



Residents' perceptions of cultural ecosystem services from urban green spaces: A comparative study of Korea and Germany

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ARTICLE INFO

Keywords:

Human-nature interactions
Human wellbeing
Cross-cultural study
Urban green spaces
Participatory mapping
Cultural ecosystem services
COVID-19
Urban biodiversity
Environmental psychology
Social-ecological systems

ABSTRACT

Understanding public needs is crucial for effective management and planning of urban green spaces (UGS). UGS offer cultural ecosystem services (CES) that enhance human wellbeing. However, CES are challenging to measure, and vary across cultures, limiting cross-cultural research. This study examines public perceptions of CES from UGS in Suwon, Korea, and Karlsruhe, Germany, through a map-based PPGIS questionnaire. Respondents were urban residents in both cities, recruited through a combination of online outreach, local postings, and snowball sampling between July and September 2023. Karlsruhe residents visited UGS more frequently and spent more time there both before and after COVID-19 than Suwon residents. Most Suwon residents favored the nearest green spaces, while Karlsruhe residents preferred UGS farther from their homes. In Suwon, higher income was linked to a lower evaluation of biodiversity importance. Age and gender influenced the evaluation of biodiversity importance in both cities. Younger people visited UGS more often than older people after COVID-19 in both cities. In Karlsruhe, female respondents visited UGS more frequently than male respondents, whereas in Suwon, male showed a higher frequency. However, female respondents in Karlsruhe spent more time in UGS than males, while there was no statistically significant difference in Suwon. Education level was significant only in Suwon, where individuals with university education spent more time in UGS after COVID-19 than those without. These findings reflect how cultural and socio-demographic factors shape human-nature interactions, supporting theoretical perspectives such as the biophilia hypothesis, social ecology, and environmental psychology. Integrating these interdisciplinary insights into UGS planning can help create inclusive, culturally responsive, and ecologically meaningful urban environments.

Introduction

Rapid urbanization, climate change, and escalating social-environmental challenges have left cities with altering landscapes and reduced biodiversity (Khanna, 2020). As cities expand, blue and green spaces are often replaced by built infrastructure, limiting residents' access to nature and weakening the connection that support individual and community wellbeing (Jabbar et al., 2022). Within urban areas, there are various ecosystems, such as rivers and lakes, parks, street trees, and forests, each providing uniquely to human well-being through different ecological structures and processes (Mundoli & Nagendra, 2020). Urban green spaces (UGS) in open public areas are one of the most readily accessible ecosystems that all urban residents share (Zhao et al., 2024). In addition to their ecological functions, UGS provide important

socio-cultural values, play a crucial role in enhancing urban citizens' physical and mental wellbeing, foster social cohesion, and stimulate a sense of place and cultural identity (Daniel et al., 2012; Milcu et al., 2013).

Cultural ecosystem services (CES) are the nonmaterial benefits of ecosystems, such as recreational and aesthetic experiences, spiritual enrichment, inspiration, cultural heritage, cognitive development, reflection, and educational and research opportunities (Millennium Ecosystem Assessment, 2005). CES directly contribute to human wellbeing and play a role in shaping human experiences with nature (Rolando et al., 2017). Preserving and enhancing CES is crucial in urban planning and policymaking to ensure healthier, more resilient communities (Tian et al., 2024). Mitigating the adverse effects of urbanization and global change helps to maintain the wellbeing of urban populations

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<https://doi.org/10.1016/j.baae.2025.08.002>

Received 11 April 2025; Accepted 6 August 2025

Available online 7 August 2025

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and better equips them for future challenges (Summers, 2018).

Nevertheless, CES are socially constructed environmental values (Stedman, 2003; Winthrop, 2014), arising from dynamic human-ecosystem relationships (Chan et al., 2012), where both the characteristics of people (demand factors) and green spaces (supply factors) influence the benefits generated by the use of these cultural services (dependent variables) (Hegetschweiler et al., 2017). People do not assess CES in a standard or objective way; some might visit urban forests, and UGS to socialize, reduce stress, or enjoy the beautiful scenery (Baumeister et al., 2020; Zheng et al., 2020; Cheng et al., 2022; Gavrilidis et al., 2024).

