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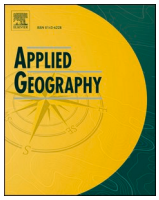

Public participation GIS can help assess multiple dimensions of environmental justice in urban green and blue space planning

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ABSTRACT

In the last two decades, there has been an exponential increase in application of public participation GIS (PPGIS) methods to urban green and blue space (UGBS) planning. However, integrating different elements of environmental justice in PPGIS research is still in its infancy, especially in regards to the deep and less visible issues related to recognition and participation of different groups in local green space planning and management. Here we present a new method for assessing perceived recognition and procedural justice with respect to UGBS in the Amager island of Copenhagen, Denmark. We collected survey data together with 2187 place-based values and preferences from 298 local residents. Using Exploratory Factor Analysis, we classified respondents in four clusters representing low to high perceived recognition and procedural justice. We then examined how these clusters relate to socio-demographics and the spatial distribution of mapped values and preferences. Results indicated no significant differences in terms of income and age between clusters. However, there was clear variation in the spatial distribution and type of values and preferences respondents from different clusters assigned, particularly for those who feel unrecognized and do not participate in local environmental decision-making compared to all other groups. In addition, gender had a significant effect on the perceptions of recognition and procedure. Female respondents scored lower on procedural justice than male and mapped landscape values and preferences closer to home than males, thus suggesting that gender inequalities can be deeply embedded in everyday public spaces and practices. Planning inclusive and environmentally just UGBS requires not only incorporating such gender perspectives, but a more flexible, intersectional and relational understanding of space that reflects the everyday needs of different and marginalized groups.

Author statement

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1. Introduction

Issues of environmental justice are crucial to consider with respect to the design, evaluation and management of urban green and blue spaces (UGBS), particularly for vulnerable communities such as low income groups and new migrants. Vulnerable groups typically have the least access to environmental amenities like UGBS, are most exposed to environmental harms and have the fewest resources to adapt (Anguelovski et al., 2020; Shokry et al., 2020). UGBS are under constant development including new demands for nature-based solutions, which

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can accelerate issues of gentrification (Anguelovski et al., 2020; Wolch et al., 2014). Further, nature-based solutions often privilege a technocratic approach (van der Jagt et al., 2021) and market-driven values (e.g. focus on economic returns and growth) over wider justice concerns (Kotsila et al., 2020).

In the literature, environmental justice is primarily conceptualised with regards to distributional, procedural and recognition justice. Distributional justice considers the fair allocation of ecosystem services (Kabisch & Haase, 2014), as well as acknowledging the historic inequalities embedded in ecosystem services production and consumption (Andersson et al., 2019; Langemeyer & Connolly, 2020). The procedural justice dimension concerns how decisions are made, which affected groups participate in design, planning and management of public spaces, and on what terms (Low, 2013; Martin et al., 2016; Schlosberg, 2007). Recognition acknowledges that social cohesion and functioning of the community, not solely individual exposures, is crucial to environmental justice (Schlosberg, 2013). Recognition is concerned with respecting identities and cultural difference, and examines the extent to which different ideas and cultures are recognised and valued in UGBS management (Fraser & Honneth, 2003).

Public Participation Geographic Information Systems (PPGIS) can enhance the spatial understanding of environmental justice (Raymond et al., 2016). As noted by Tulloch (2008), PPGIS is a field within geographic information science that focuses on how the public engages with various types of geospatial technologies to participate in public processes, which includes mapping. This study aims to scientifically advance PPGIS techniques by examining relations between multiple perceived socio-cultural and socio-spatial dimensions of justice for different user groups. We draw on case insights from Amager island in Copenhagen, Denmark to present and test the validity of a psychometric scale for measuring recognition and procedural justice concerns and then relate these findings to the distribution of spatially explicit UBGS values (i.e. values residents assign to green/blue spaces in the area) and preferences for local green space management (i.e. how green/blue spaces should be further improved or developed).

1.1. Distributional justice

A growing number of studies spatially assess issues of environmental justice in order to improve UGBS governance, planning and management. The focus has been primarily on distributional justice questions related to the fair allocation and availability of public UGBS for different social groups. Common spatial indicators include measured distances from home to UGBS and access to UGBS in relation to different marginalised communities (Kabisch & Haase, 2014; Suárez et al., 2020). In order to make inferences about distributional justice, participatory mapping often involves asking survey respondents to spatially locate their UGBS use, values and preferences which are then related to socio-demographics such as age, gender and income (e.g. Laatikainen et al., 2015; Raymond et al., 2016). However, provision of green space and measured and perceived accessibility can differ, and perceived distances may better explain actual use of UGBS (Schipperijn et al., 2010). For example, Paloniemi et al. (2018) used a PPGIS approach and found that many parts of the shoreline in Helsinki are perceived as inaccessible even though objective assessments suggest they are open to the public. Similarly, Laatikainen et al. (2015) concluded that accessibility of public spaces with regards to age, home ownership, type of residence, employment or family status can vary according to the type of accessibility measure used.

1.2. Procedural and recognition justice

Distributional justice is closely related to procedural justice. Previous studies have demonstrated the importance of social integration (including strong social networks) on accessibility to public parks, meaningful engagement of local communities, as well as open communication with residents in the languages of different ethnic groups (Enssle & Kabisch, 2020; Low, 2013; Verheij et al., 2020). They support early theoretical works on spatial justice demonstrating that the distribution of UGBS is equally important to the perceived fairness of the allocation process (Cropanzano & Randall, 1993; Tyler & Blader, 2003). Perceived environmental justice aligns with general principles within the multi-level governance and green space literatures emphasising the importance of inclusive processes for engaging with different actors and active citizen groups (e.g. Buijs et al., 2016, 2019).

Yet, measures for assessing recognition justice have received less attention in participatory mapping research and in ecosystem services research more widely (Langemeyer & Connolly, 2020). Recognition is indirectly considered in PPGIS research in terms of 'which public' participates in studies, taking account of different sampling biases (Brown, 2017; Brown et al., 2014, 2018). However, recognition also considers how an individual's basic right to flourish and to live a healthy and fulfilled life is supported or hindered by other individuals or groups (Schlosberg, 2013). Individuals need to be provided the political conditions that enable them to live a life that they perceive as meaningful (Martin et al., 2015, 2016). Gender-related inequalities is one key indicator of recognition – evidenced by gender-related barriers to recreation benefits in urban green spaces (e.g. Wang et al., 2015; Wright Wendel et al., 2012). Previous studies from the Nordic region indicate that women tend to be more active in urban green space than men, and also had higher self-reported well-being (Ode Sang et al., 2016). Movement patterns also differ between men and women – women moved in larger areas of the park than men and tended to seek out more inaccessible and remote parts of the park (Ode Sang et al., 2020). Sang proposed that these results could be explained by gender differences in experience of naturalness and safety, fear of crime, and perception of vegetation density and trail preferences. Further differences were found based on age – older residents move through more remote parts of the park compared with younger residents.

