts, green-wedges and green-grids. Our results on the European area invite decision-makers to think, within high-density cities, about developing and maintaining green spaces featuring landscaped vegetation characterized by a more wooded and natural aspect. In cities with large surface areas, it seems relevant to develop green spaces by focusing on their spatial distribution and accessibility to improve the satisfaction of the population. Zhang et al. (2020) demonstrate how park size, shape and density impact walking activity. In the same way, all UGS do not have the same impact on how people feel.

Residents' satisfaction with green spaces has several effects, the first of which is the choice of household location. The proximity and distribution of green spaces can thus have an impact on residential segregation (Schaeffer et al., 2016) and reveal inequalities between households (Schaeffer & Tivadar, 2019). Taking into account satisfaction with UGS is important because the current development of green cities runs the risk of decision making not ultimately being favourable to the community, and may for example deteriorate social ties. Loughran (2020) explains how, over time, the objectives of decision-makers evolve, shaping the production of UGS and leading to an urban structure with social and societal impacts. As demonstrated by Garcia-Lamarca et al. (2021), "cities aspiring toward a green identity need to move beyond slogans and visions to focus on socially equitable planning and decision-making processes that do not increase costs of living and thereby push the poor and minorities out of their homes in the name of a green city".

The literature shows the importance of considering UGS to achieve this objective. Kim and Wu (2022) point out the role of urban green spaces in gentrification, showing that this effect, negative from the point of view of inclusion, depends on the type of green space considered. This finding supports our conclusion that the type of UGS should be considered according to the city and the objectives pursued by local governments. The special issue of Urban Studies (Baumann & Yacobi, 2022) on infrastructural stigma and urban vulnerability invites us to consider the way the city excludes. We believe that UGS choices must also be integrated into this reflection on inclusion. Milbourne (2021: 2915) gives the example of community gardens: they are new green spaces that create social links, "they are able to create more meaningful spaces of togetherness, with the shared relationships between nature and society able to downplay or overcome existing social, cultural or ethnic divisions". Our work is in this way interesting, since it encourages the use of the point of view of inhabitants towards UGS in decision-making. However, it has several limitations.

Firstly, we did not clearly take into account the quality of the UGS (level of maintenance and equipment). Furthermore, it is limited by the nature of the vegetated areas as identified by our land-use dataset and therefore restricted to artificial green areas, agricultural land and forest and semi-natural areas. Further research should focus on informal spaces that contribute to the vegetated ambience of urban space, such as tree alignments, interstitial spaces of spontaneous vegetation or private gardens, which may influence residents' perception of their environment and therefore their level of satisfaction. In particular, Hanson et al. (2021) explain that private gardens contribute to the well-being of their owners, and Zhao et al. (2024) show that in terms of well-being, private gardens are complementary to public green spaces. Studying the link between satisfaction with public green spaces and individual well-being, according to the city's endowment of private gardens, seems a promising line of research.

Acquiring such comparable data on a large sample of European cities remains a major challenge. The quality of UGS may also vary within a given city, especially along the center-suburbs gradient, leading us to assume that responses in the survey may depend on the respondent's residential location and the green space specificities of its neighborhood. We are unable to address this spatial heterogeneity issue at our scale of work, but a more spatially targeted work (such as a case study on a particular city) could be a relevant and complementary extension of this research.

Furthermore, our work needs to be included in a more global analysis of the well-being of urban residents. As clearly and rightly stated by Moeinaddini et al. (2020), "to support European policies about urban quality of life and have better planning decisions and strategies, it is important to have deep knowledge about the factors that influence the urban quality of life in European cities". Thus, in the continuation of this work and that of Ambrey and Fleming (2014), another step would be to analyse the impact of the different UGS on the overall satisfaction felt by residents.