Socio-demographic backgrounds such as occupation and education can influence public perceptions of the environment. For example, Chen et al. (2019) found that civil servants valued biodiversity more than other occupations and that inadequate basic education might have resulted in a low level of public awareness regarding environmental protection in Malaysia and Indonesia. In addition, other studies have shown that attributes such as age, income, gender, education level shape how people perceive and use UGS (Ostojčić et al., 2017; Hami et al., 2020; Tian et al., 2020). However, there is contrasting research indicating that cultural context has a greater influence than demographic background. For example, Sieber et al. (2021) found that the cultural context in which ecosystem services matrix assessments were performed had a greater influence on the outcomes than demographic background for an expert in Suriname and French Guiana, recommending more attention when applying the results of a single location matrix to different contexts. Other research also shows that how people perceive and value environmental issues can be shaped by cultural and ideological differences (Afshar Jahanshahi et al., 2018; Eisler et al., 2003; Schelhas & Pfefer, 2005). It is essential to understand various public perceptions of CES provided by UGS in order to provide the necessary socio-cultural values to citizens through limited green spaces in the city. Thus, it is necessary to understand how different socio-demographic factors influence CES perceptions and how these perceptions vary across cultures.

This study was motivated to explore public perceptions in different cities and contrasting cultures in Western and Asian countries, while examining how socio-demographic background influences the perceptions within each city. Although there is a growing body of research of CES in UGS (Haase et al., 2014; Dobbs et al., 2021; Krsnik & Illán-Fernández, 2024), studies that explicitly compare CES across cultural contexts remain limited. For example, Lindemann-Matthies et al. (2014) found that most Chinese respondents had weaker preferences for biodiversity than Swiss respondents. However, Chinese respondents studying environmental sciences valued species-rich forests due to higher biodiversity. Oh et al. (2021) observed that Singaporean residents spent less time in nature than their Australian counterparts, highlighting the dynamics of interaction between people and nature vary significantly across localities.

Much of the existing literature on nature interactions has conducted survey questions on the frequency and duration of UGS usage (Flowers et al., 2016; Hong et al., 2019; Oh et al., 2020), motivations for visiting UGS, and the impact of COVID-19 on visitation patterns (Berdejo et al., 2021; Beckmann-Wübbelt et al., 2021; Geng et al., 2021). Other studies have explored how UGS usage during the pandemic influenced life satisfaction and mental health (Reid et al., 2022; Davies et al., 2022; Refisch et al., 2024). Although early studies on the sociocultural perspective of UGS were limited (Rall et al., 2017), current research increasingly underscores the need to incorporate social dimensions in the CES assessment, recognizing the deep interconnectedness between human and ecosystem services (Chan et al., 2012). While CES, such as perception of UGS qualities, were historically more complicated to quantify than regulating services such as carbon sequestration (Andersson et al., 2015), recent research increasingly highlights their importance in urban planning and wellbeing (Žlender, 2024; Das & Das, 2025).

However, cross-cultural CES studies remain rare, and case studies

from Asian countries, aside from China, are underrepresented (McElwee et al., 2022; Yang & Cao, 2022; Cheng, 2023). Moreover, while there are studies comparing second-tier cities, they tend to focus on economic and demographic aspects (Evans et al., 2015; Agnoletti et al., 2017; Turgel & Ulyanova, 2023) rather than CES. Second-tier cities often have distinct urban environments compared to capital cities, requiring customized, location-specific planning and management approaches (ESPON, 2016). Given the current limited scope and geographic focus on CES (Huang et al., 2024a), this study addresses these gaps by focusing on second-tier cities in different cultural contexts to better understand how CES are perceived, valued, and to support inclusive, multi-centered urban planning.

Local and place-based public perceptions are crucial ecological knowledge indicators for planning and management, yet documenting and communicating these perceptions among stakeholders can be challenging (Baur et al., 2013; Rossi et al., 2024). To address this, Public-Participation GIS (PPGIS) has been increasingly used to identify CES and collect local and contextual perceptions (Brown & Fagerholm, 2015; Brown & Kyttä, 2018). PPGIS is a mapping activity that involves the public and uses GIS-based information and maps to influence the outcome of decision-making processes (Tulloch, 2008). It facilitates statistical and spatial analyses to discover the relationships between CES and diverse factors affecting their delivery, enabling possible measures to improve CES supply (Jaligot et al., 2019).