Here, we explore how positive or negative perceptions of procedural and recognition justice, and socio-demographics (gender, age, income), affect residents' values and preferences in terms of where they are located in the landscape and how far they are located from one's home. The latter is a distance measure that represents the cognitive range of 'places of importance' for respondents, which has been previously studied in relation to *place attachment* (Brown, Raymond, & Corcoran, 2015) and individual's everyday *activity space* (Hasanzadeh et al., 2017), but not particularly in the context of distributional environmental justice. Based on the results, we then discuss how PPGIS can support planning and management of UGBS for multiple elements of justice. Our study area represents urbanizations struggles similar to many rapidly developing cities around Europe. Copenhagen has focused heavily on housing and infrastructure development including green climate change adaptation projects (Blok, 2020; Tubridy, 2020) and various urban green initiatives (see Laage-Thomsen & Blok, 2020). However, these initiatives have led to rising social and environmental justice issues related to gentrification and consequent protests such as the opposition of planned residential development in the public open space of Amager Fælled (Friis, 2020). Considering spatial aspects of recognition and procedural justice may assist in addressing challenges with gentrification processes related to the implementation of new urban parks, particularly with respect to vulnerable residential neighbourhoods such as Urbanplanen in Amager, which is home to around 6000 inhabitants with high proportion of new migrants, high unemployment, and low incomes.

2. Methods

2.1. Study area

The island of Amager, Copenhagen region, is the most densely populated island in Denmark and a rapidly developing area being home

to around 210 000 inhabitants (Statistics Denmark, 2020a, 2020b, 2020c). Amager covers 96 km^2 land of diverse landscapes. The Northern part is the most urban, home to 75% of the Island population and characterised by dense multi-story buildings (population density of 5587/km^2) and a relative young and low income population compared to the region. The remaining 25% of the population is dwelling in the center and the South parts of the Island, which is dominated by detached houses with private gardens and an older and higher income population compared to the Northern part (own calculations based on Statistics Denmark, 2020a, 2020b, 2020c). The UBGS is characterised by large natural areas on the west such as the Amager Fælled nature reserve (which consists of meadows, lakes, and forests) and the large protected natural area of Naturpark Amager including the vast uncultivated wetlands of Kalvebod Fælled, as well as a nature reserve for protected wading birds. Amager also includes an artificial island and beach park (Amager Strandpark) and the Copenhagen airport on the east side of the island. Amager is very popular among sports enthusiasts and nature lovers (Danish Nature Agency, 2020).

2.2. Sampling and PPGIS survey design

In October 2018, 298 local residents living in Amager were recruited by a panel company. The panel company used a volunteer sampling approach i.e. advertised the survey by email to their online pool of potential survey volunteers living in the area. Those who agreed to participate were asked to fill in individually a web-based PPGIS survey using the Maptionnaire software. The survey included different parts collecting spatial and aspatial data. First, respondents were asked to place one or more point markings representing their values and preferences to relevant areas in Amager. The list of attributes were selected based on insights obtained during focus groups with The Partnership (a non-for-profit organisation that supports residents in the Amager neighbourhood of Urbanplanen) and included: *sports, environment, food (harvest), meeting with friends and family, relaxation, accessibility* and *safety*, while preferences for green space development consisted of: *creation of urban gardens, nature restoration, sporting facilities for residents, meeting places,* and *lighting* (for detailed definitions, see Appendix A, Table A1). In addition, several statements were presented to measure perceived recognition justice (PRJ) and perceived procedural justice (PPJ) in relation to access to environmental decision-making and participation in local current and future green space management or nature and community events (for list of statements, see Table 1). These statements were generated from theory concerning how well actors feel included and represented, and how they participate in decision-making (Fraser, 2012; Schlosberg, 2007). The statements also aimed to assess the capacities necessary for individuals to fully function and enjoy their lives in residential neighbourhoods, building on the capacities framework of Nussbaum and Sen (1993) and Sen (2009).

PRJ statements examined if respondents feel recognised and heard, how they recognise others in the community and how they perceive opportunities and constraints for participation in local decision-making (Anand et al., 2009; Pelenc & Ballet, 2015). Participants were asked to respond to these statements using a five-level Likert scale ("strongly disagree", "disagree", "neutral", "agree", "strongly agree"). The statements measuring PPJ focused on how respondents participate in community and environmental decision-making and in what ways (Bennett et al., 2019; Gustavsson et al., 2014). These statements were measured using a six-level Likert Scale ("never", "very rarely", "rarely", "occasionally" "frequently", "very frequently"). The final part of the survey included questions on socio-demographics including residential neighbourhood, age, gender, yearly pre-tax income, occupation, education and spoken languages.

2.3. Perceived environmental justice (PEJ) clusters

We used Exploratory Factor Analysis (Principle Axis Factoring) with the statistical software SPSS (v.25) to measure the latent variables of PRJ and PPJ. To date there are few procedural and recognition psychometric scales pertinent to urban green space management. Therefore, we drew scale statements from a variety of different sources as noted above and sought to explore the underlying dimensions rather than confirm them through confirmatory factor analysis. One statement ("I find it difficult to imagine the hopes and concerns of other people in my neighbourhood") was excluded from the analysis due to low correlation (<0.30) with other variables. Since it is expected that the measured factors (PRJ and PPJ) correlate, we used oblique rotation (direct oblimin) as our rotation method (Field, 2013). Factor scores were computed with regression and missing values (each variable had 3-12 missing values) were replaced with the variable mean. The Kaiser–Meyer–Olkin measure verified the sampling adequacy for the analysis (KMO = 0.86). Then, we used k-means clustering (k = 4) to cluster respondents based on their factor scores for PRJ and PPJ. In addition, we

Table 1
Perceived environmental justice statements used in the survey and exploratory factor analysis results (N = 289).

	Rotated Factor Loadings		Cronbach's alpha
	PPJ	PRJ	
Procedural justice			
I have participated in a nature protection day	**0.813**	0.008	
I have participated in a community meeting in relation to urban renewal	**0.800**	0.023	
I talk to the people working in the field (e.g., social and community workers)	**0.799**	−0.019	
I have participated in a focus group where I could voice my preferences for the future of outdoor areas in my neighbourhood	**0.775**	−0.066	
I talk to people in organisations I know (e.g., religious organisation, school, other)	**0.670**	0.102	
I have participated in a gardening event	**0.669**	−0.015	
I participate in community events via social media such as Facebook or Twitter	**0.609**	−0.017	
I talk to friends and family about green space management	**0.601**	0.181	
I have participated in the partnership program (e.g., activity groups)	**0.585**	−0.192	
I have participated in a school council meeting	**0.510**	−0.034	**.900**
Recognition justice			
I am prevented from participating in the management of green spaces or meeting spots due to cultural reasons[a]	−0.019	**0.764**	
I am prevented from participating in the management of green spaces or meeting spots due to restrictive rules or policies set by housing associations[a]	−0.106	**0.691**	
I am able to participate in the political activities in my neighbourhood if I want to	0.058	**0.682**	
I am prevented from participating in the management of green spaces or meeting spots due to a lack of money/finances[a]	−0.010	**0.666**	
I am free to express my political views in my neighbourhood	0.064	**0.625**	
I respect, value and appreciate people from different cultural backgrounds in my neighbourhood	0.082	**0.526**	
I am prevented from participating in the management of green spaces or meeting spots due to family responsibilities and/or schooling[a]	−0.028	**0.509**	
I have experienced discrimination because of my race, sexual orientation, gender, religion or age in my neighbourhood[a]	−0.058	**0.435**	**.824**
Eigenvalues	5.32	3.71	
% of variance	29.55	20.63	

Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization.
Notes.
[a] Scores reversed.

used ordinary least squares multiple regression to measure the effects of socio-demographic variables (age, income, gender) on the PRJ and PPJ factor scores.

