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Paying for the tree on the other side of the city? How greenness and income influence WTP for healthier cities☆

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ABSTRACT

Urban green infrastructure (UGI) provides essential environmental, health, and well-being benefits, yet its distribution in cities is uneven. As UGI gains recognition, improving its availability for all residents has become a priority, though high implementation costs remain a barrier. Analyzing residents' preferences and willingness to pay (WTP) for greening initiatives is key to understanding public support. This support, however, may depend on many factors, two of which are the focus of this study: (1) whether high-income individuals are more willing to pay for urban greening and (2) how the greenness of residents' neighborhoods influences their preferences (i.e., whether respondents are willing to pay for the tree on the other side of the city).

A discrete choice experiment (DCE) with 760 respondents in Vienna was conducted to analyze preferences and calculate WTP for urban greening measures, using a mixed logit model with correlated random parameters. The study incorporated two measures of income (net income and income sufficiency) and two measures of neighborhood greenness: objective proximity to UGI and subjective perceptions, which were found to be uncorrelated.

The results of the DCE suggest that while some heterogeneity was found, the overall WTP for greening programs is not significantly different between respondents from neighborhoods with different greenness, regardless of whether that greenness was measured objectively or subjectively. Conversely, income (sufficiency) significantly influences the probability of choosing an alternative over the status quo, resulting in a lower WTP of financially constrained respondents. However, this difference reflects financial capacity rather than lower appreciation for urban greenery, as these respondents still express broad support for greening initiatives when directly asked. Notably, support remains strong across all income and greenness groups for programs targeting areas beyond respondents' own neighborhoods. Together, these findings suggest a citywide appreciation of UGI that extends beyond socio-economic groups and local neighborhood conditions, providing encouraging evidence for broad public support of equitable urban greening policies.

1. Introduction

Urban green infrastructure (UGI) is an essential component of livable and sustainable cities. Parks, street trees, and other green elements are not only aesthetically pleasing, but also provide habitat for animals and are known to have positive effects on citizens' well-being. They encourage physical activity [1], reduce stress [2], and improve overall health, including mental health [3–6]. In addition, urban greening and unsealed surfaces reduce the urban heat island effect and the associated heat exposure of citizens [7]. In the face of rising temperatures in urban areas, the expansion of green spaces and amenities is therefore essential to mitigate the negative health impacts of climate change on urban populations.

The distribution of green amenities within cities is often highly uneven, resulting in significant disparities in access to green spaces and in the provision of benefits from urban green infrastructure, including the mediation of environmental stressors, such as urban heat islands and air pollution [8,9]. Scholars refer to a supply-demand mismatch [10–12] when groups or areas most in need of the ecosystem services provided by UGI are often the least supplied. While everyone benefits from UGI, low-income households tend to rely more heavily on public green spaces because they are often more exposed to urbanization-related pressures and have fewer resources to adapt or relocate to neighborhoods with better green coverage [13,14]. At the same time, low-income households are more prone to negative health outcomes than other income groups [15–17], as health is

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frequently tied to affordability [18] and having poorer health increases the vulnerability to the adverse health effects, e.g. of urban heat [19]. In this regard, research has shown that health inequalities are reduced among populations with greater exposure to urban green [6]. Thus, the inequitable distribution of UGI is a critical environmental justice issue with profound public health implications [20].

As the importance of urban green infrastructure gains recognition, enhancing its availability has become a priority for many local governments [21,87]. While the creation of larger parks in already densely built urban areas is rarely feasible, small-scale greening measures such as street tree plantings, pocket parks, and green facades offer a practical and effective solution to bring UGI to underserved neighborhoods. These localized interventions can be strategically implemented to address disparities and deliver essential ecosystem services and health benefits. However, UGI projects rely heavily on public funding [22,88] and limited financial resources can hinder their broader implementation and maintenance. In addition, municipalities' short-term decision-making cycles, fragmented departmental budgets, and austerity-driven resource constraints also pose challenges to securing long-term funding for UGI [23–25]. To address these limitations, additional taxes or user fees have been proposed as alternatives to funding UGI through general municipal funds. For example, in stormwater management, user fees have been successfully implemented in countries such as the United States, Canada, Germany, and Australia [26]. While such models have the potential to provide a sustainable financing source for urban greening, they also raise questions about equality. To enable the equitable expansion of urban green infrastructure the support of citizens from diverse socioeconomic backgrounds is needed. Nevertheless, it is essential to ensure that financing mechanisms do not disproportionately burden low-income individuals, who often already face limited access to UGI. Against this background, understanding citizens' willingness to contribute financially, along with the factors and group differences that influence this willingness, is key for designing fair and inclusive programs.

Previous studies have analyzed citizens' willingness to pay (WTP) and preferences for urban green infrastructure in cities such as Beijing [27], Manchester [28], and Seville [29], revealing substantial variations in WTP among urban populations shaped by individual and geographic factors. Understanding this heterogeneity of preferences is essential, as group differences offer valuable insights for developing urban policies that are both more widely accepted and more effective (L. [30]). Two key findings from previous studies on preference heterogeneity motivate our research. First, evidence shows that higher income is associated with a greater WTP for urban greening, highlighting how financial constraints limit both the willingness and the capacity to support such initiatives [31–33]. Some studies, however, find no or a negative impact of income on WTP, with underlying reasons regarding the latter not yet well understood [27,34,35].

Second, given the spatial patterns of UGI within cities and the localized nature of their effects [36], the question arises as to how the current distribution of urban greenery influences citizens' preferences and WTP for additional greening programs. Two hypotheses can be proposed: (1) Residents of already greener areas, in which additional greening measures will have less noticeable impact on ecosystem services and health benefits, may exhibit lower WTP for citywide greening efforts. Some may ask provocatively, “Why should I pay for a tree on the other side of the city?”. Studies supporting this hypothesis find that individuals living in greener areas are indeed less likely to support urban greening programs [37,38], whereas those with limited proximity or exposure to urban green spaces, or who are likely to benefit more from new green spaces, are more likely to express support [39]. (2) Conversely, residents of greener areas may have a stronger preference for urban green infrastructure, reflected in their choice of where to live, and may support further greening efforts. Empirical studies have also supported this hypothesis, revealing that households with closer proximity to green spaces tend to place a higher value on them [40].

Beyond the mixed evidence on the effect of greenness on WTP, the interaction between income and greenness has received limited attention. Accordingly, high-income households may reside in affluent, green neighborhoods on the city outskirts or in urban centers with limited green spaces. Similarly, low-income households might be found in central areas or low-income yet green neighborhoods on the city's periphery. Therefore, examining the interplay between income and greenness is crucial for developing a comprehensive understanding of how these factors jointly influence WTP. By testing the two hypotheses above and integrating the income dimension, this analysis offers valuable insights with significant policy implications, supporting the development of strategies to promote greening in underserved areas and thereby helping to equalize the health benefits across the population. Concretely, this paper addresses two central research questions: (1) Are individuals who have the financial capacity to contribute to urban greening programs willing to do so? (2) Do residents of greener neighborhoods demonstrate a greater WTP for additional greening initiatives in other areas (“the tree on the other side of the city”), or are they less willing due to their existing needs being met?

A conceptual challenge relevant to testing the above hypotheses, however, arises from the inherently fluid nature of the concept of greenness as well as the size and density of green spaces [41–43] and differences in perceptions of proximity and accessibility [44–46]. While some individuals may perceive a neighborhood as sufficiently green, others may argue that it still lacks adequate green infrastructure. Objective measures of greenness can be, for instance, derived from geospatial or satellite data, which capture the quantitative dimension [47–49]. Subjective measures of urban greenness are based on survey responses and also consider more qualitative factors [50]. Recent studies trying to analyze both subjective and objective indicators of greenness found stark differences supporting the argument that they capture different aspects of neighborhood greenness [42,48,51–53].

Differences between subjective and objective greenness measures are also relevant in a public health context. Subjective measures were found to correlate more strongly with self-reported health outcomes of UGI, such as stress reduction and mental well-being [54,55]. They also capture individual perceptions, including the perceived quality and accessibility of green spaces, which influence behaviors like frequency of use [56,57]. For instance, a study in Seattle finds that subjectively defined greenness is positively correlated with the number of walking trips, while objective measures of actual greenness were not [53]. In contrast, objective measures are meant to systematically assess the stock of UGI and may be more strongly associated with health-relevant ecosystem services, such as improved air quality or enhanced urban microclimate [8,9]. Urban greening initiatives increasingly rely on data to guide planning. Yet most research still emphasizes either physical metrics (i.e., objective measures) or self-reported perceptions (i.e., subjective measures) of greenness in isolation. This neglects the complex relationship between the physical presence of green spaces and how they are perceived and used by residents. Addressing this gap is essential for tailoring green infrastructure to actual needs.

This paper uses a discrete choice experiment (DCE) to investigate how objective and subjective neighborhood greenness influences the willingness of residents from different socio-economic backgrounds to pay for urban greening measures. The analysis is based on a representative sample of 760 respondents from Vienna, incorporating additional data such as geolocated home addresses and perceptions of neighborhood greenness. Greenness is operationalized through both subjective and objective indicators, which are used as interaction terms in a Mixed Logit (MXL) Model with correlated random parameters. This approach allows the study to explore the impact of green infrastructure distribution and perception on WTP for urban greening. Furthermore, it examines whether those who are most financially capable or derive the greatest benefits from such initiatives are also the most willing to contribute. The findings provide policymakers with valuable insights into measuring urban green space and designing UGI policies that improve public health, maximize acceptance, and address the supply-demand gap in urban green infrastructure.

The rest of the paper is organized as follows. The second section provides a comprehensive overview of the methods, data, and variable descriptions, beginning with an introduction to the study site, Vienna, in Section 2.1. The core of the analysis is a DCE conducted in September

2024, and the design of the experiment is described in detail in Section 2.2. The sample population is described in Section 2.3, followed by an explanation of the modeling approach in Section 2.4. In addition, Section 2.5 discusses how both objective and subjective variables were compiled to measure neighborhood greenness and explores the relationship between these variables. In the Results section, the base model is presented first. Section 3.2 presents a heterogeneity analysis that examines the variation in responses based on socioeconomic variables and the measures of greenness. Section 3.3 presents a WTP analysis that differentiates between different levels of greenness and income sufficiency. The results are discussed in Section 4, followed by the conclusion section.