This study presents a comparative CES assessment from UGS between the second-tier cities Suwon in Korea¹ and Karlsruhe in Germany. As per our literature review in English, German, and Korean language, this is the first study on CES comparison between a pair of second-tier cities in Korea and Germany. The study is based on a PPGIS survey conducted in both cities from July 2nd to September 30th, 2023, following the removal of COVID-19 restrictions. This study aims to address the following research questions:

1. How do residents in Suwon and Karlsruhe access, utilize, and value CES from UGS?
2. What is the spatial distribution of CES in these cities?
3. How do socio-demographic factors influence residents' perspectives on CES in Suwon and Karlsruhe?

Material and methods

Case study cities and selection criteria

The study focused on Suwon and Karlsruhe, second-tier cities in Korea and Germany (Figs. 1 and 2). Suwon (121.10 km²) is the capital and largest city of Gyeonggi-do Province, located approximately 30 km from Seoul, the Korean capital (Suwon City, 2022). Karlsruhe (173.4 km²) is the second largest city of Baden-Württemberg, located in the Upper Rhine Valley of Germany (Stadt Karlsruhe, 2024). While they are similarly sized, Suwon has a much higher population (1.23 million) than Karlsruhe (309 thousand) (Stadt Karlsruhe, 2024; Suwon City, 2024), which is common in Asian countries due to higher population density compared to European countries (World Bank, 2022). The population disparity may influence residents' perception of CES from UGS, potentially affecting their valuation of CES.

The selection of Suwon and Karlsruhe as case studies was based on several criteria: total area, Gross Regional Domestic Product (GRDP), green space coverage, climate (seasons and annual mean temperature), and social context. First, ten Korean cities by population (Seoul, Busan, Incheon, Daegu, Daejeon, Gwangju, Suwon, Ulsan, Yongin, Goyang) were listed. The capital city, Seoul, was removed from consideration. The total area of each city was then evaluated. Among these cities, only

¹ In this study, Korea refers exclusively to the Republic of Korea (commonly known as South Korea).

Suwon (121.10 km²) and Goyang (268.12 km²) had comparable total areas with German cities. However, Goyang has the lowest per capita GRDP among metropolitan cities and provinces, whereas Suwon City is the administrative and economic center of Gyeonggi Province, making it more relevant and interesting for an international second-tier cities comparison.

Among German cities, Karlsruhe (173.46 km²), Freiburg (153.1 km²), Mannheim (145 km²), Bonn (141.1 km²), and Potsdam (187.3 km²) have similar total areas to Suwon. Karlsruhe was selected due to its similar green space percentage (49.1 %) and GRDP (€22.143 billion) compared to Suwon (53.9 %, €23.566 billion) (Incheon Ilbo, 2022; Statista, 2022). Both cities experience four distinct seasons and have similar annual temperatures (11.5 °C in Suwon, and 11.2 °C in Karlsruhe) (KMA Weather Data Service, 2020; Climate Data, 2022). Additionally, both cities have technical universities and a technology park/techno valley with start-ups. They are also both recognized by UNESCO for their cultural significance: Suwon Hwaseong Fortress is a UNESCO World Heritage site, and Karlsruhe is designated as a UNESCO City of Media Arts. These factors led to the selection of both cities as case studies.

Suwon and Karlsruhe are well-equipped with UGS at a landscape scale of 200 km²; however, there is heterogeneity of UGS distribution within built-up areas. 54.41 % of Suwon is a green area, comprising 47.92 % natural area (preserved green space restricting development), 5.59 % green production area (agricultural production), and 0.8 % conservation area (conserving the natural environment) (Suwon, 2024). These include various types of public green spaces such as urban parks, forested areas, green corridors, and riverside greenways, which differ in their ecological functions and cooling effects (Lee & Jeon, 2023). In Karlsruhe, 49.1 % of the area is vegetation; 22.5 % being agricultural land and 25.6 % forest (Stadt Karlsruhe, 2024). Public green spaces in

Karlsruhe include urban parks, historical gardens, forests, riverside paths, playgrounds, and community gardens (Stadt Karlsruhe, 2022). With similar geographical size, distinct seasons and temperatures, academic institutions, economic strengths, recognized cultural heritage, and well-established green infrastructure, Suwon and Karlsruhe provide a valuable context for comparative studies between Korea and Germany.