2.4. Spatial analysis

First, in ArcGIS (v.10.3.1), initial data cleaning was performed by intersecting all PPGIS point data (i.e. mapped landscape value and preference points) with a 2 km buffer around the study boundary. Then, using point pattern analysis (Hengl, 2006) and a heuristic approach by testing different grid sizes for optimal visual representation, we created a Fishnet of 250 × 250 m and tabulated the number of points per cell size to portray density of values and preferences per cluster. In addition, we tested for significance in spatial clustering of mapped values and preferences (using Average Nearest Neighbour Ratio in ArcGIS) and examined their differences in spatial distribution per cluster.

A simplified land use map was created consisting of eight classes: 1) *Natural areas* (wetland, meadows, forest, semi-natural areas), 2) *Agriculture* (mainly extensive); 3) *Recreational green areas* (parks and urban green spaces including cemeteries, allotments and golf fields); 4) *Other green spaces* (private gardens, courtyards, in-between spaces excluding street vegetation); 5) *Water* (marine, lakes, streams); 6) *Paved, built-up* (roads and buildings); 7) *Coastal beach areas*, and; 8) *Non-classified* (Fig. 2A). The map was based on aggregation of land use classes from a basemap provided by Aarhus University (2019) (with manual reclassification of '*Non-classified*' category) and supplemented by municipal (www.opendata.dk) and national geodata (GeoDenmark 2020). To identify primary land use type around each value and preference point marking, a 100 m buffer (buffer size was estimated based on point pattern analysis as in Hengl, 2006) was tabulated with the land use raster using Zonal Statistics in ArcGIS. The results of the actual proportion of values and preferences per land use type were then compared to expected distribution based on the proportion of land use type in the overall landscape (% area size) (Brown et al., 2019).

Then, we used a distance-based measure (distance in meters) to examine proximity of mapped values and preferences to participants' home, termed "mapped values and preferences (MVP) home range" hereafter. Since individuals were not asked to map their exact home location, Euclidian distance was calculated from the centroid of their neighbourhood to each mapped value and preference point.

We used Welch's ANOVA to measure differences in distances (for both values and preferences) between PEJ clusters and neighbourhoods. Welch's ANOVA was used since the assumption of equal standard deviations (or variances) between groups was not met with our data. Because our data had extreme observations (distances are right skewed) and did not follow a normal distribution, we used a robust linear model to measure the effect of gender, age and income on values and preferences distances (i.e. mean distance of mapped points to one's home). The method is robust to outliers in the response variable (distances), as is the case in our data. For robust regression, we used the MASS package in R (Ripley et al., 2018) and the rlm () function.

3. Results

3.1. Respondents' characteristics

Out of the 298 local adult residents (above 19 years old) that took part in the online survey, 53.6% were female and 46.4% were male. In accordance with the spatial population distribution, 75% of respondents were dwelling in the Northern urban districts, while the remaining 25% were residents in the detached housing areas in the center and South parts of the Island. However, respondents' were significantly older compared to the Amager population. Only 27.1% of the respondents were in the age group of 20–39 years old (46.8% for Amager), while 41% of respondents were above 60 years old (21.8% for Amager) (Appendix B, Table B1). The respondents also had a higher than average mean income of 374 000 DKK (compare to 366 000 DKK for Amager), and a higher share with a formal education of a Bachelor degree or higher (67.6% compare to 48.9% for Amager). Thus, compared to census data, our sample was biased towards older and more educated residents with higher yearly income.

3.2. PEJ clusters in relation to socio-demographics

We retained two factors based on scree plot inflections and the theoretical assumptions that the two scales should measure PRJ and PPJ (see Table 1 for rotated factor loadings of all items). The items that cluster on the same factor suggested that factor 1 represents PPJ and that factor 2 represents PRJ. A two-factor solution was chosen since we theoretically focused on procedural and recognition justice and because a third factor would have explained only a little more variance: factor 1 explained 29.55% of variance, factor 2–20.63%, while factor 3 would have explained only 8.95% (see scree plot in Appendix C, Fig. C1). Then, based on the k-means clustering (see Appendix C, Fig. C2), the respondents were classified into four PEJ clusters (Fig. 1;Appendix C, Fig. C2). Respondents in different clusters shared similar demographic

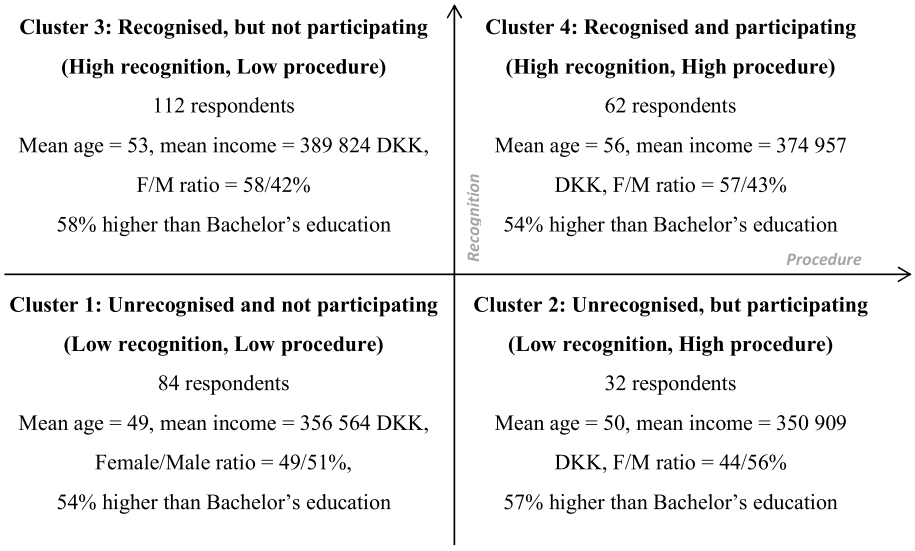

Fig. 1. Key socio-demographic characteristics per PEJ cluster.