2. Methods, data and variables

To investigate citizens' preferences and WTP for small-scale greening measures, a DCE was conducted in September 2024.[1] This experiment builds on a previous choice experiment conducted two years earlier, but was adapted to capture shifts in preferences and to incorporate new factors of interest.

Findings from a heterogeneity analysis published as part of [33] motivated an extended analysis into specific factors influencing WTP for urban greening. The analysis revealed, first, that higher income positively correlates with WTP, although income disparities were not further explored. Second, it indicated that residents of areas with fewer trees and green spaces showed more support for greening programs. However, the concept of greenness was not further elaborated, and the two measures were treated solely as binary variables, distinguished by whether they fell above or below the city-wide median.

To further explore respondents' decision-making heuristics, the choice experiment data were integrated with survey responses embedded in the DCE and geospatial information derived by linking participants' addresses to publicly available geo-data on green amenities in Vienna. The following section outlines the study site (Vienna), presents the design of the DCE,[2] describes the sample population, and details the construction of subjective and objective measures of greenness.

2.1. Study site

As part of the analysis, the present study analyzes objective and subjective measures of greenness in Austria's capital, the City of Vienna. Vienna is generally known as a green city, with green spaces making up more than 50 % of the city's administrative area. The city is surrounded by a protected green belt of forest (most importantly the Viennese forest), riparian woodlands (the Danube lowlands) and fields, which also serve as important recreational areas [58]. However, in the densely build parts of the city there are areas which that considered underserved by UGI [59]. Following their principle of green space equity, the city government seeks to enhance green infrastructure in these neighborhoods by increasing the urban tree stock and introducing other forms of greenery [58]. These small-scale greening measures are also the city's main strategy to reduce urban heat islands, which are considered a threat to public health [60].

The city's strong political commitment to enhancing equitable access to green infrastructure is evident in its ongoing greening initiatives, ensuring that most residents are now acquainted with these efforts. However, significant disparities in the distribution of green infrastructure persist, resulting in varying levels of access to green spaces and exposure to environmental stressors among Vienna's residents, including those represented in the choice experiment sample. This combination of diverse levels of UGI and proactive policy efforts makes Vienna an especially suitable case study for analyzing how the exposure to urban green infrastructure influences preferences and WTP for further greening efforts.

2.2. Discrete choice experiment design

Building on the 2022 DCE, this study investigates the preferences and WTP of Viennese citizens for city-wide greening programs using small-scale greening measures. Two greening attributes were selected: greening measures in streetscapes, which involve planting trees and creating flowerbeds in public spaces, and greening measures on buildings which entail installing green facades and roofs on existing buildings. These measures were chosen for their distinctiveness, familiarity to Viennese citizens, feasibility due to minimal space requirements, and reliance on substantial financial resources while being within the realm of influence of the city government. A split sample approach was used to test the influence of highlighting the effect of greening measures on the urban microclimate.[3] In total, 260 respondents received additional pictograms indicating the cooling effects associated with urban greening (right side of Fig. 1, as street furniture and cost are not changing they are not depicted). Further, the DCE included a third attribute: street furniture, representing urban redesign elements such as benches and fountains. This attribute was included to allow for the separation of preferences for greening from other enhancements to public space quality. Each attribute was divided into four implementation levels - “rarely,” “scattered,” “frequently,” and “everywhere” - representing varying densities of the greening measures that were described to be implemented over the next five years. These levels were visually illustrated on the choice cards, verbally explained, and quantified. For example, “frequently” for streetscape greening was described as a considerable increase, with a tree placed in front of every second house.

Each choice card also included a cost attribute, which was described as the financial contribution required from citizens to implement the greening programs. Costs were presented as monthly contributions to a dedicated greening fund, ranging from €1 to €6 per month, with the equivalent annual sums (€12–72) also provided for clarity. The cost attribute was anchored to the annual budget of Vienna's gardening department (€13 per citizen, [61]) and underwent qualitative pre-testing to ensure relevance and comprehensibility. An example of a choice card is shown in Fig. 1.

For consistency with the previous choice experiment (although comparison is not the focus of this paper), the same choice cards were used. The experimental design followed a D-efficient framework (D-error of 0.0317), to compile 24 choice cards. Respondents were randomly assigned to one of four blocks, each containing six choice scenarios. In each scenario, participants chose between two alternative greening programs or the status quo.

2.3. Survey and sample population

The choice experiment was embedded within a broader survey collecting additional information about the respondents. The survey was distributed via an online panel provider, enabling access to a large and representative sample of Viennese citizens in terms of gender, education, income, and age, although participation was limited to individuals aged 18 to 69. While online panelists are often experienced in completing surveys, this can result in both advantages and limitations. On the one hand, they tend to be more capable of handling complex questions and willing to complete longer questionnaires. On the other hand, their familiarity with surveys may introduce systematic differences compared to the general population. Furthermore, reliance on an online panel introduces the risk of sample self-selection bias, as preferences of individuals who opt to participate in such surveys might differ in meaningful (and potentially unobserved) ways from those who opt out of participating. To mitigate concerns regarding the study's representativeness, particular attention was given to ensuring that the geographical distribution of respondents was designed to closely mirrored the actual population distribution across Vienna's districts.

[1] The datasets and codes used in this study are available from the authors upon reasonable request.

[2] For additional information on the choice experiment and earlier results see [33].

[3] As the differences between the samples are not the focus of this paper, the samples were pooled and analyzed together. However, a binary heat info variable was included in the analysis to still account for the effect of the different representations.

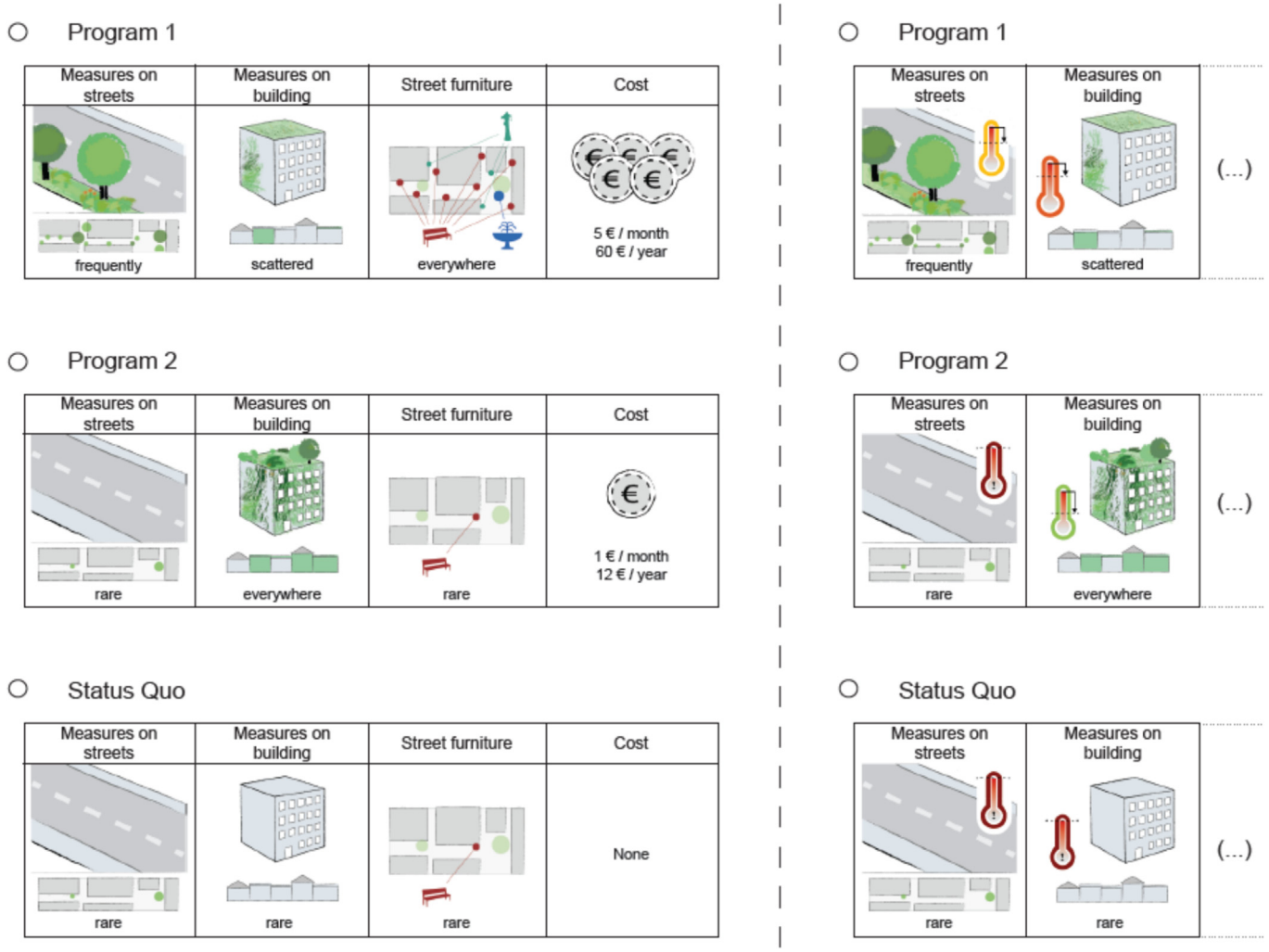

Fig. 1. Example of a choice card, without and with additional heat-effect pictograms. (Source: Own depiction)

Out of 870 respondents who participated in the choice experiment, 110 were excluded from the analysis due to missing or suspicious information, particularly regarding their home addresses. This resulted in a final sample of 760 respondents with complete and reliable data. Table 1 provides an overview of the sample population. In addition to standard socio-economic variables (gender, age, education, and income) also a question on respondents' financial well-being is shown in the table. This self-assessed measure complements the monthly net income, as it accounts for both income and expenses, in terms of the unavoidable living costs. Among the respondents, 39 % reported experiencing difficulties managing their available income, with 7 % indicating that these difficulties were severe.

Table 1
Sample structure.