In view of these results, and in line with Kronenberg et al. (2020), future research should explore the role of urban green spaces in environmental justice. Our study shows a gender difference, and this calls for further investigation. Wu et al. (2022) point out that EVUs are generally male-friendly in their use and exposure, while Sillman et al. (2022) explain that green spaces could help reduce certain gender-related health disparities, adding not all types of green space are equal in this respect. It would be important to study the characteristics of an urban green space that is beneficial to populations that are usually marginalized.

CRediT authorship contribution statement

Thomas Coisnon: Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Investigation, Data curation, Conceptualization. **Anne Musson:** Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Investigation, Conceptualization. **Serigne Daouda Pene:** Writing – original draft, Software, Formal analysis, Data curation. **Damien Rousselière:** Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization.

Declaration of competing interest

The authors report there are no competing interests to declare.

Data availability

The authors do not have permission to share data.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cities.2024.105154.

References

Aerts, R., Nemery, B., Bauwelinck, M., Trabelsi, S., Deboosere, P., Van Nieuwenhuyse, A., … Casas, L. (2020). Residential green space, air pollution, socioeconomic deprivation and cardiovascular medication sales in Belgium: A nationwide ecological study. *Science of the Total Environment, 712*, Article 136426.

Akaike, H. (1974). A new look at the statistical model identification. *IEEE Transactions on Automatic Control, 19*(6), 716–723.

Allison, P. D. (2009). *Fixed effects regression models* (vol. 160). SAGE publications.

Ambrey, C., & Fleming, C. (2014). Public greenspace and life satisfaction in urban Australia. *Urban Studies, 51*(6), 1290–1321.

Aram, F., García, E. H., Solgi, E., & Mansournia, S. (2019). Urban green space cooling effect in cities. *Heliyon, 5*(4), Article e01339.

Aune-Lundberg, L., & Strand, G. H. (2021). The content and accuracy of the CORINE Land Cover dataset for Norway. *International Journal of Applied Earth Observation and Geoinformation, 96*, Article 102266.

Avon, C., Bergès, L., & Roche, P. (2014). Comment analyser la connectivité écologique des trames vertes ? cas d'étude en région méditerranéenne. *Sciences Eaux & Territoires, 2*, 14–19.

Badiu, D. L., Ioja, C. I., Patroescu, M., Breuste, J., Artmann, M., Nita, M. R., … Onose, D. A. (2016). Is urban green space per capita a valuable target to achieve cities' sustainability goals? Romania as a case study. *Ecological Indicators, 70*, 53–66.