Survey design

For this study, a PPGIS survey was developed using the softGIS survey tool Maptionnaire (<https://www.maptionnaire.com/>), including map-based and structured survey questions. The survey was available in Korean, German, and English. The first author initially crafted the questionnaire in English and translated it into Korean. Likewise, the English questionnaire was translated into German. The questionnaire was first reviewed by an expert at the survey design and methodology department of Leibniz Institute for the Social Sciences (GESIS) in Germany. Afterward, nine people at the Karlsruhe Institute of Technology (KIT) with backgrounds in environmental science, ecology, geography, urban ecology, biology, forestry, and engineering reviewed the questionnaire, checking it in English and German. Subsequently, 4 Korean researchers from European countries, including Germany, with backgrounds in environmental science, sustainability management, urban planning, and engineering reviewed the Korean survey, suggesting translations and making it understandable in both contexts. Finally, an English native speaker with a background in environmental science checked the English questionnaire to see if anything might need editing. The questionnaire was adapted based on those suggestions. Similar approaches to improving a survey before conducting it can be found in previous studies, such as a pilot survey with staff and students at the

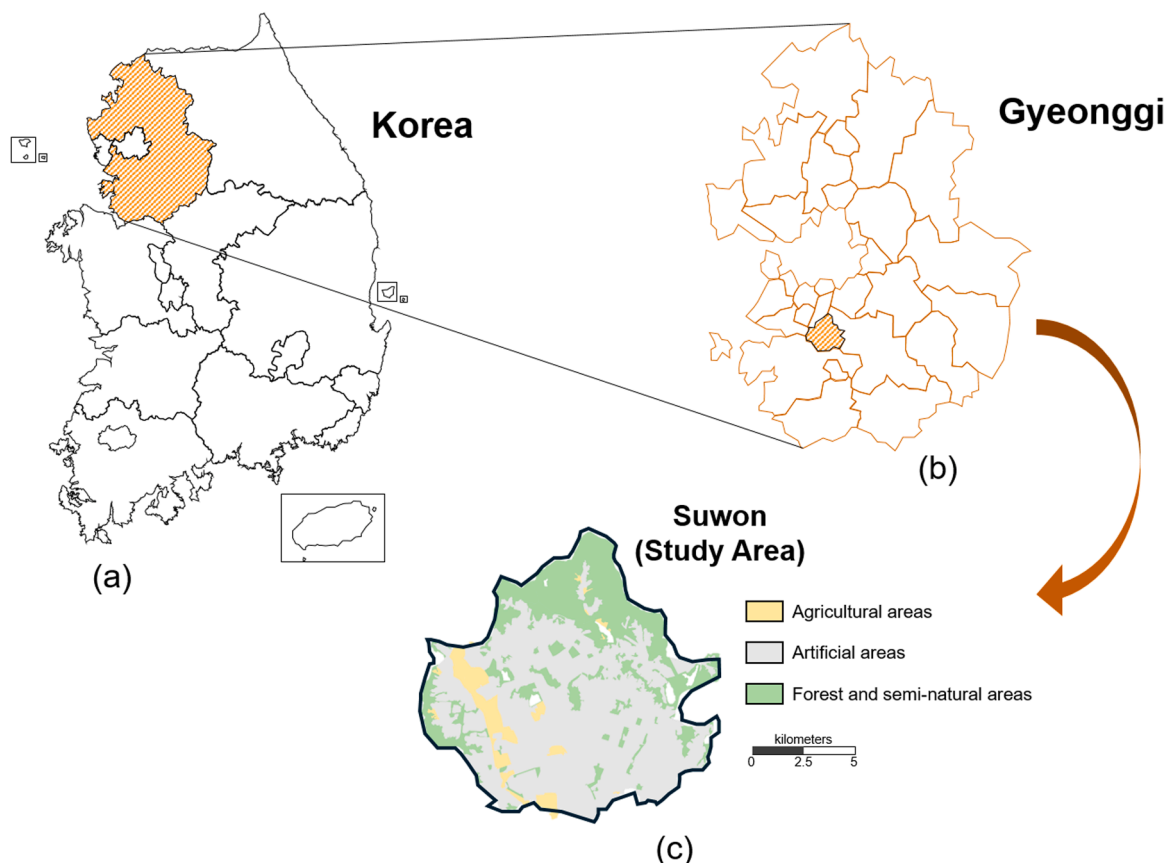


Fig. 1. Geospatial location and land use distribution of Suwon, Gyeonggi, Korea (Source: Author, based on Wikimedia Commons, 2009b, 2016, 2022; Geofabrik, 2018).