Variables	Abs.	%	Variables	Abs.	%
Gender			Monthly income		
Male	391	51.4 %	<2.000€	168	22 %
Female	367	48.3 %	2.000–4.000€	272	36 %
Diverse	2	0.3 %	4.000€	192	25 %
Age			NA	128	17 %
<30 years	97	13 %	How well does the household manage with the available income?		
30–55 years	400	53 %	with great difficulty	56	7 %
55 years	263	35 %	with difficulties	81	11 %
Highest Education			with minor difficulties	156	21 %
Elementary School, Apprenticeship	362	48 %	relatively well	232	31 %
High School	174	23 %	good	147	19 %
Tertiary Education	224	29 %	very good	88	12 %

2.4. Model approach

A Mixed Logit Model with correlated random parameters was employed, incorporating covariates through interactions with the means of random parameters. This discrete choice modeling approach closely followed the methodology detailed in our previous paper [33]. This section offers a concise overview of the key elements of the methodological framework.

The DCE framework is grounded in Lancaster's characteristics theory [62], which posits that the value of a good or service is derived from its characteristics (attributes). In this framework, respondents are presented with a series of choice cards, each displaying a set of alternatives – offered products or proposed services – defined by their attributes and respective levels. By systematically varying these attribute levels, DCEs allow researchers to examine trade-offs between attributes, including cost, facilitating the estimation of an individual's marginal WTP. While the primary goal of a DCE is to simulate realistic decision-making scenarios, its strength lies in its controlled experimental design, which enables the exploration of hypothetical scenarios beyond those observed in actual markets. This feature is particularly valuable for non-market valuation, where markets for the

examined goods do not exist. In such cases, stated preference choice experiments provide critical insights into respondents' preferences, offering policymakers essential data to guide decision-making [63].

Discrete choice models are based in the random utility framework [64], which assumes that individuals follow a utility-maximizing behavior. According to this framework, the utility derived by an individual i in choice situation t for choosing alternative j comprises two components: a deterministic part (a function of observed attributes from specific alternative X_{itj}, multiplied by a vector of parameters, β_i) and a stochastic part (a random error term, e_{itj}, representing the influence of unobserved factors). Specifically, the unconditional choice probability in the Mixed Logit Model can be expressed as:

$$P_{ijt}(\beta_i|\Omega) = \int_{\beta_i} \left[\frac{\exp(X_{itj}\beta_i)}{\sum_{k=1}^{K} \exp(X_{itk}\beta_i)} f(\beta_i|\Omega) \right] d\beta_n,$$

where β_i is assumed to follow a statistical distribution $f(\beta_i|\Omega)$. In this analysis, all parameters were treated as normally distributed except for the cost parameter, which was modeled with a log-normal distribution. This approach reflects current best practice, as the normal distribution is simple, widely understood, and well-suited for capturing reference heterogeneity (notably, it is symmetric, centered around a mean, and characterized by a standard deviation that describes the spread across individuals). On the contrary, while the use of normal distribution for non-monetary attributes is widely accepted, it is standard to model cost (or price) parameters with a log-normal distribution to impose a theoretically consistent negative sign on cost coefficients, ensuring that higher costs reduce utility [65,66]. The flexibility in parameter distributions introduces additional complexity, as the integral (required to calculate choice probabilities) lacks a closed-form solution and thus must be approximated numerically through simulation-based methods. To address this, we applied a simulated log-likelihood maximization approach, employing 10,000 Sobol draws [67] with Owen scrambling [68] and Faure-Tezuka scrambling [69], as recommended by Czajkowski and Budziński [70]. In this approach, a large number of random values (i.e., 10,000 draws) are generated from the assumed distributions of the random parameters, the choice probability is calculated for each draw, and the results are averaged to approximate the integral. Furthermore, we extended the model to incorporate correlated random parameters [71–73] and included covariates by interacting them with the means of the random parameters. These enhancements provide a more nuanced understanding of preference heterogeneity across respondents, while the use of a large number of simulation draws serves to mitigate potential sampling errors inherent in the estimation process.

To simulate WTP measures, we employed the Krinsky and Robb [74] method. This approach involves performing 10,000 iterations, with each iteration drawing 100,000 draws from a multivariate normal distribution. The mean of this distribution was defined by the vector of estimated parameters (from the MXL model with correlated random parameters), while the variance was specified by the corresponding inverse Hessian (i.e., the asymptotic variance-covariance matrix). This procedure provided estimates of standard error and percentile-based confidence intervals for the WTP measures [75,76].

2.5. Construction of greenness measures

As highlighted in the introduction, measuring greenness is not straightforward. Greenness extends beyond quantifiable aspects like the number or size of green spaces, encompassing factors such as accessibility, usability and naturalness which significantly shape how greenness is experienced [46]. Many benefits of urban greenery, such as stress reduction, the impact on physical activity or aesthetic enjoyment, are inherently subjective and cannot be sufficiently captured by objective measures [53,54]. Perceptions of greenness are influenced by personal experiences, habits, and the neighborhood radius individuals associate with their sense of place [42]. While survey-based measures can provide valuable insights into the perceived quality and functionality of urban green infrastructure, they limit comparability and are less able to estimate physical effects like temperature reduction or air purification, which are tied to the quantity of green space [9].

In this context, analyzing the WTP using both subjective and objective measures of greenness is particularly valuable, as it highlights the differences between personal experiences of green spaces and their measurable attributes. This distinction allows policymakers to design strategies that address not only the tangible environmental benefits of greenery but also the diverse ways residents perceive and interact with urban green spaces. Building on this premise, the present study explores two complementary measures of greenness: an objective measure based on publicly available geospatial data and a subjective index derived from survey responses. Using respondents' home addresses, each respondent is attributed an objective greenness indicator. This section correlates and compares these two measures. Later, they are used as interaction variables to analyze their influence on citizens' WTP for urban greening.

We begin with constructing the objective greenness measure. To quantify the stock of urban green infrastructure in Vienna, three publicly available geospatial datasets are used which are summarized in Table 2.

The City of Vienna maintains these registers primarily for urban planning, maintenance, and green space management, ensuring they are regularly updated. However, their focus is on public UGI, meaning that trees on private properties and privately owned green areas are not included in the datasets. As a result, the total greenery, particularly in suburban areas with a higher concentration of private gardens, is underrepresented. Despite this limitation, the emphasis on public urban green infrastructure aligns well with the scope of this study. Since the small-scale greening initiatives discussed here involve public interventions funded through public expenditure, this targeted focus provides a more relevant and detailed basis for analysis compared to broader but less specific measures, such as using satellite imagery and indices like the Normalized Difference Vegetation Index (NDVI).

For each building block, the number of trees within a 250-m radius, and the size of public green spaces within the same radius (according to the two data sources) were calculated. 250 m is a well established radius when analyzing the effects of urban greenery (e.g. [5,80]). As it roughly equates to a 5-min walk it should also align well with residents' daily experiences of the greenness of their surrounding. The calculation based on the three datasets were then each classified into five categories rating building blocks from greyest to greenest. Based on this, two sub-indices were built, Objective Green UGS, representing the higher category value between the two green space datasets,[4] and Objective Green Trees. Two maps in the appendix illustrate the classification of building blocks based on tree density and green space size. Finally, a composite score was calculated by summing the category values, to derive the objective measure of greenness for each building block. The results are presented in Fig. 2.

The greyest building blocks (depicted in red) are clearly concentrated in the more central districts, most notably in the western areas between the major streets Ring and Gürtel, as well as to the west and south outside of the Gürtel. The first district, surrounded by the Ring, which is a significant green alley, also has a grey center. In other parts of the city, grey spots exist, but the presence of larger parks and green spaces leads to higher values in the objective greening measure.

In addition to the objective greenness measure, an index based on three elements from the survey is developed to capture a subjective perspective on greenness in Vienna. Respondents provided feedback on several statements, each rated on a 5-point Likert scale ranging from *I totally agree* to *I do not agree at all.* There are three questions, relating to relative greenness, focusing on streetscape greenery, parks, as well as the overall greenness of

[4] While many green spaces are included in both datasets, the data by the MA 22 contains smaller inner-city parks while larger green areas, such as the forests surrounding Vienna are better described in the land use mapping. Therefore, the greenness value is calculated for both datasets, ensuring that households' proximity to UGS is appropriately accounted for, whether they reside in inner-city districts near smaller parks or on the outskirts of the city closer to forests.

Table 2
Description of datasets used to construct the objective measure of greenness (sub-indices).

Measure	Sub-index	Data-type	Background /	Source
Distribution and number of street trees	Objective Greenness Trees	Point	Official tree register of the Municipal Department MA 42 - Parks and Gardens used for planning and maintenance purposes	[77]
Distribution and size of parks and urban green spaces	Objective Greenness green	Polygon	Data on publicly accessible parks and green spaces and the associated access points as published by the Municipal Department MA 22 – Environmental Protection	[78]
Distribution and size of public green spaces	UGS	Polygon	Land use category "Green spaces" as indicated in the land use mapping (Realnutzungskartierung). The land-use classification is based on aerial image interpretation and conducted by the Municipal Department MA 18 – Urban Development and Urban Planning	[79]

the district. While the original wording of all question was in German Table 3 presents translations of the relevant questions.

As the objective greenness measures also distinguish between street trees and parks, this distinction is also approximated in the subjective greenness measure using a variable on street trees (Subj. Green Trees) and one referring to parks (Subj. Green UGS). Additionally, the Subj. Green Neighborhood variable sums up an overall feeling of greenness. To mathematically construct the variables used in the analysis, the three Likert-scale statements were aligned in the same direction to ensure higher values reflected greener perceptions. There are significant correlations between the variables. The data indicates that respondents who perceive their neighborhood as relatively greener also tend to report a higher presence of parks and, particularly, trees in their area. The correlation between neighborhood greenness and the presence of trees is the highest at 0.7, while the correlation with the presence of parks is 0.4. This suggests that trees are more strongly considered when respondents evaluate overall neighborhood greenness. Additionally, there is a moderate positive correlation between the presence of parks and trees, with a value of 0.31.

The map in Fig. 3 shows the index for each respondent, revealing no clear pattern of perceived greenness. On the contrary, even nearby respondents rate their neighborhood greenness differently. This might have several reasons: UGI can be small-scale with varying appearances street by street, individuals perceive their neighborhood boundaries differently, and people may perceive and express preferences for the same UGI differently.

In line with previous research, we begin our analysis with the assumption that subjective and objective measures of greenness capture different

Table 3
Description of statements used to construct the subjective measure of greenness.