Barker, A., Crawford, A., Booth, N., & Churchill, D. (2020). Park futures: Excavating images of tomorrow's urban green spaces. *Urban Studies, 57*(12), 2456–2472.
Baumann, H., & Yacobi, H. (2022). Introduction: Infrastructural stigma and urban vulnerability. *Urban Studies, 59*(3), 475–489.
Bertram, C., Meyerhoff, J., Rehdanz, K., & Wüstemann, H. (2017). Differences in the recreational value of urban parks between weekdays and weekends: A discrete choice analysis. *Landscape and Urban Planning, 159*, 5–14.
Bertram, C., & Rehdanz, K. (2015). The role of urban green space for human well-being. *Ecological Economics, 120*, 139–152.
Biernacka, M., & Kronenberg, J. (2018). Classification of institutional barriers affecting the availability, accessibility and attractiveness of urban green spaces. *Urban Forestry & Urban Greening, 36*, 22–33.
Blackwell, M., Honaker, J., & King, G. (2017). A unified approach to measurement error and missing data: Overview and applications. *Sociological Methods & Research, 46*(3), 303–341.
Boulton, C., Dedekorkut-Howes, A., & Byrne, J. (2018). Factors shaping urban greenspace provision: A systematic review of the literature. *Landscape and Urban Planning, 178*, 82–101.
Boura, M., & Caruso, G. (2020). *Land cover, landscape metrics and typology of European cities for Urban Forest Ecosystem Services (UFES) evaluation*. https://doi.org/10.5281/zenodo.4301952
Bourdeau-Lepage, L. (2015). La nature en question. Aménager en ménageant l'homme et son milieu. *Géocarrefour, 90*(90/3), 191–192.
Bourdeau-Lepage, L., Texier, P., & Carré, H. (2018). Évaluer les déterminants du bien-être sur un territoire. *Revue d'Economie Régionale et Urbaine, 4*, 775–803.
Bryan, M. L., & Jenkins, S. P. (2016). Multilevel modelling of country effects: A cautionary tale. *European Sociological Review, 32*(1), 3–22.
Buckland, M., & Pojani, D. (2022). Green space accessibility in Europe: A comparative study of five major cities. *European Planning Studies*, 1–22.
Burnham, K. P., & Anderson, D. R. (2004). Multimodel inference: Understanding AIC and BIC in model selection. *Sociological Methods & Research, 33*(2), 261–304.
Coisnon, T., Musson, A., & Rousselière, D. (2022). Caractériser l'offre en espaces végétalisés au sein des villes européennes. *Revue d'Economie Régionale et Urbaine*, 91–114.
De Vries, S., Verheij, R. A., Groenewegen, P. P., & Spreeuwenberg, P. (2003). Natural environments—Healthy environments? An exploratory analysis of the relationship between greenspace and health. *Environment and Planning A, 35*(10), 1717–1731.
Diya, L., Li, B., Van den Heede, K., Sermeus, W., & Lesaffre, E. (2014). Multilevel factor analytic models for assessing the relationship between nurse-reported adverse events and patient safety. *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, 237–257.
European Commission. (2009). *The Gallup Organization: Perception survey on quality of life in European cities*. Brussels: European Commission. November 2009 http://ec.europa.eu/public_opinion/flash/fl_277_en.pdf.
European Commission. (2011). *Flash Eurobarometer 194 (urban audit perception survey 2006)*. Brussels: The GALLUP Organisation. https://doi.org/10.4232/1.10092. GESIS Data Archive, Cologne. ZA4727 Data file Version 1.0.0.
European Commission, Brussels. (2016). *Flash Eurobarometer 419 (quality of life in European cities 2015)*. Cologne: GESIS Data Archive. https://doi.org/10.4232/1.12516. ZA6641 Data file Version 1.0.0.
European Commission, Brussels. (2017). *Flash Eurobarometer 366 (Quality of Life in European Cities)*. TNS Political & Social [producer]. Cologne: GESIS Data Archive. https://doi.org/10.4232/1.12910. ZA5885 Data file Version 1.1.0.
Feltynowski, M., Kronenberg, J., Bergier, T., Kabisch, N., Łaszkiewicz, E., & Strohbach, M. W. (2018). Challenges of urban green space management in the face of using inadequate data. *Urban Forestry & Urban Greening, 31*, 56–66.
Frijters, P., Clark, A. E., Krekel, C., & Layard, R. (2020). A happy choice: Wellbeing as the goal of government. *Behavioural Public Policy, 4*(2), 126–165.