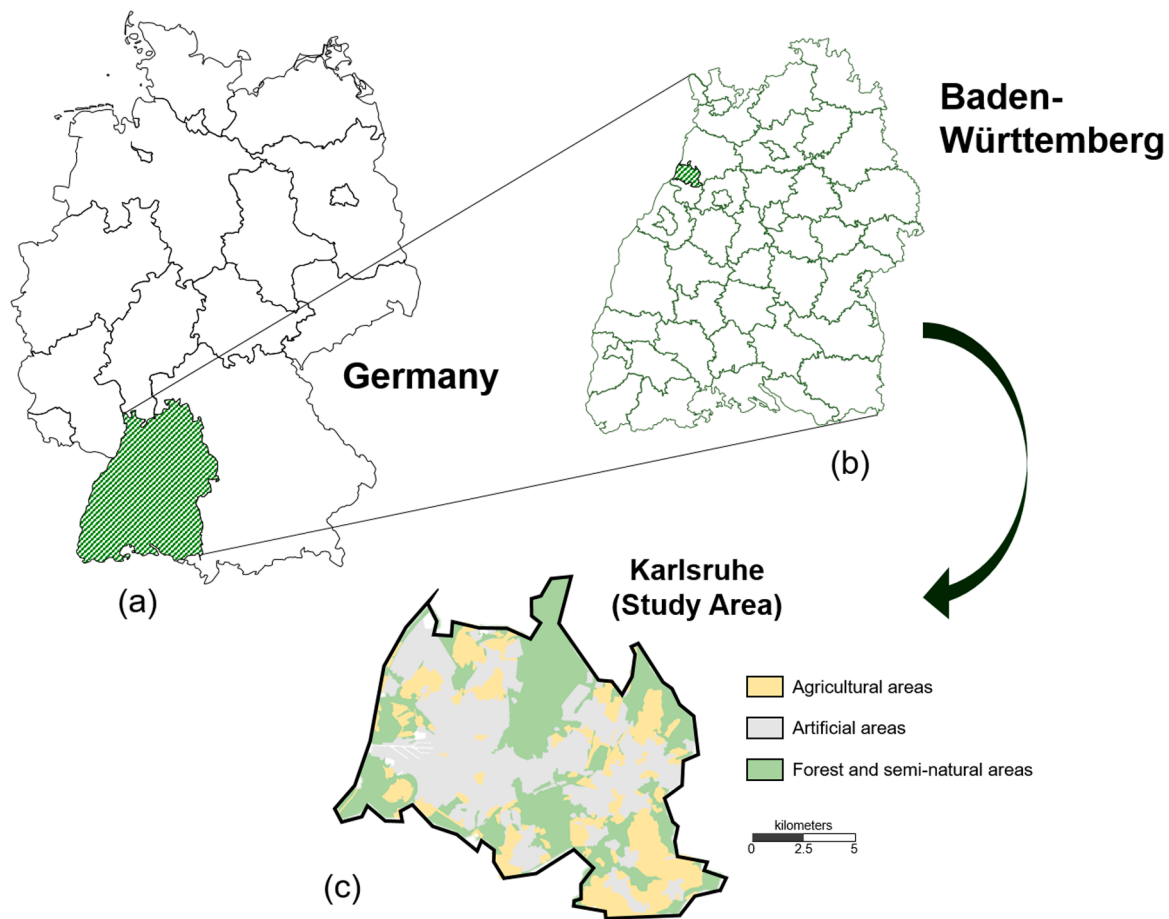


Fig. 2. Geospatial location and land use distribution in Karlsruhe, Baden-Württemberg, Germany (Source: Author, based on [Wikimedia Commons 2009a, 2012](#); [Geofabrik, 2018](#)).

university with residents ([Jones et al., 2020](#); [Lindemann-Matthies & Brieger, 2016](#)), or developing a survey based on a literature review and discussion with academic staff and stakeholders ([Haase & Gaeva, 2023](#)).