Measure	Statement / Question	Scale / Points
Relative neighborhood greenness	"In my neighborhood, there are more streets with trees and shrubs than in most other parts of Vienna."	1… I do not agree at all - 5… I totally agree
Relative neighborhood greenness	"In most parts of Vienna, there are more green spaces/parks than in my neighborhood."	(reverse coded) 5… I do not agree at all - 1… I totally agree
Relative neighborhood greenness	"My neighborhood is greener than most other parts of Vienna."	1… I do not agree at all - 5… I totally agree

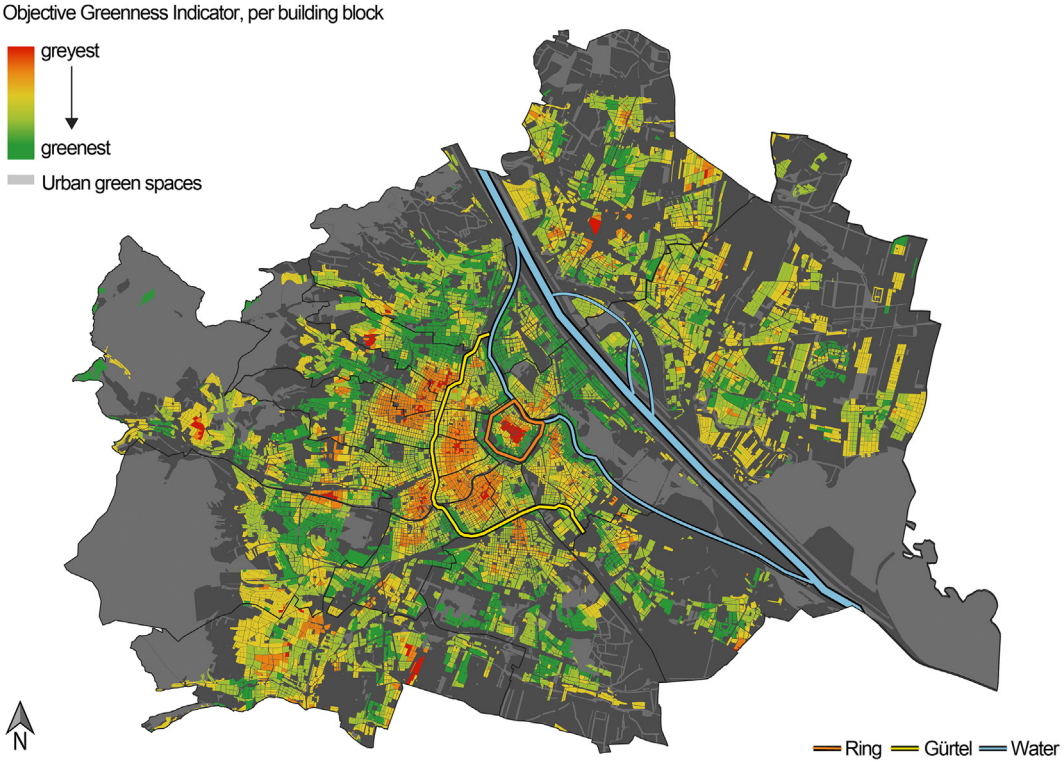

Fig. 2. Objective Greenness Indicator, per building block (according to the distribution of UGI). Source: Own depiction and calculation based on [60,77,78,81].

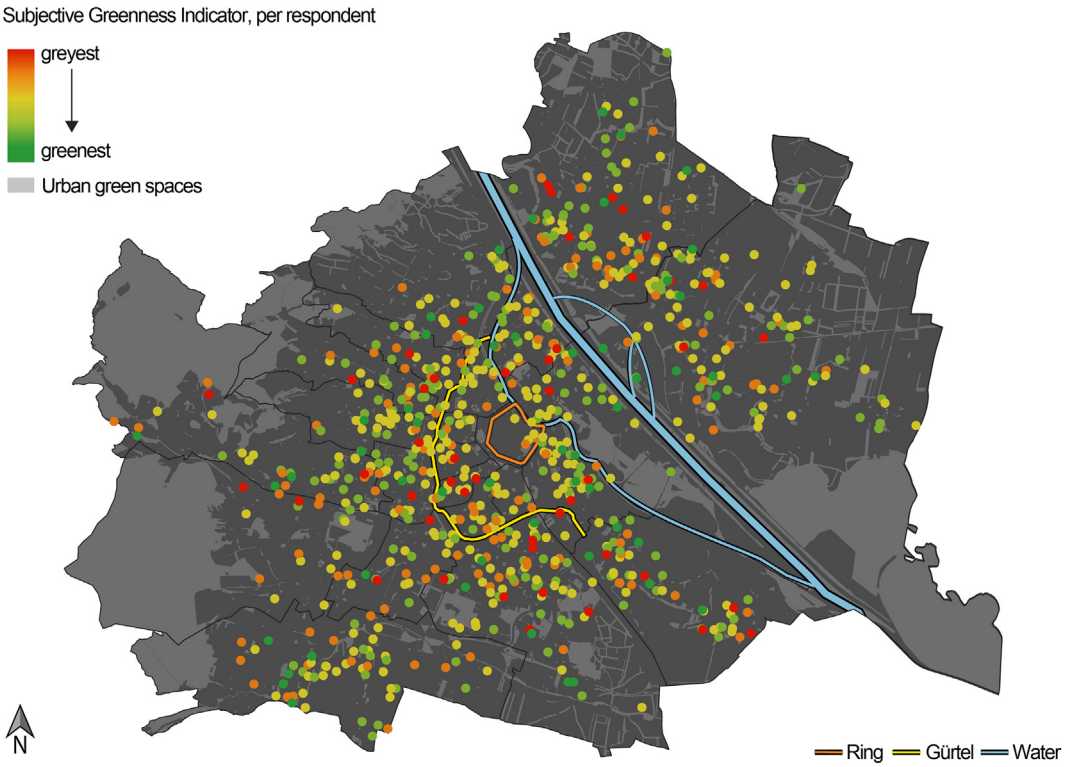

Fig. 3. Subjective Greenness Indicator, per respondent (according to survey responses). Source: Own depiction, base map based on MA 21 A - Municipal Department 21 A - Stadtteilplanung und Flächenwidmung Innen-Südwest [81].

phenomena. While it is not the aim of this paper to identify perfect mirror indicators for greenness, we seek to explore whether this assumption holds in our case by examining the correlations between these variables. Table 4 illustrates the correlations, offering an overview of the relationships between the individual sub-indices for the two measures and the aggregated indices. In the table, we first assess the pairwise correlations between all three subjective and the two objective sub-indices. To reduce dimensionality and capture general trends, we created composite indices by aggregating the subjective and objective sub-indices separately.[5] These aggregated measures were used in subsequent analyses to simplify interpretation, minimize measurement noise in individual items, and focus on the broader distinction between perceived and physical greenness. The correlation between these aggregated indices is shown in the right lower corner of Table 4.

Two key observations emerge from this analysis. First, the three variables describing subjective greenness show no correlation with the objective tree and park sub-indices, even when measuring similar aspects (e.g., the number of trees in the neighborhood). This lack of alignment is particularly noteworthy. Second, there is no significant correlation between the aggregated subjective and objective greenness indices, highlighting a clear disconnect between respondents' perceptions of greenness and the objectively measured greenness of their surroundings using geospatial data. In this regard we affirm earlier findings (e.g. by [42,48,51–53]), which have argued that subjective and objective measures of greenness are describing distinct dimensions.

As a result, this implies that the indices should be both considered when estimating WTP for urban greenery. Aggregating the indices or relying solely on one could lead to biased or incomplete valuation models. For instance, individuals may assign greater monetary value to subjective aspects of greenness, such as aesthetic enjoyment or psychological comfort, compared to the physical quantity of greenery. This is also crucial when considering the role of household income on WTP as income levels and the ability to meet basic needs may influence how urban green spaces are valued. Higher-income groups might prioritize aesthetic aspects and assign them greater monetary value, while lower-income groups may focus on accessibility and functionality. Modeling subjective and objective indices independently is essential to accurately capture these nuanced relationships.

3. Results

In this section we examine the relationship between the WTP for urban greening measures, income sufficiency), and the previously discussed measures of greenness. First, the base model is presented, then the greenness and income variables are used, inter alia, as interactions in the MXL models to better explain heterogeneity. Finally, the total WTP and support for greening programs are explored in regard to group differences.

3.1. Base model and WTP

Table 5 presents the estimates for the base model (a MXL model with correlated random parameters). On the left, the parameter means and standard deviations are displayed, while the right side illustrates how these

Table 4
Correlation of the objective and subjective neighborhood greenness indices.

	Objective Greenness		
Subjective Greenness	UGS	Trees	Index
Trees	−0.04	0.02	
Parks	0.01	0.03	
Neighborhood	0.00	0.00	
Index			0.03

[5] To construct composite indices of subjective and objective greenness, each sub-index was first standardized using z-score transformation. After standardization, the mean of the z-scores within each greenness measure (objective and subjective) was computed to generate a single composite score. The resulting aggregated indices provide a continuous measure of greenness perception (subjective) and physical greenery (objective).

Table 5
Mixed logit model estimates of the base model in preference and WTP space.

	Base model			Annual simulated WTP (in €)	
	distribution	μ parameter (std. error)	σ parameter (std. error)	Mean WTP (std. error)	Confidence intervals 2.5 % | 97.5 %
ASC	normal	2.8 (0.37)***	3.37 (0.42)***	5.8 (2.58) **	1.98 | 11.96
Street 1	normal	1.17 (0.21)***	1.37 (0.28)***	2.88 (1.59) *	0.71 | 6.8
Street 2	normal	2.09 (0.23)***	2.27 (0.29)***	5.98 (2.54) **	2.09 | 11.87
Street 3	normal	2.27 (0.19)***	2.01 (0.24)***	8.3 (3.28) **	3.13 | 15.62
Furniture 1	normal	0.07 (0.17)	1.36 (0.26)***	0.13 (0.27)	−0.15 | 0.89
Furniture 2	normal	0.24 (0.16)	1.14 (0.23)***	0.39 (0.44)	−0.02 | 1.6
Furniture 3	normal	0.15 (0.1)	1.46 (0.2)***	0.24 (0.27)	−0.02 | 0.97
Build 1	normal	0.69 (0.17)***	1.26 (0.31)***	1.51 (1.03)	0.25 | 4.11
Build 2	normal	1.49 (0.18)***	1.67 (0.28)***	4.11 (2.09) **	1.11 | 9.13
Build 3	normal	1.43 (0.15)***	1.91 (0.31)***	3.34 (1.63) **	0.97 | 7.23
-Cost	log-normal	−5.51 (0.3)***	2.71 (0.22)***		

Notes: Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Street = Measures in streetscapes | Build = Measures on buildings | Furniture = Street furniture – the numbers represent the changes in level: 1) rare to scattered | 2) rare to frequently | 3) rare to everywhere.

values translate into WTP estimates. The results reveal significant positive effects for all levels of both greening attributes, as well as a significant, negative effect for the cost attribute, consistent with expectations. Additionally, the alternative-specific constant (ASC) is significant, capturing preferences for urban greening that extend beyond the attributes included in the DCE. Notably, the higher parameters for greening measures in streetscapes compared to green roofs and facades suggest these initiatives had a greater impact on respondents' decisions.