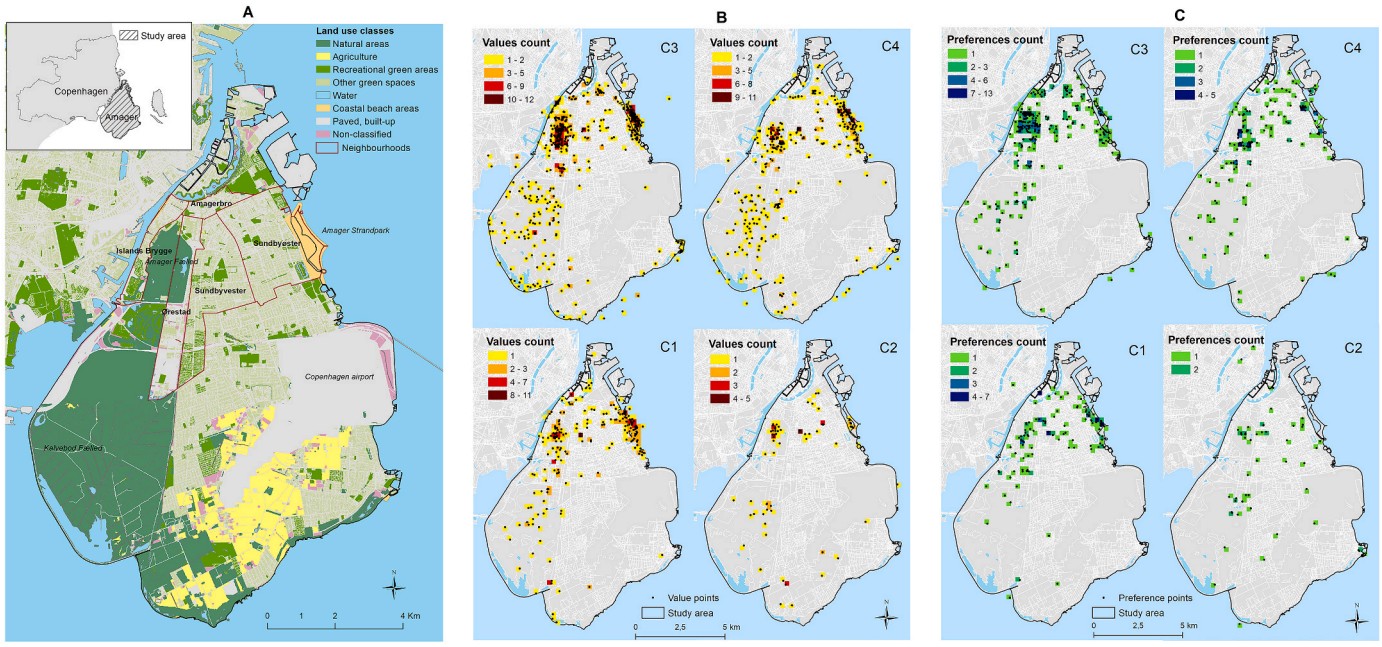

Fig. 2. A) Study area, neighbourhoods and land use classes used in the analysis; and density (in 250 m grid cells) of mapped landscape values (2 B) and preferences (2C) per PEJ cluster (C1 = LR/LP; C2 = LR/HP; C3=HR/LP; C4=HR/HP).

characteristics as in our overall sample: generally older than average, showing relatively equal gender proportions, having above the average income and of high education (Fig. 1).

Overall, respondents scored higher on questions related to recognition justice (mean score = 3.86) than to procedural justice (=2.22). Results from an ordinary least squares multiple regression analysis showed that gender had a statistically significant effect on both PRJ (p = 0.016) and PPJ (p = 0.044) factor scores, when controlled for age and income (Table 2). While female and male respondents scored fairly equally on questions related to recognition (mean PRJ score for female = 3.89 and male = 3.82), males stated to participate more in environmental decision-making with mean PPJ score being slightly higher (= 2.30) than mean score for females (=2.14).

3.3. *PEJ clusters in relation to landscape values and preferences*

3.3.1. *Spatial distribution*

All four clusters showed significant spatial clustering of values (Average Nearest Neighbour (ANN) ratio <1, z-score ranging from – 19.7 to - 6.6 and p < 0.001) and preferences (ANN <1, z-score ranging from −13.9 to – 2.1 for all clusters, p < 0.001 – clusters 1, 3 and 4; and p = 0,037 for cluster 2). Fig. 2B and C shows the spatial distribution of mapped values and preferences per PEJ cluster. Among all clusters, value points were disproportionally located in *natural areas* (C1 = 38.0%, C2 = 59.3%, C3 = 50.7%, C4 = 47.2% of values and 15.0% of the whole landscape) such as the Amager Fælled nature reserve and Kalvebod Fælled semi-natural area. In addition, respondents from all clusters placed disproportionally more values in *recreational green areas* (C1 = 7.1%, C2 = 8.5%, C3 = 8.9%, C4 = 10.7% of values, 5.9% of the landscape) e.g. parks such as Englandsparken and Remiseparken which provide a range of recreational opportunities and facilities for sports, play and socializing. Respondents also valued highly *coastal beach areas* particularly in Amager Strandpark, which is an artificial island with a newly developed beach popular for recreation. However, respondents in cluster 1 (recognised and not participating) placed more values than any other cluster in beach areas (C1 = 23.9% of values, C2 = 3.4%, C3 = 14.1%, C4 = 16.7%; 0.7% of landscape). For all clusters, values were disproportionally less concentrated in the rest of the land use classes (*agriculture, other green, water, paved/built-up and non-classified*) compared to the proportion of land use in the area. Similar overall tendencies were seen between male and female respondents and proportions were roughly the same.

Results for preferences slightly differed both in terms of PEJ clusters

Table 2
Recognition and procedural justice questionnaire scores and socio-demographics. Coefficients with lower and upper bounds of 95% confidence intervals.

Variable	Coefficient	Std. Coefficient	Std. Error	t-Statistic	p
Recognitional Justice					
Intercept	−.523 (−0.984, −0.076)		.230	−2.301	0.022*
Gender (male)	−.315 (−0.570, −0.060)	−0.172	.129	−2.438	0.016*
Age	.011 (0.003, 0.018)	0.191	.004	2.709	0.007**
Income (thousands)	.0006 (<0.0001, 0.0012)	0.138	.0003	2.027	0.044*
Procedural Justice					
Intercept	−.241 (−0.716, 0.234)		.241	−0.999	0.319
Gender (male)	.274 (0.008, 0.541)	0.146	.135	2.030	0.044*
Age	.004 (−0.004, 0.012)	0.070	.004	0.982	0.327
Income (thousands)	−.0002 (−0.0008, 0.0003)	−0.047	<.001	−0.674	0.501

Notes: Residual standard error: 0.8926 on 205 degrees of freedom (81 observations deleted due to missingness). Multiple R-squared: 0.06394. Adjusted R-squared: 0.05024. F-statistic: 4.668 on 3 and 205 DF. p-value: 0.003539. *p < 0.1; **p < 0.05; ***p < 0.01. Gender "male" is coded as 1 in the regression. Residual standard error: 0.934 on 205 degrees of freedom (81 observations deleted due to missingness). Multiple R-squared: 0.033. Adjusted R-squared: 0.018. F-statistic: 2.298 on 3 and 205 DF. p-value: 0.078. *p < 0.1; **p < 0.05; ***p < 0.01. Gender "male" is coded as 1 in the regression.

and gender. Similarly to the values, in all clusters, preference points were disproportionally concentrated in *natural areas* (C1 = 31.3%, C2 = 26.7%, C3 = 47.5%, C4 = 44.8% of preferences, 15.0% of the landscape) and *coastal beach areas* with cluster 1 indicating highest concentration in beach areas (C1 = 20.8%, C2 = 2.2%, C3 = 8.9% C4 = 9.7% of preferences, 0.7% of landscape). In addition, preferences of respondents who feel unrecognised (cluster 1 and 2) were more concentrated *in other green areas* (12.5% and 22.2% of preferences, 12.8% of landscape) and for those who feel unrecognised, but participate (cluster 2) preferences were also disproportionally more located in *paved, built-up areas* (33.3% of preferences, 28.1% of the landscape), for example, *in terms of meeting places in* harbours or *creation of urban gardens* around residential buildings. In addition, the results indicated some gender differences in regards to preferences and land use: males mapped disproportionally more and roughly twice as high number of preferences for *recreational green areas* than females (M = 19.1% and F = 8.3%, 5.9% of landscape). For the rest of the land use classes, proportions were similar between female and male and across clusters.

In terms of the type of landscape attributes respondents assigned (Table 3), the highest number of values points across all clusters was for *environment* (22.1%), followed by *relaxation* (18.7%) and *sports* (17.7%), lowest was for *safety* (6.3%). Highest number of preference points was allocated for *lighting* (27.2%), followed by *nature restoration* (26.5%), while the smallest was for *sporting facilities* (12.1%).