Fuller, R. A., & Gaston, K. J. (2009). The scaling of green space coverage in european cities. *Biology Letters, 5*, 352–355.
Garcia-Lamarca, M., Anguelovski, I., Cole, H., Connolly, J., Argüelles, L., Baro, F., … Shokry, G. (2021). Urban green boosterism and city affordability: For whom is the 'branded' green city? *Urban Studies, 58*(1), 90–112.
Gesler, W. M. (1992). Therapeutic landscapes: Medical issues in light of the new cultural geography. *Social Science & Medicine, 34*(7), 735–746.
Gozalo, R. G., Barrigón Morillas, J. M., Montes González, D., & Atanasio Moraga, P. (2018). Relationships among satisfaction, noise perception, and use of urban green spaces. *Science of the Total Environment, 624*(2018), 438–450 (ISSN 0048-9697).
Greene, W. H., & Hensher, D. A. (2010). *Modeling ordered choices: A primer*. Cambridge: Cambridge University Press.
Grilli, L., & Rampichini, C. (2007). Multilevel factor models for ordinal variables. *Structural Equation Modeling, 14*(1), 1–25.
Gueymard, S. (2006). Facteurs environnementaux de proximité et choix résidentiels. Le rôle de l'ancrage communal, des représentations et des pratiques des espaces verts. In *Développement durable et territoires. Économie, géographie, politique, droit, sociologie* (Dossier 7).
Han, S., Kwan, M. P., Miao, C., & Sun, B. (2023). Exploring the effects of urban spatial structure on green space in Chinese cities proper. *Urban Forestry & Urban Greening, 87*, 2023.
Hanson, H. I., Eckberg, E., Widenberg, M., & Alkan Olsson, J. (2021). Gardens' contribution to people and urban green space. *Urban Forestry & Urban Greening, 63* (2021), 127198.
Ignatieva, M., & Mofrad, F. (2023). Understanding urban green spaces typology's contribution to comprehensive green infrastructure planning: A study of Canberra, the National Capital of Australia. *Land, 12*(5), 950.
Irvine, K. N., Fuller, R. A., Devine-Wright, P., Tratalos, J., Payne, S. R., Warren, P. H., … Gaston, K. J. (2010). Ecological and psychological value of urban green space. In M. Jenks, & C. Jones (Eds.), *Dimensions of the Sustainable City* (pp. 215–237). Springer. https://doi.org/10.1007/978-1-4020-8647-2_10.
Kabisch, N., Strohbach, M., Haase, D., & Kronenberg, J. (2016). Urban green space availability in European cities. *Ecological Indicators, 70*, 586–596.
Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*. CUP Archive.
Kim, S. K., & Wu, L. (2022). Do the characteristics of new green space contribute to gentrification? *Urban Studies, 59*(2), 360–380.
Krekel, C., Kolbe, J., & Wüstemann, H. (2016). The greener, the happier? The effect of urban land use on residential well-being. *Ecological Economics, 121*, 117–127.
Kronenberg, J., Haase, A., Łaszkiewicz, E., Antal, A., Baravikova, A., Biernacka, M., Dushkova, D., Filčak, R., Haase, D., Ignatieva, M., Khmara, Y., Razvan Niţă, M., & Onose, D. A. (2020). Environmental justice in the context of urban green space availability, accessibility, and attractiveness in postsocialist cities. *Cities, 106*(2020), Article 102862.
Kuo, F. E., & Faber Taylor, A. (2004). A potential natural treatment for attention- deficit/hyperactivity disorder: Evidence from a national study. *American Journal of Public Health, 94*(9), 1580–1586.
Larsen, K., Petersen, J. H., Budtz-Jørgensen, E., & Endahl, L. (2000). Interpreting parameters in the logistic regression model with random effects. *Biometrics, 56*(3), 909–914.
Long, N., & Tonini, B. (2012). Les espaces verts urbains : étude exploratoire des pratiques et du ressenti des usagers. *[VertigO] La revue électronique en sciences de l'environnement, 12*(2).
Loughran, K. (2020). Urban parks and urban problems: An historical perspective on greenspace development as a cultural fix. *Urban Studies, 57*(11), 2321–2338.
Ma, B., Zhou, T., Lei, S., & Wen, Y. (2019). Effects of urban green spaces on residents' well-being. *Environment, Development and Sustainability, 21*, 2793–2809.