The WTP for measures in streetscapes, such as planting street trees and installing planters, increases with the scale of the proposed greening initiatives. Specifically, respondents express an annual WTP of nearly €3 for a shift from "rare" to "scattered", €6 for a shift from "rare" to "regularly", and €8 for a shift from "rare" to "everywhere". In contrast, the results for the street furniture attribute were not statistically significant. Similarly, small changes in greening measures on buildings (from "rare" to "scattered") did not yield significant WTP results. However, WTP for greening buildings, including green roofs and facades, was both positive and significant for more extensive changes (the "regularly" and "everywhere" levels) and oscillated between €3–4. Interestingly, respondents showed a higher WTP for the "regularly" level (€4.11) than for the "everywhere" level (€3.34), suggesting that some participants may have perceived the "everywhere" level as excessive or unrealistic in practice.

All parameters are obtained from a Normal(μ, σ^2) distribution, except for the cost attribute for which a Lognormal(μ, σ^2) distribution was assumed. For a normal distribution, the mean is μ, whereas for a log-normal distribution, the mean is given by $exp\left(\mu + \frac{\sigma^2}{2}\right)$.

3.2. Model with heterogeneity and objective and subjective greenness variables

To examine the influence of different measures of greenness and explore preference heterogeneity, covariates are interacted with the means of random parameters in the MXL model. The model presented in Table 6 contains interactions with socio-economic characteristics, including gender, age, education, and income as well as interactions with the greenness variables. As the subjective and objective greenness variables are not correlated with each other, suggesting that they measure different dimensions of urban greenness, they are analyzed in the same model.[6] Notably, the model is simplified compared to the base model presented in Section 3.1– specifically, all of the main attributes were shortened, representing an overall preference toward the change in the attribute presented (i.e., a joint shift from "rare" to "scattered", "regularly" or "everywhere").[7]

Only a few socio-economic characteristics exhibit statistically significant effects. To begin with, there is no significant effect of age. Conversely, having secondary or tertiary education (compared to only completing elementary school or an apprenticeship) shows a slight negative interaction with the street furniture, or a positive one with the cost attribute, respectively. Women also display a lower likelihood of choosing an alternative program over the status quo. Additionally, a significant positive interaction with the street furniture attribute can be observed. However, the interaction is less relevant because the street furniture variable itself has a non-significant main effect, as already indicated in the base model. Nevertheless, this observation might indicate that while street furniture is not an essential attribute for the general population, it is for specific individuals. Furthermore, respondents who received additional heat effect pictograms on the choice card (heat info variable) show reduced preferences for greening measures on buildings, a result that seems counterintuitive.

In contrast to the relatively less informative results observed for other socio-economic variables, the interactions with income covariates offer a more detailed understanding of the factors shaping WTP. Respondents with a high income are less cost-sensitive, which translates into a higher WTP. Conversely, having a monthly net income below €1125 or perceiving household income as insufficient (managing expenses with minor to major difficulties) shows a significant negative interaction with the alternative-specific constant (ASC), indicating a lower likelihood of choosing a greening program over the status quo. Interestingly, this negative influence is observed on the ASC rather than the cost attribute, suggesting that respondents in these income groups may not explicitly weigh the cost attribute but instead broadly reject programs. Further, having financial difficulties also negatively interacts with greening measures on streets, which supports this assumption.

As Table 6 shows, the objective greening variables have two significant interactions. First, respondents living in areas with large parks or other urban green spaces exhibit a positive interaction with the cost attribute, indicating a higher cost sensitivity. This heightened sensitivity leads to a lower WTP for additional greening, as the interaction increases the cost parameter (which appears in the denominator of the WTP calculation. Second, a high density of trees around the home is positively associated with support for green roofs and facades.

The interactions with the subjective greenness sub-indices demonstrate that different types of perceived greenness (general neighborhood greenness vs. parks) influence WTP in two distinct ways. First, respondents who view their neighborhood as green(er) show a lower cost sensitivity, but they tend to be more supportive of improvements of street furniture. This suggests that while perceived greenness increases their overall willingness to invest in urban greening programs they prefer greening programs that enhance the quality of existing UGI rather than (merely) expand them. Second, respondents who perceive their neighborhoods as having

[6] It was also tested to estimate the objective and subjective greenness variables in separate models. However, as the results were not significantly different, Table 5 shows the full model.
[7] The base model in the simplified version can be found in the appendix.

Table 6
Mixed logit model with correlated random parameters estimates incorporating interactions (I) with socio-economic variables and objective and subjective measures of greenness.

	Distribution	Main effects: μ parameter (std. error)	Main effects:σ parameter (std. error)	I: Heat Info	
ASC	normal	3.8 (0.77) ***	2.66 (0.33) ***	0.48 (0.45)	
Street ≥1	normal	1.69 (0.3) ***	1.4 (0.12) ***	−0.1 (0.19)	
Furn ≥1	normal	0.05 (0.22)	0.76 (0.11) ***	−0.21 (0.14)	
Build ≥1	normal	1.13 (0.29) ***	0.89 (0.15) ***	−0.43 (0.19) **	
-Cost	log-normal	−6.1 (0.59) ***	2.99 (0.24) ***	0.08 (0.35)	
	I: Gender = Female	I: Age ≤ 30	I: Age 55	I: Secondary education	I: Tertiary education
ASC	−0.69 (0.4) *	−1.06 (0.71)	−0.07 (0.43)	−0.08 (0.5)	0.66 (0.51)
Street ≥1	0.06 (0.17)	−0.39 (0.3)	0.06 (0.19)	0.03 (0.22)	−0.01 (0.21)
Furn ≥1	0.26 (0.13) **	−0.02 (0.23)	0.08 (0.14)	−0.38 (0.16) **	−0.18 (0.16)
Build ≥1	−0.11 (0.16)	0.34 (0.31)	0.05 (0.18)	−0.28 (0.21)	−0.23 (0.2)
-Cost	−0.19 (0.28)	0.04 (0.74)	−0.15 (0.34)	−0.08 (0.34)	0.79 (0.37) **
	I: Income ≤1125	I: Income ≥4325	I: With Income Difficulties		
ASC	−1.07 (0.45) **	−0.76 (0.53)	−0.72 (0.41) *		
Street ≥1	−0.29 (0.2)	0.13 (0.22)	−0.54 (0.18) ***		
Furn ≥1	−0.17 (0.15)	−0.12 (0.17)	0.05 (0.13)		
Build ≥1	−0.16 (0.19)	0.07 (0.21)	−0.03 (0.17)		
-Cost	0.24 (0.31)	−0.69 (0.38) *	0.03 (0.31)		
	I: Obj. Green UGS Kat ≥4	I: Obj. Green Tree Kat ≥4	I: Subj. Green Trees	I: Subj. Green Parks	I: Subj. Green Neighborhood
ASC	0.03 (0.4)	−0.5 (0.39)	−0.66 (0.48)	1.52 (0.44) ***	−0.48 (0.5)
Street ≥1	0.12 (0.17)	0 (0.17)	0.03 (0.21)	0.34 (0.19) *	−0.03 (0.22)
Furn ≥1	−0.07 (0.13)	0 (0.13)	−0.12 (0.16)	−0.13 (0.14)	0.51 (0.17) ***
Build ≥1	0.25 (0.16)	0.38 (0.16) **	0.31 (0.2)	0.21 (0.18)	−0.07 (0.21)
-Cost	0.53 (0.25) **	−0.02 (0.28)	−0.06 (0.56)	1.09 (0.37) ***	−1.01 (0.56) *
LL at convergence			−3651.7		
LL at constant(s) only			−5033.2		
McFadden's pseudo-R^2			0.27		
Ben-Akiva-Lerman's pseudo-R^2			0.50		
AIC/n			1.52		
BIC/n			1.64		
n (observations)			4920		
r (respondents)			820		
k (parameters)			75		

Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

more parks are more likely to choose the proposed greening programs (as reflected by the ASC), but they also exhibit greater sensitivity to the associated costs. However, because the ASC effect is stronger than the cost effect, and the ASC is relatively high in the base model, these respondents still tend to have a higher overall WTP. This indicates that, despite their sensitivity to costs, their positive perception of park availability increases their likelihood of supporting greening initiatives and their WTP for them. The subjective greenness sub-index, which refers to the perceived number of trees in the neighborhood, showed no significant interaction with the attributes. This could indicate that respondents do not primarily consider the trees in their immediate surroundings when making city-wide greening decisions. Alternatively, this lack of interaction might be related to the high correlation between the subjective tree and neighborhood greenness sub-indices.

3.3. WTP and support for urban greening programs based on greenness and income sufficiency

In this section, we examine the relationship between both the subjective (perceived) and objective greenness of respondents' neighborhoods and their overall impact on WTP for greening programs. To do this, we use the aggregated greenness indices introduced in Section 2.5 and divide the respondents into three groups based on quartiles: those in the least green 25 %, the middle 50 %, and the greenest 25 % of neighborhoods. For each greenness measure, we compare WTP values across these groups to identify potential patterns or disparities.

Fig. 4 presents the WTP results, distinguishing between these greenness categories and also separating respondents based on their financial situation, specifically, whether they reported experiencing financial difficulty. Each WTP value, in the plot, represents the total WTP for all attributes (for a change from rare to scattered, regularly, or everywhere) as well as the ASC. The model estimates on which these WTP measures were calculated are presented in the appendix (Table A2 and Table A3).