Respondents in cluster 2, 3 and 4 mapped values mostly for the *environment* (i.e. they enjoyed the animals, plants and nature there) (% points in cluster = 23.9%, 23.9%, 22.1% respectively) (Fig. 3). Respondents in cluster 1 (scoring lowest on recognition and procedural justice) on the other hand, placed the most value markings for *sports* (20.2%). In general, there were very small proportional differences in the assignment of values between males and females (Table 3). Both men and women valued UGBS mostly for the *environment* (F = 25.6% of values, M = 23.7%) and *sports* (F = 24.2%, M = 23.4). However, respondents scoring low on procedural justice (cluster 1 = 28.0% and cluster 3 = 36.4% respectively) and females (34.1%) assigned most preferences for *lighting* (i.e. places where more lighting should be installed), while those who scored high on PPJ (cluster 2 = 26.5% and cluster 4 = 39.0%) and males placed most preference points for *nature restoration* (i.e. places which should be restored for the protection of native plants and animals).

3.3.2. MVP home range

Overall, the results of the distance-based measures from centroids of one's neighbourhood showed larger mean distance for values (= 3439 m) than for preferences (=2627 m). Results from Welch's ANOVA indicated that differences in values and preferences home range between PEJ clusters were not statistically significant, while the differences between neighbourhoods were (Table 4). However, Games-Howell post-hoc tests revealed that these differences are significant mostly due to a single neighbourhood – the harbourfront neighbourhood of Islands Brygge (Fig. 1). This is also evident from the raincloud plots in Fig. 4 (AB and CD).

Table 5 illustrates the robust regression analysis results of socio-demographic variables (gender, age and income) on both values and preferences distances. In both models, the effect of gender on distances is statistically significant ($p < 0.001$), with males having higher distance ranges for values and preferences (when controlled for age and income). Across all clusters, female respondents mapped values and preferences closer to home compared to male respondents (see Fig. 5 for an illustrative example), with mean distance of values = 3182 m for females and 3886 m for males, and similarly for preferences - females = 2461 m and males = 2951 m (Fig. 4 E and F).

4. Discussion

4.1. PEJ clusters and landscape values and preferences

The purpose of this study was to develop and test a PPGIS method for assessing place-based differences in values and preferences with respect to procedural, recognition and distributional justice in urban planning. The new method for spatially assessing these multiple elements of justice has a number of strengths. First, the clustering method enables spatial targeting of infrastructure and facilities to those with specific justice needs, which is closely linked to the distributional aspect of environmental justice, but it is not limited to (un)equal access to UGBS. Infrastructure can also be targeted in relation to aspects of environmental quality. Looking at the overall sample, we found that respondents valued most areas for the quality of the *environment* (i.e. presence of plants, animals and nature there) and least for *safety,* and in accordance they mapped most preferences for development of *lighting* for better safety and security. However, the EJ clustering showed an important finding from this work concerning the dissimilarities in type and location of values assigned by respondents who self-reported feeling unrecognised and do not tend to participate in community and environmental decision-making (Cluster 1) compared to respondents in all other clusters. Those participants value public areas for sports over

Table 3
Frequency of mapped values and preferences points per cluster and gender. Bold numbers represent highest proportional value per cluster.

			Cluster 1 (LR/LP)	Cluster 2 (LR/HP)	Cluster 3 (HR/LP)	Cluster 4 (HR/HP)	Female	Male
	Total N points (all clusters)	% points (all clusters)	% points in cluster	% points	% points	% points	% points	% points
Values								
Accessibility	176	14.5	16.3	12.7	13.8	14.6	11.1	14.2
Environment	268	22.1	17.2	**23.9**	**23.9**	**22.1**	25.6	23.7
Food (harvest)	79	6.5	5.6	14.1	5.5	7.2	6.1	6.1
Meeting with friends and family	173	14.2	15.0	15.5	12.9	15.5	13.5	13.6
Relaxation	227	18.7	19.3	14.1	18.6	19.3	14.7	15.9
Safety	77	6.3	6.4	8.5	6.7	5.2	4.8	3.1
Sports	215	17.7	**20.2**	11.3	18.6	16.0	24.2	23.4
Total	1215	100	100	100	100	100	100	100
Preferences								
Creation of urban gardens	145	14.9	11.9	24.5	12.9	14.9	12.2	19.3
Lighting	265	27.2	**28.0**	12.2	**36.4**	22.0	**34.1**	20.5
Meeting places	186	19.2	24.6	18.4	18.2	16.3	15.0	18.0
Nature restoration	258	26.5	17.8	**26.5**	23.5	**39.0**	31.9	**27.3**
Sporting facilities for residents	118	12.1	17.8	18.4	9.1	7.8	6.9	14.9
Total	972	100	100	100	100	100	100	100

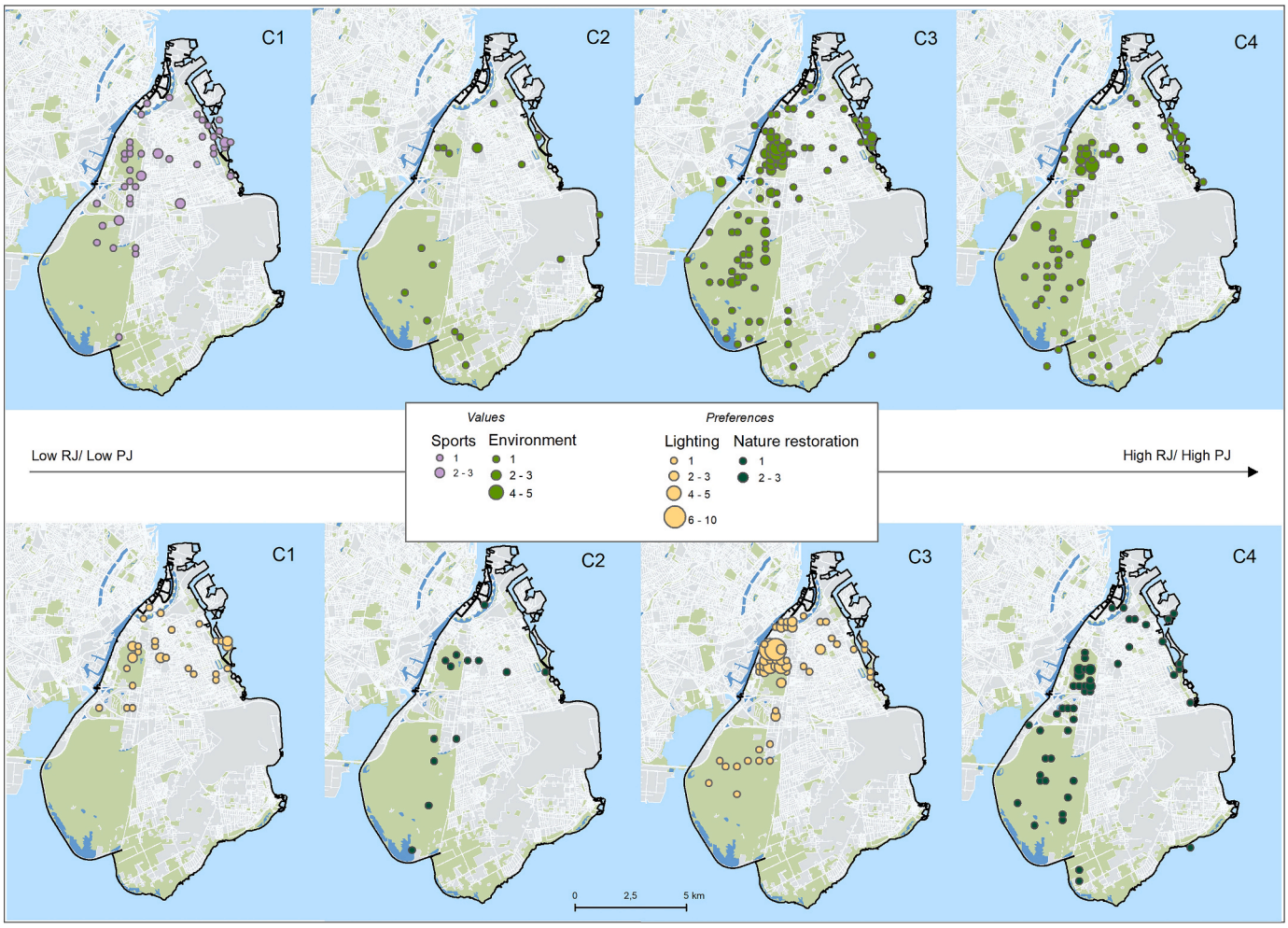

Fig. 3. Spatial distribution of highest proportion of mapped values > 20% (top) and preferences >25% (bottom) per PEJ cluster (C1 (LR/LP), C2 (LR/HP), C3 (HR/LP), C4 (HR/HP).