Ma, M., & Jin, Y. (2019). Economic impacts of alternative greenspace configurations in fast growing cities: The case of greater Beijing. *Urban Studies, 56*(8), 1498–1515.
Madureira, H., Nunes, F., Oliveira, J. V., Cormier, L., & Madureira, T. (2015). Urban residents' beliefs concerning green space benefits in four cities in France and Portugal. *Urban Forestry & Urban Greening, 14*, 56–64.
Masoudi, M., & Tan, P. Y. (2019). Multi-year comparison of the effects of spatial pattern of urban green spaces on urban land surface temperature. *Landscape and Urban Planning, 184*, 44–58.
McEachan, R. C., Yang, T. C., Roberts, H., Pickett, K. E., Arseneau-Powell, D., Gidlow, C. J., Wright, J., & Nieuwenhuijsen, M. (2018). Availability, use of, and satisfaction with green space, and children's mental wellbeing at age 4 years in a multicultural, deprived, urban area: Results from the Born in Bradford cohort study. *The Lancet Planetary Health, 2*(6), e244–e254.
Milbourne, P. (2021). Growing public spaces in the city: Community gardening and the making of new urban environments of publicness. *Urban Studies, 58*(14), 2901–2919.
Moeinaddini, M., Asadi-Shekari, Z., Aghaabbasi, M., Saadi, I., Zaly Shah, M., & Cools, M. (2020). Applying non-parametric models to explore urban life satisfaction in European cities. *Cities, 105*, Article e102851.
Mundlak, Y. (1978). On the pooling of time series and cross-section data. *Econometrica*, 69–85.
Neuhaus, J. M., & Kalbfleisch, J. D. (1998). Between-and within-cluster covariate effects in the analysis of clustered data. *Biometrics*, 638–645.
OECD. (2020). How's life? 2020: Measuring well-being.. Paris: Éditions OCDE https://doi.org/10.1787/9870c393-en.
Olsen, J. R., Nicholls, N., & Mitchell, R. (2019). Are urban landscapes associated with reported life satisfaction and inequalities in life satisfaction at the city level? A cross-sectional study of 66 European cities. *Social Science & Medicine, 226*, 263–274.
Ostoić, S. J., van den Bosch, C. C. K., Vuletić, D., Stevanov, M., Živojinović, I., Mutabdžija-Bećirović, S., … Malovrh, Š. P. (2017). Citizens' perception of and satisfaction with urban forests and green space: Results from selected Southeast European cities. *Urban Forestry & Urban Greening, 23*, 93–103.
Pacione, M. (2003). Urban environmental quality and human wellbeing—A social geographical perspective. *Landscape and Urban Planning, 65*(1–2), 19–30.
Park, J., Kim, J. H., Lee, D. K., Park, C. Y., & Jeong, S. G. (2017). The influence of small green space type and structure at the street level on urban heat island mitigation. *Urban Forestry & Urban Greening, 21*, 203–212.
Paveglio, T. B., Kooistra, C., Hall, T., & Pickering, M. (2016). Understanding the effect of large wildfires on residents' well-being: What factors influence wildfire impact? *Forest Science, 62*(1), 59–69.
Pietrzyk-Kaszyńska, A., Czepkiewicz, M., & Kronenberg, J. (2017). Eliciting non-monetary values of formal and informal urban green spaces using public participation GIS. *Landscape and Urban Planning, 160*, 85–95.
Raftery, A. E. (1995). Bayesian model selection in social research. *Sociological Methodology*, 111–163.
Roberts, H., Sadler, J., & Chapman, L. (2019). The value of Twitter data for determining the emotional responses of people to urban green spaces: A case study and critical evaluation. *Urban Studies, 56*(4), 818–835.
Rousselière, D. (2019). A flexible approach to age dependence in organizational mortality: Comparing the life duration for cooperative and non-cooperative enterprises using a Bayesian generalized additive discrete time survival model. *Journal of Quantitative Economics, 17*(4), 829–855.
Rousselière, D., & Rousselière, S. (2017). Is biotechnology (more) acceptable when it enables a reduction in phytosanitary treatments? A European comparison of the acceptability of transgenesis and cisgenesis. *PLoS One, 12*(9), Article e0183213.
Rubin, K., Burgess, K., Kennedy, A., & Stewart, S. (2003). Social withdrawal and inhibition in childhood. *Child Psychopathology, 2*, 372–406.