The analysis reveals some variation in WTP based on the greenness of the neighborhood and the respondents' financial situation. Respondents who report financial difficulties exhibit a lower average WTP across all greenness categories compared to those without such difficulties. However, when comparing residents of objectively or subjectively green neighborhoods (75th percentile) to those in grey neighborhoods (<25th percentile), only minor differences in mean WTP emerge. Furthermore, all WTP estimates show wide confidence intervals, suggesting a lack of statistical stability. This is further supported by a Poe et al. [82] test, which confirms that the differences in estimates are not statistically significant. Notably, the highest WTP values, as well as the widest confidence intervals, are observed in the medium-green category, which comprises 50 % of respondents living in areas that are neither particularly green nor grey. This group appears to be highly heterogeneous. One possible explanation for the elevated WTP in this segment is that residents of moderately green neighborhoods may not aspire to live in central (grey) neighborhoods, yet still perceive substantial potential for environmental improvement compared to those already residing in very green neighborhoods.

Overall, the findings suggest that neither neighborhood greenness nor income sufficiency serves as a strong predictor of total WTP for urban greening among Vienna's residents. Although some differences in average WTP exist, they do not translate into statistically significant variations in the empirical WTP distributions. Nevertheless, these results may also be interpreted as evidence of broad-based public support for greening initiatives that extends beyond specific socioeconomic or neighborhood characteristics.

This interpretation is further supported by responses to two follow-up survey questions posed after the DCE. Respondents were asked whether they would still support greening programs if the measures were

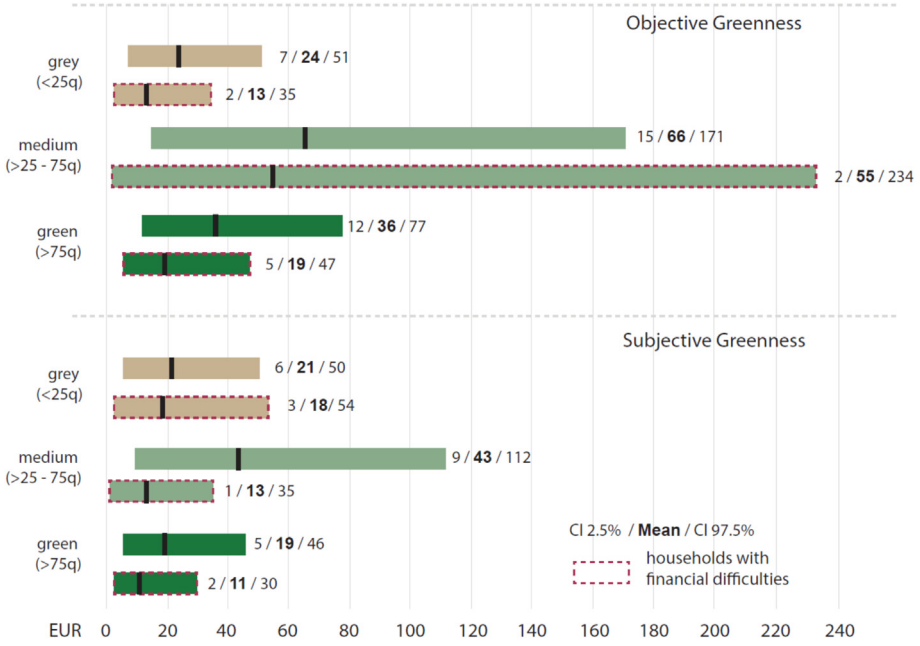

Fig. 4. WTP based on objective and subjective measures of neighborhood greenness for baseline respondents with and without stated financial difficulties. (Source: Own depiction.)

(1) predominantly implemented in neighborhoods that are less green than their own and (2) implemented in neighborhoods where they rarely or never visit. Responses were analyzed in terms of both subjective and objective greenness, as well as in relation to financial situation. As shown in Fig. 5, the results are remarkably stable across all groups, with no systematic differences observed. Regarding the first question, over 50 % of respondents in every group expressed support for implementing measures targeting less green neighborhoods, while only 5–10 % opposed such initiatives. Support was even stronger for greening programs in areas respondents rarely visit, with approximately 75 % of respondents indicating their approval.

4. Discussion

This study examined how both objective and subjective greenness, as well as income and perceived financial sufficiency, influence individuals' preferences, WTP, and support for urban greening programs. The base model demonstrated a clear overall WTP among Vienna's residents for urban greening initiatives, with a pronounced preference for streetscape interventions over building-based measures – a finding consistent with previous studies conducted in Vienna [33] and Prague [83]. Furthermore, the heterogeneity analysis indicated that preferences for urban greening programs are relatively stable across demographic factors such as education, gender, and age.

4.1. Influence of income (sufficiency)

Given that lower-income households are often disproportionately affected by health disadvantages [84], such as higher rates of chronic conditions [85], and overall social vulnerability, a focus of this study was to examine how income and financial capacity influence preferences for urban greening. To better capture financial capacity, the analysis complemented the numeric income measure with the qualitative indicator of income sufficiency. While income data is commonly used to assess financial means, it does not fully reflect financial well-being, as people with similar incomes may face very different financial pressures depending on household composition or local costs-of-living. Income sufficiency, on the other hand, is an individual's assessment of whether their income adequately meets basic needs and provides, therefore, an additional dimension.

The results of the heterogeneity analysis show that when a financial contribution is required, available income has an influence on respondents' choices. Significant interactions were observed between income-related variables and the attributes in the DCE. Revisiting the research question (1): *Are individuals who have the financial capacity to contribute to urban greening programs willing to do so?* The evidence suggests that they are. Respondents with high monthly incomes were less cost-sensitive, which indicates higher WTP values. Conversely, those earning less than €1125 per month or reporting difficulty managing expenses showed a significant negative interaction with the alternative-specific constant, suggesting a reduced likelihood of choosing a greening program over the status quo. These findings are in line with previous research on the effect of income on the WTP for urban greening (e.g., [31–33]). For respondents in households struggling to make ends meet, the opportunity to invest in a greening program may not seem like a viable option and they may deprioritize environmental improvements in favor of more immediate needs, even if the long-term benefits are acknowledged. Accordingly, also the total WTP values for financially constrained respondents were lower across all greenness levels, although the group differences lacked statistical significance. However, in scenarios in which a personal financial contribution was not explicitly mentioned, and respondents were asked about their support of greening programs in less green areas or neighborhoods where they rarely spend time, no income (sufficiency) effect was observed. This indicates that while financial constraints might limit WTP, this is not necessarily the case for support or valuation of urban greening itself. In other words, lower-income respondents may value urban green infrastructure equally but lack the capacity to act on that valuation.

In Vienna, the lowest levels of UGI, as depicted by the objective greenness measure (Fig. 2), are found in the most central districts. This comprises some of the areas with the city's highest-income households, such as the inner-city (1. district) and several central neighborhoods within the Gürtel ring road. However, just beyond this road are some of the city's most financially disadvantaged areas. Higher-income residents have greater residential mobility and may choose to live in denser, greyer, but more central areas. Lower-income households, however, often have fewer options. Their financial constraints and Vienna's segmented housing market may confine them to certain neighborhoods [86] which are often also characterized by limited UGI. These residents are the ones who would particularly benefit from UGI due to their

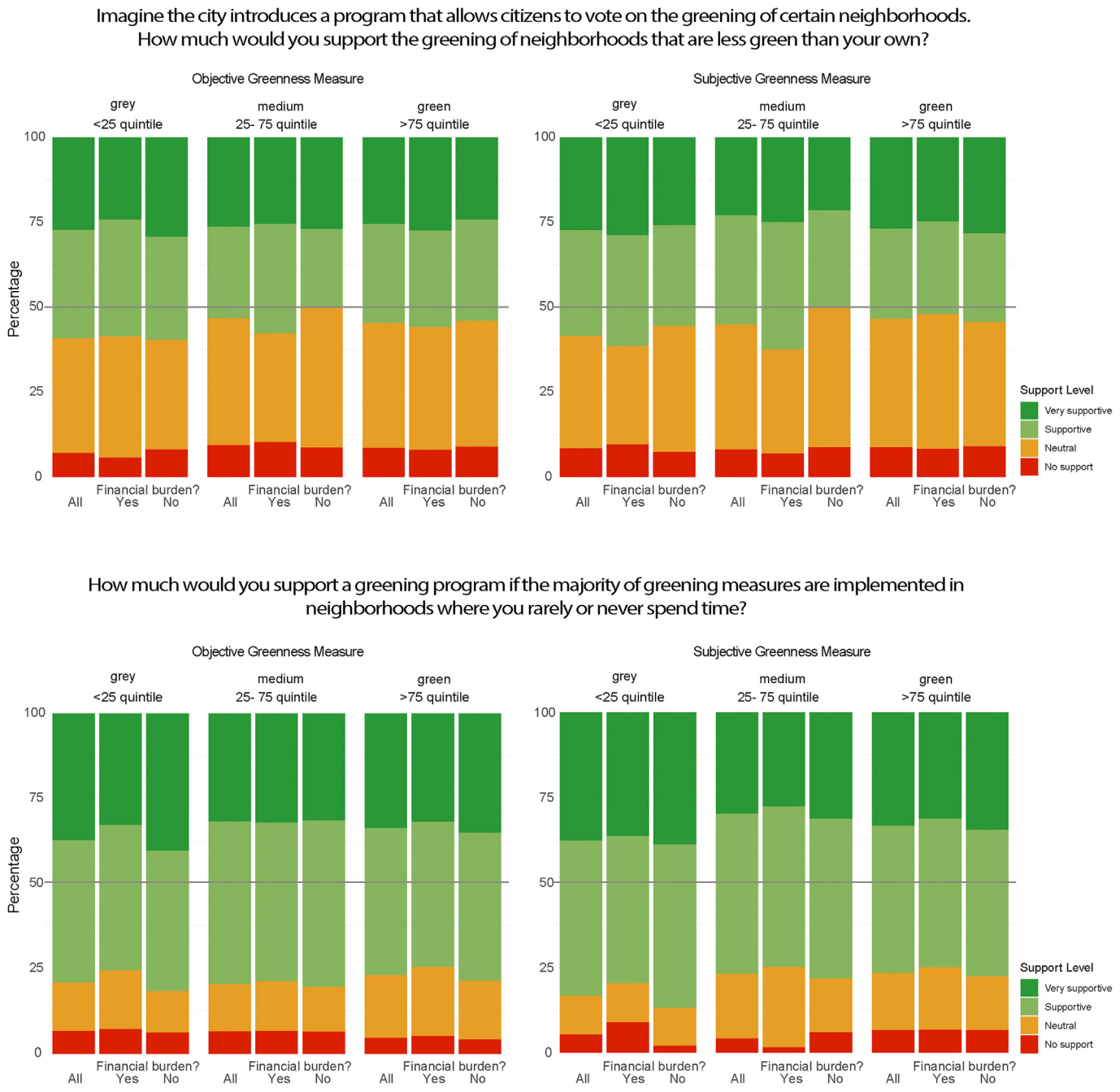

Fig. 5. Stated support for greening programs under two scenarios. (Source: Own depiction.)

increased vulnerability and higher exposure to environmental and health risks [13,14]. Overall, this underscores the importance of implementing city-wide greening programs that focus on green equity and do not depend on residents' financial capacity.