Table 4
Differences of values and preferences distances to respondents' home between clusters and neighbourhoods (Welch's ANOVA).

	Values distance	Preferences distance
Between clusters	F (3,218.3) = 0.741, p = 0.529	F (3,134.73) = 0.834, p = 0.476
Between neighbourhoods	F (4,432.32) = 17.730, p < 0.001***	F (4,197.15) = 10.152, p < 0.001***

Notes: *p < 0.1; **p < 0.05; ***p < 0.01.

nature-based/environmental activities and tend to recreate on beaches rather than in large natural areas. These findings further support the works of Kabisch and Haase (2014), who found that although Tempelhof in Berlin is accessible to a large number of residents, specific groups such as older residents and immigrants use it less since they have different cultural and recreational needs (e.g. immigrants prefer barbeque areas and areas for picnicking), which are not well-reflected in the planning and design of green spaces. Rigolon (2016) also showed that analysis of green space proximity may not identify issues in environmental justice, however inequalities in green space size and quality are evident in various places and countries in relation to low socio-economic status and ethnic minorities.

The method presented here enabled consideration of the interface between multiple elements of justice and land-use types, which has been highlighted as an important knowledge gap in ecosystem management research (Langemeyer & Connolly, 2020). This spatial method also has implications for environmental governance. Much of the existing literature relies on the engagement of 'active citizens', when citizens act voluntary to co-produce knowledge related to sustainability (Moulaert et al., 2013), and innovations or interventions are employed for scaling up or scaling out nature-based solutions in urban areas (see Buijs et al., 2016, 2019). However, like our results suggest not all residents interests in urban green space management are 'active.'

The presented psychometric scale captures underlying dimensions of procedural and recognition justice, which are often ignored in urban greening projects (see e.g. Shokry et al., 2020; Verheij et al., 2020; Wolch et al., 2014) and continue to be overlooked in recent attempts to develop indicators of justice within the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (Schröter et al., 2020). The scale was also useful to distinguish between PEJ groups. The PRJ and PPJ factors accounted for over 50% of the overall variation in justice scores. The procedural justice dimension had higher reliability than recognition justice (Cronbach Alpha = 0.900 vs. 0.824). Interestingly, scale items relating to participation in nature restoration and community meetings was more closely associated with the procedural justice dimension compared with talking with people in organisations, suggesting that organised meetings play a stronger role in supporting procedural justice than informal encounters. The strongest loading item for recognition justice was: "I am prevented from participating in the management of green spaces or meeting spots due to cultural reason" highlighting the influence of cultural norms on UGBS use.

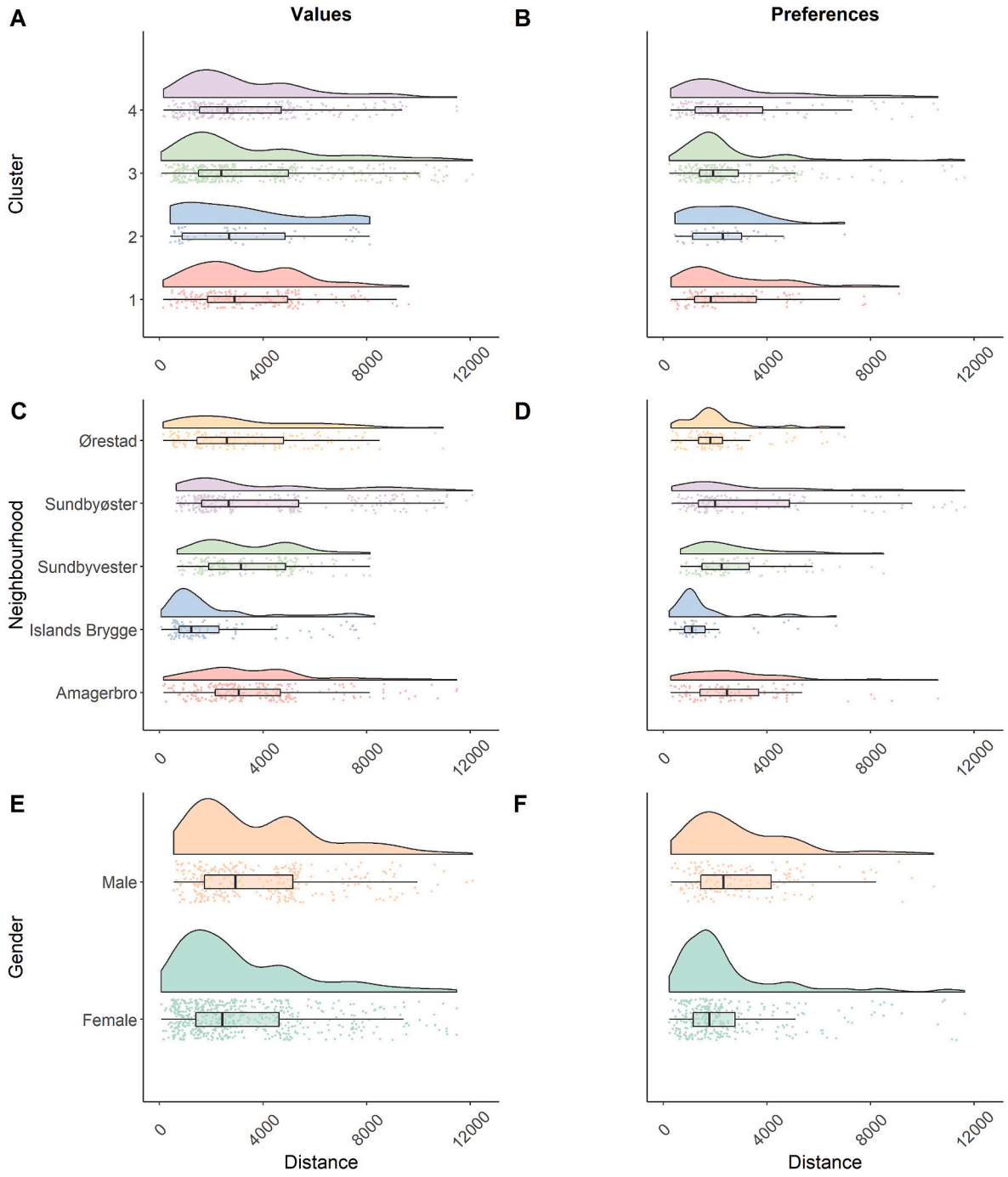

Fig. 4. Distance (from neighbourhood centroid, in meters) of mapped values and preferences by PEJ cluster, neighbourhood and gender.