The questionnaire was structured into five sections, each addressing different aspects of UGS usages and perceptions:

1. **Introduction:** The landing page provided information on the purpose of the survey, privacy policies, and a clear definition of CES in accessible language. A contact email address was also provided for questions.
2. **UGS visits:** This section included questions about the frequency and duration of UGS visits, companionship during these visits, activities at the green spaces, and the impact of COVID-19 on visitation patterns, using a three-point Likert scale ([Likert, 1932](#)). The question on visit frequency did not specify a time frame (e.g., past 12 months), and was intended to capture respondents' general habits and perceptions of typical visitation patterns.
3. **UGS qualities:** This section asked respondents to evaluate the importance of different qualities of urban green spaces with a five-point Likert scale, such as safety, facilities (e.g., drinking water, toilets, playgrounds and benches), cleanliness, maintenance, quietness, less pollen, and biodiversity. In addition, participants assessed the importance of UGS for human wellbeing and climate change mitigation.
4. **Favorite and closest UGS (mapping question):** After indicating their city of residence, participants were shown a map of their respective city and asked to mark their favorite green space. Survey questions included the type of UGS, its proximity to their home, reasons for their preference with a five-point Likert scale, and whether it was the

closest green space. If it was not, then respondents were asked to select the closest green space on the map and provide details on its type and distance from their home. All distance-related data were self-reported, reflecting participant's perceived proximity.

5. **Socio-demographic information:** The final section collected demographic information, including age, gender, educational level, gross monthly income, years of residence in the city, and nationality.

The survey was conducted in accordance with the data protection guidelines of the KIT. The questionnaire and associated data protection measures were reviewed by the Data Protection Officer at the Institute for Technology Assessment and Systems Analysis (ITAS), KIT, and were formally documented in KIT's electronic processing directory (eVV). Informed consent was obtained through a clear introductory statement on the survey's landing page, which explained the study's purpose, voluntary participation, anonymity, and data protection policies in Korean, English, and German. Participants were explicitly instructed not to enter any personal data in free-text fields. According to the Ethical Principles of KIT, formal ethics approval was not required for this type of anonymous, non-interventional survey research. The study adhered to the principles of informed consent and data minimization in line with the EU General Data Protection Regulation (GDPR) and the Korean Personal Information Protection Act (PIPA). The full privacy notice and survey can be found in Supplementary Material S1 and S2.

Participant recruitment and sampling strategy

Previous studies have recruited participants via social media and word of mouth ([Rapuno et al., 2022](#)), through market research

companies (Berdejo et al., 2021), or by sending flyers to homes and emails (Baumeister et al., 2020). This study employed a comprehensive strategy for participant recruitment to reach a diverse audience. Initial invitations were distributed via mailing lists and newsletters of relevant institutes and associations, as well as social media platforms such as X (previously Twitter), LinkedIn, Instagram, and Facebook. Later, the survey information was posted on the online communities of universities and companies in both Suwon, Korea, and Karlsruhe, Germany. While monitoring the responses as the survey progressed (Jaligot et al., 2019), offline distributions were initiated to boost sample sizes, with hundreds of flyers and posters personally administered by the first author via university buildings, public information boards, and houses in both cities. Participants were encouraged to share the survey with others, facilitating a snowballing process (Bryman, 2016; Haase & Gaeva, 2023).

While the recruitment strategy in this study was comprehensive and adaptive, the sampling approach employed a non-probabilistic design, relying on voluntary participation through public outreach and peer sharing. This aligns with convenience sampling methods, where the probability of inclusion for each individual cannot be determined and participation is left to individual choice (Fricker, 2008). The goal was to collect approximately 900 valid responses, with a valid distribution between Suwon and Karlsruhe, to support comparative analysis. This target was informed by sample sizes used in previous urban perception and PPGIS studies, which have ranged from a few hundred to around 1000 participants. For example, Berdejo et al., 2021 collected 1002 responses in Brisbane; Baumeister et al. (2020) gathered 397, 643, and 745 responses in three German cities; and Oh et al. (2020) conducted 311 household surveys in Singapore. The present study was conducted independently by the researcher, without institutional or third-party support for sampling. Although the sample is not statistically representative, efforts were made to reach a broad and diverse cross-section of urban residents in both cities.

Data analysis

Data preparation and statistical analyses

The responses were extracted as Microsoft Excel files from the Maptionnaire platform (Maptionnaire, 2024). Data analysis was conducted using IBM SPSS Statistics 27 (IBM Corp, 2020) and Excel 2019 (Microsoft Corporation, 2019). Frequencies and mean values were calculated across multiple parameters, including self-reported distance from the preferred location, agreement on the influence of COVID-19 on UGS visits, activities in UGS, reasons for preference, type of UGS, visiting time, frequency, time spent in UGS, the importance of UGS for human wellbeing, and climate mitigation.