4.2. Influence of neighborhood greenness

In light of Vienna's commitment to promoting green equity and mitigating urban heat island effects [58,60], expanding green infrastructure in currently underserved neighborhoods has become a strategic priority. In this context, it is particularly relevant to understand how the existing distribution of urban green infrastructure shapes public support for such strategies. Specifically, it is worth asking whether residents of already green neighborhoods also endorse greening efforts in less green areas, even when they are unlikely to benefit from them directly.

To address this, the study employed two complementary indicators of neighborhood greenness: an objective measure derived from geospatial data that captures the presence of street trees and other forms of UGI in Vienna, and a subjective measure derived from respondents' survey responses. While objective indicators such as green space density reflect the physical availability of greenery, subjective perceptions capture how residents evaluate and experience their environment, often varying even in neighborhoods with similar levels of green infrastructure. This dual approach responds to a growing body of literature emphasizing the divergence between objective and perceived greenness (e.g. by [42,48,51–53]). Consistent with these findings, our data showed minimal to no correlation between the two measures.

Analyzing preferences and WTP for urban greening using both objective and subjective measures of neighborhood greenness yielded mixed and nuanced results. The heterogeneity analysis suggests that residents living in

close proximity to large parks or larger green spaces (objective green) exhibit higher cost sensitivity, indicating a lower WTP. However, for those who perceive their neighborhoods as having more parks than other parts of Vienna (subjective green), the higher cost sensitivity appears to be counterbalanced by a higher preference for ASC (which reflects a greater general likelihood of selecting a proposed greening program, regardless of attribute levels). Additionally, respondents who subjectively view their neighborhood as greener tend to be less cost-sensitive overall, indicating stronger approval of urban greening initiatives. These divergent patterns underscore the importance of incorporating both objective and subjective measures, as each may exert distinct influences on preferences.

Another insight is that respondents tend to favor greening measures that are less prevalent or not widely implemented in their own neighborhoods. While streetscape greening is generally preferred over green roofs and facades, as shown in the base model, these preferences appear to be shaped by local context. For example, residents of tree-rich areas show stronger support for greening measures on buildings, whereas those who perceive their neighborhood as already green place greater value on the addition of street furniture. This suggests a compensatory logic, whereby individuals prioritize interventions that complement, rather than replicate, their existing urban environment.

When analyzing the total WTP for urban greening programs using composite indicators of greenness, neither objective nor subjective measures revealed statistically significant differences across the groups. Confidence intervals were wide, and mean WTP values, particularly for the respondent who live in the 25 % greenest and 25 % least green neighborhoods, were largely similar. As such, these findings offer no conclusive support for either of two opposing hypotheses derived from literature and outlined in the introduction: (1) that residents of greener areas exhibit lower WTP due to already benefiting from existing green infrastructure, or (2) that these residents demonstrate a stronger, intrinsic appreciation for urban greenery as reflected when choosing their place of residence. Specifically, it may be the case that neighborhood greenness plays a minor role in respondents' decision-making regarding support for additional urban greening. Alternatively, the opposing effects of the two hypotheses may cancel each other out, resulting in no net difference in WTP at the extremes of the greenness distribution. By contrast, respondents from mid-green neighborhoods, whether objectively or subjectively defined, displayed more heterogeneous and generally higher mean WTP estimates. While these results are not statistically robust, they may suggest that residents in moderately green areas perceive a greater need for improvement, which could drive stronger support for greening initiatives.

Furthermore, when considering the mixed and inconclusive findings related to neighborhood greenness, it is also important to recognize that respondents benefit not only from UGI in close proximity to their homes but also along their everyday paths, such as commuting routes or areas near their workplaces. Consequently, when evaluating urban-wide greening scenarios, individuals' perceptions of green space in all areas where they spend significant time are likely to shape their WTP as well. Gaining a clearer understanding of how everyday exposure to urban green influences preferences will require future research.

Nonetheless, the lack of group differences according to the distribution and perception of UGI provides encouraging support for citywide greening programs. The data suggest that there is no structural opposition against such programs among any specific group. This claim is further reinforced by the response patterns regarding the question of the willingness to support greening programs in other parts of the city, which is, literally, the “tree on the other side of the city”. Here too, no systematic variation was observed across greening categories, with 75 % of respondents explicitly indicating they would support greening efforts even if the measures were implemented in areas they seldom visit. Overall, residents across all levels of neighborhood greenness demonstrated consistent support for urban greening, indicating a broad, citywide appreciation of urban green infrastructure that transcends local or self-interested considerations.

5. Conclusion

Understanding citizens' preferences and WTP for urban greening programs is a critical issue in the context of urban health and equity. However, urban green infrastructure is unevenly distributed within most cities. In many cities, including Vienna, there are inhabitants of areas with limited urban greenery which are less likely to experience the health benefits associated with UGI. Considering the limited residential mobility of lower-income households, the unequal distribution of greenery become not just an environmental issue but also a socio-economic one.

This paper connects the current distribution of urban green infrastructure, perceptions of greenness and income sufficiency with the preferences and WTP for urban greening. Thereby two questions guided the analysis: (1) Are those who are financially capable of contributing to urban greening programs willing to do so? (2) Are residents of greener neighborhoods more willing to pay for additional greening initiatives elsewhere (“the tree on the other side of the city”) or less willing because their needs are already met? Using a discrete choice model, this study explores how household income and the ability to meet basic needs affect WTP, as well as how objective and subjective measures of neighborhood greenness influence these preferences.

Employing both types of greenness measures, is valuable, as they capture different dimensions of UGI, the physical presence of green elements (objective greenness) and how residents perceive the availability and quality of UGI in their neighborhood (subjective greenness). Our results confirm that objective and perceived greenness are uncorrelated and shows how the measures influence preferences differently. Based on these findings, it is also recommended for policy makers to integrate both objective and subjective indicators of greenness also in the planning process. As perceived and actual UGI availability often diverge, a dual approach, informed by both physical data and residents' lived experiences, can help design more equitable and effective greening strategies.

The results of the DEC reveal some heterogeneity in preferences for urban greening programs. When examining sub-indices, a tendency emerges for respondents to prefer features less prevalent in their immediate environments, such as higher appreciation for green roofs and facades in tree-rich areas. However, when analyzing the composite greenness indicators, we find no significant differences in the overall WTP for greening programs. Notably, the WTP of residents living in both the greenest and greyest neighborhoods was remarkably similar, regardless of whether objective or subjective greenness measures were used, and remained fairly stable across income levels. While it is possible that the current level of neighborhood greenness may indeed have limited influence on preferences, also other reasons could lead to this result, such as respondents considering more the broader urban context than their immediate surrounding as well as residential-sorting. Regardless of the underlying mechanism, which opens room for further analysis, this outcome is encouraging for planners: it suggests that opposition to urban greening based on existing access to greenery is unlikely. This interpretation is further supported by stated opposition rates, which remained below 10 % even for greening measures that would not directly benefit respondents.

Conversely, financial constraints do appear to shape preferences. Having a low income or struggling to manage household finances significantly reduced the probability of choosing a greening alternative over the status quo in the DCE. Lower-income respondents, despite potentially benefiting the most from urban green terms of health improvements, expressed lower WTP for greening programs. However, this does not equal lower support for urban greening. When questions did not involve personal financial contributions, lower-income individuals expressed similar levels of support for greening initiatives elsewhere in the city. This suggests that lower WTP is driven by financial limitations rather than a lack of appreciation for urban greenery.

Altogether, our findings reveal broad and consistent support for urban greening programs in Vienna, which extends across socio-economic groups and different types of neighborhoods. Notably, high levels of support were observed even for greening measures in areas that respondents rarely visit, what might be termed “the tree on the other side of the city”, indicating some presence of altruistic values or a collective interest in a more livable, sustainable urban environment. At the same time, it is important to recognize that residents with limited financial resources often lack the residential mobility to relocate to greener neighborhoods that better meet their needs. Therefore, policymakers should prioritize interventions in areas which residents experiencing the dual burden of income and limited urban greenery, where the benefits of UGI are most urgently. Ultimately, urban greening policy should go beyond simply planting more trees and align environmental and social objectives to ensure broader access to the benefits of a healthier, greener city.

AI statement

During the preparation of this work the authors used ChatGTP and DeepL Write in order to improve the fluency of the text. After using these services, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

CRediT authorship contribution statement

Antonia Elisabeth Schneider: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Tatjana Neuhuber:** Writing – review & editing, Writing – original draft, Visualization, Formal analysis, Conceptualization. **Wojciech Zawadzki:** Writing – review & editing, Writing – original draft, Software, Methodology, Investigation, Formal analysis, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Appendix