Cultural norms have been considered indirectly by comparing differences in urban space visitation patterns across sub-groups. For example, passive recreation and social activities like picnicking, barbequing, and socializing, may be more important for migrants or ethnic minority groups while active recreation such as hiking in forests, camping, jogging and dog walking may be more important for non-migrants (Floyd, 1999; Gobster, 2002; Schelhas, 2002). Also, non-migrants and ethnic minorities have a greater preference for more developed facilities and amenities that promote more social interaction (Gobster, 2002; Payne et al., 2002). In contrast, more affluent groups tend to socialise more frequently in forests and other less-developed areas (Seeland et al., 2009).

Explanatory power of recognition justice could be improved by experimenting with additional measures that not only address indicators of capability but also address gender relations tied to ethnicity as well as those of class (Anthias & Yuval-Davis, 1989); and issues of domestic, gender or honour-based violence (incident committed to protect the honour of a family or cultural group) which affect the recognition of individuals or groups in the community (see Anthias, 2014).

4.2. *Gender differences*

The findings from this case study recurrently demonstrated the role of gender when assessing procedural, recognition and distributional justice. Gender had a significant effect on the perceptions of recognition and procedural justice. On average, women scored lower on procedural

Table 5
Robust regression results for the effects of sociodemographic variables on values and preferences distances to respondents' home.

Variable	Coefficient (with 95% CI)	Std. Error	p-value
Values distance			
Intercept	2381.766 (1840.382, 2944.499)	321.854	<.001
Gender (male)	718.897 (340.252, 1086.807)	185.577	<.001
Age	7.052 (−3.646, 17.32)	6.088	.247
Income (thousands)	0.543 (−0.38, 1.436)	0.416	.191
AIC: 13981.932			
Preferences distance			
Intercept	2234.464 (1611.561, 2916.963)	320.392	<.001
Gender (male)	696.832 (371.362, 1040.951)	152.148	<.001
Age	−11.845 (−22.072, −1.357)	5.219	.024
Income	0.875 (−0.184, 2.083)	0.482	.07
AIC: 7506.6			

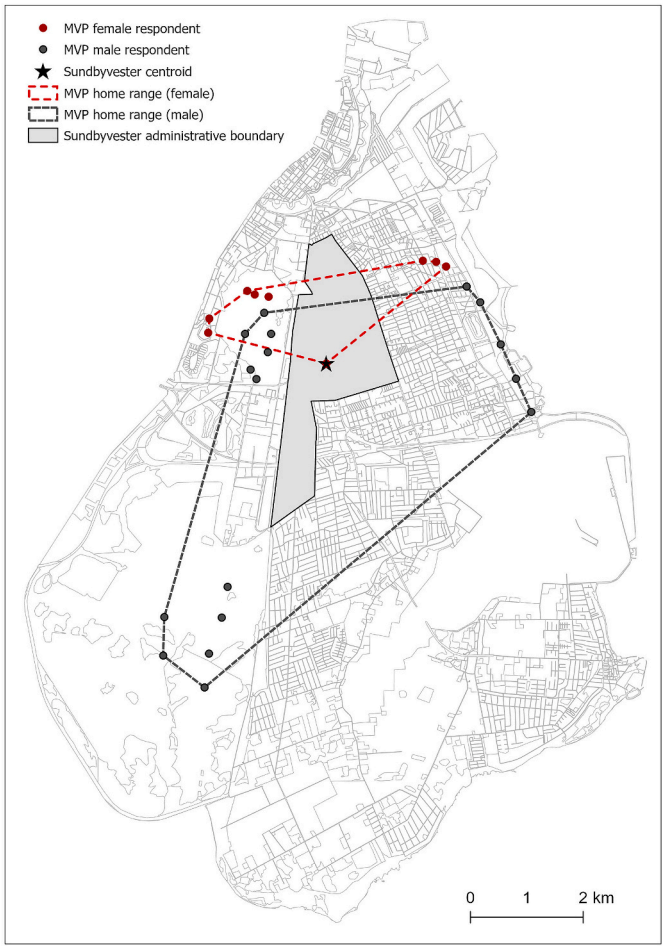

Fig. 5. An example of mapped values and preferences (MVP) home range for a random female and a random male respondent living in the same neighbourhood (Sundbyvester). The individual respondents were selected as closest to the median distance of MVP to one's home among the female and male sample respectively.

justice than men, indicating that they are less engaged in decision-making processes. In addition, women mapped landscape values and preferences closer to home than men, which could be influenced by different interrelated social factors. This is despite wider studies indicating that women in the Nordic region tend to be more active in green spaces with higher naturalness ratings, and associate greater aesthetic values and well-being outcomes with these areas (Ode Sang et al., 2016). In vulnerable or marginalised areas, specific attention needs to be devoted to how neo-liberal trends such as the provision of increased services and amenities in green areas could affect the needs of women. The supply of infrastructure and design of recreational facilities in cities may not respond to women's specific needs. For example, Lindberg and Schipperijn (2015) found that in Copenhagen, males use UGS and their facilities more often than females, suggesting the need for making public spaces more inclusive and attractive to women. Our results support these findings as males mapped disproportionally and roughly twice as much preference points in recreational green areas than females. On the other hand, in both western and non-western contexts, many UGBS cannot be used by women especially due to cultural, religious or safety reasons (Fenster, 2005; Kronenberg et al., 2020; Leszczynski & Elwood, 2015). Fear and safety are a perceived accessibility issue that crosses boundaries of nationalities, age and social status (Fenster, 2005), which was also suggested in our study as women from all clusters mapped most preferences for lighting. For example, Amager Fælled, a natural area where many of the preferences were clustered, has been perceived by women from various ages and ethnicities as scary and hostile area because of past indecent exposure of men. This also reflects issues of recognition and interactional justice as the appropriation of public space by some groups leads to restricted use by others (Kronenberg et al., 2020).

Another reason for the reported gender difference in the mapped values and preferences home range could be that women are mostly responsible for domestic and care work (Fenster, 2005; Garcia-Ramon et al., 2004; Ortiz Escalante & Gutiérrez Valdivia, 2015), thus, forming stronger place attachment to home and close surroundings. Yet, being the main care-givers also means that women often have extensive knowledge and understanding of the needs of others including children and the elderly. In Barcelona, Spain, various participatory projects led by feminist architects and planners have shown that incorporating women's preferences and needs in urban planning and design can transform neighbourhoods into safe, attractive and inclusive spaces for a variety of users including the elderly, young parents and children (Ortiz Escalante & Gutiérrez Valdivia, 2015). Similar aspects are also reflected in the sense of place literature – a shift from an essentialist, fixed tradition on sense of place to progressive plural perspectives on place recognition and the possibility for multiple fixed and fluid connections in response to different mobilities and cultural representations of place (Di Masso et al., 2019).

4.3. Limitations and future perspectives

A major limitation of this work is limited size and the lack of representativeness of the study sample in regards to age, education and income. Participants were older, more educated and with higher income compared with the population recorded in the Danish census. While issues of representative bias in spatial data are a common concern in PPGIS literature (Brown and Fagerholm, 2015; Brown & Kyttä, 2018), it is important to note that the sampling procedure of using a panel company may have considerably affected our possibilities to reach more vulnerable groups (such as migrants or low-income communities). Future research could make use of a combination of random and purposive sampling (see e.g. Brown, Raymond, & Corcoran, 2015) and more qualitative methods (such as interviews and focus groups) to reach diverse stakeholders, as well as more silent and under-represented groups. However, the study has substantial methodological innovation. The methods for spatial assessing the associations between recognition and procedural justice and values and preferences could be further developed in other studies with more representative samples.