A series of Mann-Whitney U tests were conducted to identify statistically significant difference between Suwon and Karlsruhe. This non-parametric test was chosen because it is suitable for comparing two independent groups when the data are ordinal, such as Likert-scale responses (Laerd Statistics, 2024). Specifically, the tests were used to assess differences between the two cities in:

1. the valuation of CES
2. the influence of COVID-19 on the frequency of visits to UGS
3. the reasons for liking UGS, based on respondents' selections from a list of possible motivations (e.g., recreation, aesthetics, health benefits).

Since the dependent variables in this study are ordinal categorical, ordinal logistic regression was the appropriate analytical method (Sokal & Rohlf, 1987). Accordingly, four ordinal logistic regressions and corresponding likelihood ratio tests were conducted to identify the influence of the demographic variables in both cities on:

1. duration of visits to UGS;

2. frequency of visiting UGS;
3. the influence of COVID-19 on the frequency of visits to UGS;
4. public valuation of the importance of biodiversity

Interaction tests were conducted to determine whether the effects of independent variables (e.g., age and residence) on the dependent variable (e.g., importance of biodiversity) differed between Karlsruhe and Suwon. Subsequently, likelihood ratio tests were used to evaluate whether the inclusion of interaction terms provided a better-fitting model. A p-value is below 0.05 indicated a significant interaction, justifying the use of interaction model; otherwise, an additive model was selected for simplicity and accuracy. The additive model assumes that each independent variable affects the dependent variable separately. In contrast, the interaction model assumes that the effect of each independent variable on the dependent variable—such as respondents' perceived importance of biodiversity—may vary depending on the other variables, indicating an interaction. Additionally, Spearman correlation analysis was used to examine the relationship between age and the time spent in UGS.

Visualization of map-based responses

Weighted heat maps were generated for each city using the built-in heatmap visualization tools provided by Maptionnaire based on the per value and sum of participants in Suwon and Karlsruhe. The heatmap generation process in Maptionnaire involves several key parameters. The color gradient represents different density levels, specified as an array of CSS color strings. The radius, measured in pixels, determines the area around each data point that influences the heatmap, while the blur size smooths the transitions between colors, creating a more gradual visual effect. Additionally, the weight attribute, which can be a feature attribute or a function returning a weight from a feature, influences the intensity of each point on the heatmap.

To ensure comparability between the two cities, the same geographical scale—defined by the radius setting in the heatmap function—was applied, along with consistent visualization settings across both maps. Specifically, the radius and blur were set to 50 pixels, and the opacity was set to 0.8 for both cities when creating the heatmaps. These parameters collectively ensure a visually informative representation of data density, similar to the principles outlined in the OpenLayers (2024) and Esri (2024) documentation on heatmap visualization.

Results

Socio-demographic profile of respondents

A total of 975 respondents participated in the questionnaire. 67 respondents who did not specify their city of residence were excluded to ensure data quality, leaving 908 valid responses. Of the 908 respondents, 433 were from Suwon, Korea (47.7 %), and 475 were from Karlsruhe, Germany (52.3 %).

Demographic questions beyond city of residence were optional, leading to varying response rates across variables. Therefore, demographic characteristics are presented separately for each city to provide a clearer picture of the respondent profiles (Table 1). For all statistical analyses, only complete cases relevant to each specific test were included.

Although the legal age of adulthood is 18 in Germany and 19 in Korea, we included respondents aged 16 and above in our analysis, as we considered them capable of providing informed and meaningful responses regarding UGS use. Income categories were designed based on the respective minimum income levels in each country to ensure contextual relevance. For comparability, the thresholds of 3,000 euros in Germany and 3,000,000 won (approximately €1,898 as of June 27, 2025) in Korea were used as benchmarks for higher income, both of which are well above the national minimum wage levels. Please note that currency values fluctuate and this conversion is provided for

Table 1
Demographic profile of respondents in Suwon and Karlsruhe.