Schaeffer, Y., Cremer-Schulte, D., Tartiu, C., & Tivadar, M. (2016). Natural amenity-driven segregation: Evidence from location choices in French metropolitan areas. *Ecological Economics, 130*, 37–52.
Schaeffer, Y., & Tivadar, M. (2019). Measuring environmental inequalities: Insights from the residential segregation literature. *Ecological Economics, 164*, Article 106329.
Schunck, R., & Perales, F. (2017). Within-and between-cluster effects in generalized linear mixed models: A discussion of approaches and the Xthybrid command. *The Stata Journal, 17*(1), 89–115.
Seo, S., Choi, S., Kim, K., Kim, S. M., & Park, S. M. (2019). Association between urban green space and the risk of cardiovascular disease: A longitudinal study in seven Korean metropolitan areas. *Environment International, 125*, 51–57.
Sharifi, F., Nygaard, A., & Stone, W. M. (2021). Heterogeneity in the subjective well-being impact of access to urban green space. *Sustainable Cities and Society, 74*, Article 103244.
Sheets, V. L., & Manzer, C. D. (1991). Affect, cognition, and urban vegetation: Some effects of adding trees along city streets. *Environment and Behavior, 23*(3), 285–304.
Sikorska, D., Łaszkiewicz, E., Krauze, K., & Sikorski, P. (2020). The role of informal green spaces in reducing inequalities in urban green space availability to children and seniors. *Environmental Science & Policy, 108*, 144–154.
Sillman, D., Rigolon, A., Browning, M. H. E. M., Yoon, H. V., & McAnirlin, O. (2022). Do sex and gender modify the association between green space and physical health? A systematic review. *Environmental Research, 209*, 112869, 2022 Jun.
Stiglitz, J. E., Sen, A., & Fitoussi, J. P. (2009). *Report by the commission on the measurement of economic performance and social progress*.
Su, L., Zhou, S., Kwan, M.-P., Chai, Y., & Zhang, X. (2022). The impact of immediate urban environments on people's momentary happiness. *Urban Studies, 59*(1), 140–160.
Sun, Y., & Shao, Y. (2020). Measuring visitor satisfaction toward peri-urban green and open spaces based on social media data. *Urban Forestry & Urban Greening, 53*, Article e126709.
Ulrich, R. S. (1984). View through a window may influence recovery from surgery. *Science, 224*(4647), 420–421.
Vidal, D. G., Dias, R. C., Teixeira, C. P., Fernandes, C. O., Leal Filho, W., Barros, N., & Maia, R. L. (2022). Clustering public urban green spaces through ecosystem services potential: A typology proposal for place-based interventions. *Environmental Science & Policy, 132*, 262–272.
Waitt, G., & Knobel, H. (2018). Embodied geographies of liveability and urban parks. *Urban Studies, 55*(14), 3151–3167.
Wu, J., Xu, Z., Jin, Y., Chai, Y., Newell, J., & Na, T. N. (2022). Gender disparities in exposure to green space: An empirical study of suburban Beijing. *Landscape and Urban Planning, 222*(2022), Article 104381 (ISSN 0169-2046).
Yang, T., Barnett, R., Fan, Y., & Li, L. (2019). The effect of urban green space on uncertainty stress and life stress: A nationwide study of university students in China. *Health & Place, 59*, Article 102199.
Žabkar, V., Brenčič, M. M., & Dmitrović, T. (2010). Modelling perceived quality, visitor satisfaction and behavioural intentions at the destination level. *Tourism Management, 31*(4), 537–554.
Zhang, X., Melbourne, S., Sarkar, C., Chiaradia, A., & Webster, C. (2020). Effects of green space on walking: Does size, shape and density matter? *Urban Studies, 57*(16), 3402–3420.
Zhang, Y., Van den Berg, A. E., Van Dijk, T., & Weitkamp, G. (2017). Quality over quantity: Contribution of urban green space to neighborhood satisfaction. *International Journal of Environmental Research and Public Health, 14*, 53.
Zhao, Y., van den Berg, P. E. W., Ossokina, I. V., & Arentze, T. A. (2024). How do urban parks, neighborhood open spaces, and private gardens relate to individuals' subjective well-being: Results of a structural equation model. *Sustainable Cities and Society, 101*(2024), Article 105094.