Unlike previous studies which have shown that age, self-reported knowledge, income and place of residence have impact on spatial distribution of values and preferences (Laatikainen et al., 2015; Paloniemi et al., 2018; Raymond et al., 2016; Suárez et al., 2020), here we did not identify significant differences between age, income groups and neighbourhoods, which could be largely due to our limited and homogenous

sample. We strongly encourage the use and testing of the presented PPGIS methodology in future research, where larger, more representative and diverse sample can gather stronger empirical evidence. The proposed PPGIS method can be also further improved by collecting home locations (in accordance with privacy and ethics standards) to examine further the relationship between environmental justice, place attachment and values and preferences home range using both distance-based and area-based measures (Brown, Raymond, & Corcoran, 2015). In terms of the empirical findings, future research could examine more deeply similarities and conflicts between past, current and future UGBS planning and management practices in relation to stated preferences of local residents e.g. how investments and maintenance over the past ten years into lighting, nature restoration and sporting facilities may affect different user groups' needs and recreational demands.

5. Conclusions

This study builds upon current PPGIS literature by combining aspatial and spatial measures of environmental justice in new ways. Our approach focuses on the perceived aspects of recognition and procedure, thus, helping to identify some underlying reasons why UGBS user groups may not be involved in environmental decision-making. This could help researchers and planners gain deeper understanding of not only who is included and who is excluded in multi-level governance and planning processes, but what are the less salient barriers and enablers of participation for those most at stake.

For example, the spatial assessment of justice elements could be particularly relevant for new green initiatives such as Nordhavn area in Copenhagen, which have brought 'low-carbon gentrification' (Bouzarovski et al., 2018) concerns meaning that only wealthier populations are able to benefit from newly developed low-carbon infrastructures such as energy-efficient housing, renewable energy provisioning and car-free transport (Blok, 2020). However, economically privileged classes are also not homogenous and may experience a subset of power dynamics and socio-cultural disparities as suggested by our results. Despite that participants in this study represented high-income groups, there were still clear differences among them in terms of gender and perceptions of recognition and procedural justice e.g. women participated less in environmental decision-making and used UGBS closer to home compared to men. This implies that environmental justice inequalities can be deeply embedded in everyday spaces and practices, not exclusive to the more affluent and educated groups of society. To enhance our understanding of why and how low recognition or procedure justice is also experienced by lower-income and more vulnerable groups, further research could include qualitative approaches such as interviews or focus groups with key informants belonging to age and ethnic groups from different socio-economic backgrounds.

Recent arguments in the justice literature calls for a more intersectional and decolonial approach to environmental justice that acknowledges the indispensability of both humans and non-humans to ecosystem management, while also recognising power dynamics and complex interactions among various types of injustice (see e.g. Menton et al., 2020). Supporting these debates and recent developments in feminist geography (Hopkins, 2018; Mollett & Faria, 2018; Rodó-de-Zárate & Baylina, 2018), we argue that planning inclusive and environmentally just UGBS requires not only incorporating gender perspectives, but a more fluid, intersectional and relational understanding of space (Anguelovski et al., 2020). This means going beyond provision of safety and services to people of different genders, race, age or class, but acknowledging embedded inequalities and power relations and how we understand, use and design urban space that reflects the everyday needs of different groups (see e.g. Ortiz Escalante & Gutiérrez Valdivia, 2015; Tozer et al., 2020), especially those that are often marginalised (e.g. the elderly, minorities, people with disabilities) in mainstream urban planning.

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Appendix A

Table A.1
List of landscape values and preferences used in the survey.

Value categories		Preference categories	
Sports	*I value these places because I enjoy playing individual or group sports there*	Creation of urban gardens	*Use these dots to identify places where you would like to be involved in the creation of urban gardens for growing fruits and vegetables*
Environment	*I value these places because I enjoy the plants, animals, and nature there*	**Nature restoration**	*Use these dots to identify places which should be restored for the protection of native plants and animals*
Food (harvest)	*I value these places because they provide food for harvesting, such as fruit and vegetables*	**Sporting facilities for residents**	*Use these dots to identify places where new sporting facilities (football grounds, tennis courts, skating areas) should be developed*
Meeting with friends or family	*I value these places because I enjoy meeting with friends or family there*	**Meeting places**	*Use these dots to identify where meeting places (e.g., BBQ facilities, music venues, tables, etc.) should be developed*
Relaxation	*I value these places because they provide opportunities to rest and relax*	**Lighting**	*Use these dots to identify places where more lighting should be installed*
Accessibility	*I value these places because they are easily accessible and enjoyable for my family (i.e., children of diverse ages)*		
Safety	*I value these places because they are well-lit and the majority of foot-paths have clear sight lines and well-kept vegetation*		

Appendix B

Table B.1
Socio-demographic key numbers of sample compare to official statistics.

	Variable	Sample	Amager
Spatial distribution	Northern urban districts (KBH S)	75,1%	76,8%
	Southern municipalities (Tårnby and Dragør)	24,1%	23,2%
Age	20–39	27,1%	46,8%

(*continued on next page*)

Table B.1 (*continued*)

	Variable	Sample	Amager
	40–59	31,9%	31,4%
	60-	41,0%	21,8%
Gender	Female	53,6%	51,2%
Education	Above BA	67,6%	48,9%
Income	Mean (DKK)	374000	366000

Sources: Statistic numbers from Amager is calculated by aggregating numbers from the two Copenhagen Municipal districts (Amager Øst and Amager Vest) and the two municipalities Tårnby and Dragør. All numbers are calculated from the adult population above 19 years old in accordance with the sample age segments. Statistic from the Copenhagen districts (https://statistikbanken.kk.dk/), statistics from Tårnby and Dragør (www.statistikbanken.dk).

Appendix C

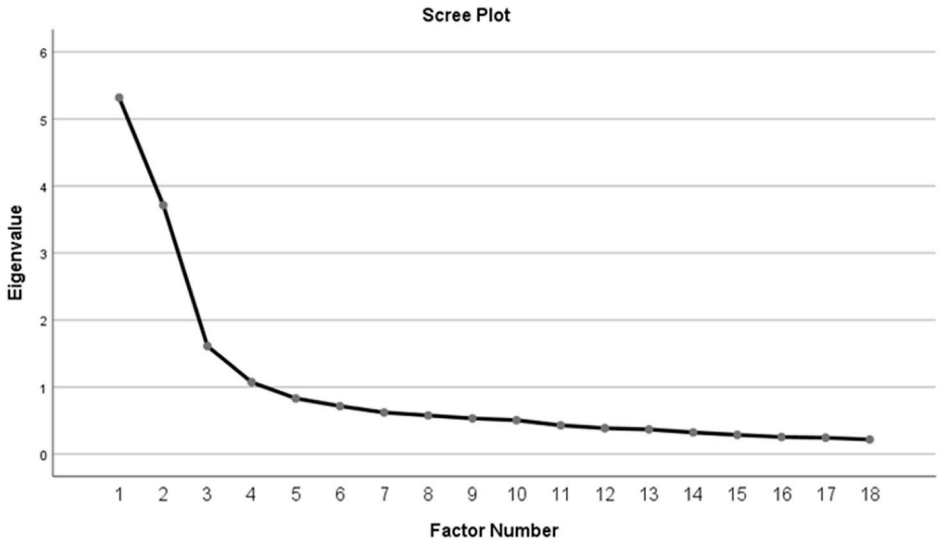

Fig. C.1. Scree plot for factor analysis.

Fig. C.2. K-means clustering of Procedural Justice and Recognition Justice

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