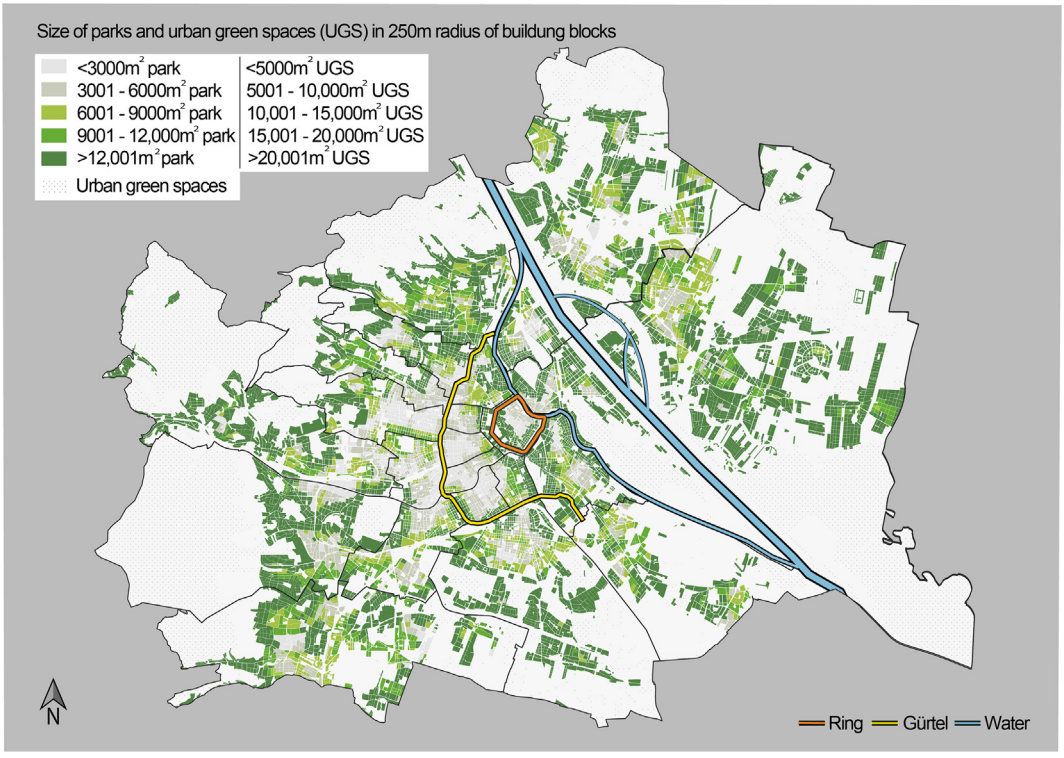

Fig. A1. Size of parks and urban green spaces (UGS) in 250 m radius of building blocks. Source: Own depiction and calculation based on [78,79].

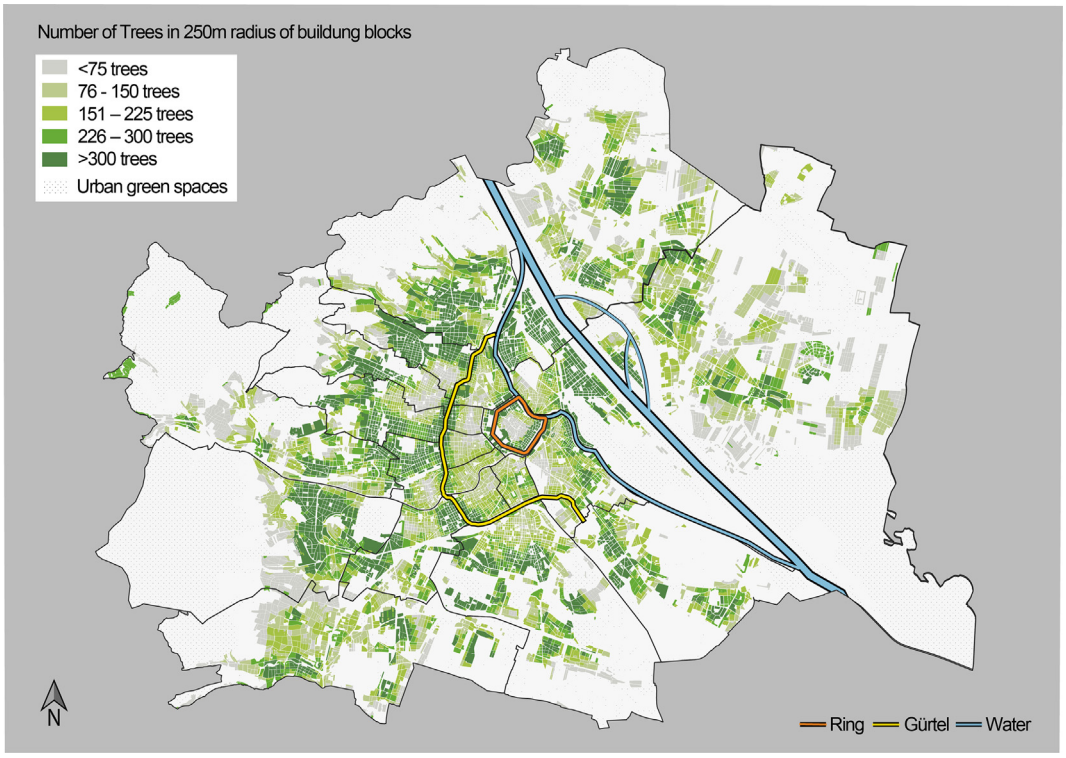

Fig. A2. Number of trees in 250 m radius of building blocks. Source: Own depiction and calculation based on [77].

Table A1
Mixed logit model with correlated random parameters, simplified base model.

	Distribution	μ parameter (std. error)	σ parameter (std. error)
ASC	normal	3.05 (0.32)***	3.09 (0.39)***
Street ≥1	normal	1.53 (0.09)***	1.45 (0.12)***
Furniture ≥1	normal	−0.01 (0.07)	0.83 (0.11)***
Build ≥1	normal	1.14 (0.1)***	0.93 (0.18)***
-Cost	log-normal	−5.67 (0.29)***	2.77 (0.25)***

Note: Significance levels: * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A2
Mixed logit model with correlated random parameters estimates incorporating interactions (I) with subjective greenness and financial difficulties.

	Distribution	Main effects: μ parameter (std. error)	Main effects:σ parameter (std. error)	I: Respondent with financial difficulties and low subjective greening in the neighborhood (q.025-)	I: Respondent with financial difficulties and medium subjective greening in the neighborhood (q.025-q.075)
ASC	Normal	3.39 (0.61) ***	3.08 (0.39) ***	−0.77 (0.71)	−2.03 (0.76) ***
Street ≥1	Normal	2.04 (0.21) ***	1.41 (0.12) ***	−1.09 (0.27) ***	−0.76 (0.32) **
Furn ≥1	Normal	−0.02 (0.15)	0.82 (0.11) ***	−0.08 (0.20)	0.04 (0.24)
Build ≥1	Normal	1.60 (0.20) ***	0.91 (0.18) ***	−0.56 (0.27) **	−0.52 (0.32)
-Cost	Log-normal	−5.57 (0.37) ***	2.64 (0.21) ***	0.22 (0.42)	−1.14 (0.86)
	I: Respondent with financial difficulties and high subjective greening in the neighborhood (q.075+)	I: Respondent without financial difficulties and low subjective greening in the neighborhood (q.025-)	I: Respondent without financial difficulties and medium subjective greening in the neighborhood (q.025-q.075)	I: Respondent without financial difficulties and high subjective greening in the neighborhood (q.075+) (baseline)	
ASC	0.38 (0.83)	0.70 (0.72)	−0.73 (0.74)		
Street ≥1	−0.52 (0.31) *	−0.28 (0.27)	−0.44 (0.28)		
Furn ≥1	0.18 (0.23)	−0.15 (0.20)	0.11 (0.21)		
Build ≥1	−0.45 (0.31)	−0.81 (0.26) ***	−0.42 (0.28)		
-Cost	0.47 (0.41)	0.30 (0.35)	−1.01 (0.45) **		
LL at convergence			−3682.7		
LL at constant(s) only			−5033.2		
McFadden's pseudo-R^2			0.27		
Ben-Akiva-Lerman's pseudo-R^2			0.50		
AIC/n			1.52		

(continued on next page)

Table A2 (*continued*)

	Distribution	Main effects: μ parameter (std. error)	Main effects:σ parameter (std. error)	I: Respondent with financial difficulties and low subjective greening in the neighborhood (q.025-)	I: Respondent with financial difficulties and medium subjective greening in the neighborhood (q.025-q.075)
BIC/n			1.57		
n (observations)			4920		
r (respondents)			820		
k (parameters)			45		

Note: Significance levels: * p < 0.1, ** p < 0.05, *** p < 0.01 || The level of objective and subjective greenness was categorized into three groups to distinguish respondents with low greening in their neighborhood (classified lower than the 25th percentile), medium (between the 25th and 75th percentile), and high (over 75th percentile).

Table A3
Mixed logit model with correlated random parameters estimates incorporating interactions (I) with objective greenness and financial difficulties.

	Distribution	Main effects: μ parameter (std. error)	Main effects:σ parameter (std. error)	I: Respondent with financial difficulties and low objective greening in the neighborhood (q.025-)	I: Respondent with financial difficulties and medium objective greening in the neighborhood (q.025-q.075)
ASC	Normal	3.13 (0.51) ***	3.09 (0.35) ***	−0.93 (0.64)	−0.47 (0.75)
Street ≥1	Normal	1.78 (0.18) ***	1.42 (0.12) ***	−0.84 (0.27) ***	−0.51 (0.32)
Furn ≥1	Normal	0.04 (0.13)	0.83 (0.11) ***	0.20 (0.21)	−0.43 (0.25) *
Build ≥1	Normal	1.28 (0.18) ***	0.90 (0.18) ***	−0.68 (0.25) ***	0.22 (0.32)
-Cost	Log-normal	−5.65 (0.36) ***	2.81 (0.23) ***	−0.82 (0.44) *	0.18 (0.40)

	I: Respondent with financial difficulties and high objective greening in the neighborhood (q.075+)	I: Respondent without financial difficulties and low objective greening in the neighborhood (q.025-)	I: Respondent without financial difficulties and medium objective greening in the neighborhood (q.025-q.075)	I: Respondent without financial difficulties and high objective greening in the neighborhood (q.075+) (baseline)
ASC	−0.31 (0.68)	0.61 (0.63)	0.22 (0.83)	
Street ≥1	−0.36 (0.27)	−0.04 (0.25)	0.17 (0.31)	
Furn ≥1	0.03 (0.20)	−0.10 (0.19)	−0.13 (0.23)	
Build ≥1	0.11 (0.27)	−0.23 (0.24)	−0.12 (0.29)	
-Cost	0.42 (0.44)	−0.03 (0.33)	−0.73 (0.48)	
LL at convergence			−3691.9	
LL at constant(s) only			−5033.2	
McFadden's pseudo-R^2			0.27	
Ben-Akiva-Lerman's pseudo-R^2			0.50	
AIC/n			1.52	
BIC/n			1.58	
n (observations)			4920	
r (respondents)			820	
k (parameters)			45	

Note: Significance levels: * p < 0.1, ** p < 0.05, *** p < 0.01 || The level of objective and subjective greenness was categorized into three groups to distinguish respondents with low greening in their neighborhood (classified lower than the 25th percentile), medium (between the 25th and 75th percentile), and high (over 75th percentile).

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ecofro.2025.06.011.

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