Characteristics	Category	Suwon	Karlsruhe
Gender	Total respondents	354 (100 %)	404 (100 %)
	Male	197 (55.65 %)	167 (41.34 %)
	Female	150 (42.37 %)	219 (54.20 %)
	Non-binary	0 (0.00 %)	6 (1.49 %)
	Prefer not to answer	7 (1.98 %)	12 (2.97 %)
Age	Total respondents	285	271
	Mean \pm SD	43.52 \pm 13.90	35.9 \pm 11.97
Nationality	Total respondents	336 (100 %)	352 (100 %)
	German	2 (0.60 %)	305 (86.65 %)
	Korean	321 (95.54 %)	1 (0.28 %)
	Others	13 (3.87 %)	46 (13.07 %)
Education	Total respondents	349 (100 %)	405 (100 %)
	Primary school	0 (0.00 %)	1 (0.25 %)
	Secondary school	2 (0.57 %)	11 (2.72 %)
	High school	38 (10.83 %)	46 (11.36 %)
	University	301 (87.75 %)	340 (83.94 %)
	Prefer not to answer	10 (2.85 %)	7 (1.73 %)
Gross monthly income	Total respondents	350 (100 %)	403 (100 %)
	Not applicable	26 (7.43 %)	23 (5.71 %)
	Below €2,000 / 2,000,000 won per month	19 (5.43 %)	63 (15.63 %)
	€2,000–3,000 / 2,000,000–3,000,000 won per month	51 (14.57 %)	79 (19.60 %)
	Above €3,000 / 3,000,000 won per month	217 (62.00 %)	187 (46.40 %)
	Prefer not to answer	37 (10.57 %)	51 (12.66 %)
Years of residence	Total respondents	347 (100 %)	385 (100 %)
	Less than 1 year	22 (6.34 %)	29 (7.53 %)
	1–5 year	101 (29.11 %)	110 (28.57 %)
	More than 5 years	224 (64.55 %)	246 (63.90 %)
Total		433	475

Note. Demographic questions were optional besides city of residence. Sample sizes (n) vary accordingly. Analyses were conducted using available data per variable.

reference only.

In Suwon, gender information was provided by 354 respondents, with a majority identifying as male (55.65 %) and female (42.37 %). No respondents identified as non-binary, and 2 % preferred not to answer. The average age was 43.52 years (SD = 13.9). Most respondents identified as Korean (95.54 %), with a small number identifying as other nationalities. Educational level was high, with 87.75 % having attended or completed university education. In terms of income, 62 % reported earning >3,000,000 won in Korea. A majority (64.55 %) had lived in Suwon for more than five years.

In Karlsruhe, 404 respondents provided gender information, with 54.2 % identifying as female and 41.34 % as male. Six respondents (1.49 %) identified as non-binary, and 2.97 % preferred not to answer. The average age was 35.9 years (SD = 11.97). Most respondents were Germans (86.65 %), while others identified as Korean or from other nationalities. University education was reported by 83.94 % of respondents. In terms of income, 46.4 % earned more than 3,000 EUR per month. Most participants (63.9 %) had lived in Karlsruhe for more than five years.

Access, utilization, and valuation of cultural ecosystem services

Frequency and duration of visits to urban green spaces

For frequency of visits, the Mann-Whitney U test indicated a statistically significant difference between the two cities ($p < 0.001$). The ordinal logistic regression further confirmed that Karlsruhe residents visited UGS significantly more often than Suwon residents ($\beta = 1.12$, $SE = 0.13$, $z = 8.80$, $p < .001$). The median frequency of Karlsruhe was 1 to 3 times a week, compared to 2 to 3 times per month for Suwon. Additionally, 30.7 % of Karlsruhe residents visited UGS 4 to 7 times a week, more than double Suwon's 13.9 %. Conversely, 33.8 % of Suwon residents visited UGS once or less a week, compared to only 9.4 % in Karlsruhe.

For the duration of visits, the Mann-Whitney U test also showed a significant difference ($p < .001$). Ordinal logistic regression revealed that Karlsruhe residents tended to spend more time in UGS than Suwon

residents ($\beta = 0.53$, $SE = 0.13$, $z = 4.16$, $p < .001$). While the median time spent was less than 1 hour in both cities, 38.32 % of Karlsruhe respondents spent 1 to 2 h and 7.37 % spent more than 2 h, compared to 29.10 % and 4.85 % in Suwon, respectively. Additionally, 21.3 % of Suwon residents spent less than 30 minutes in UGS, nearly twice the percentage in Karlsruhe (12.42 %). Figs. 3a and 3b illustrate these differences in frequency and duration of UGS visits.

In Suwon, most people visited UGS on weekends (28.08 %), with the least visits occurring on weekday mornings (9 %). Similarly, in Karlsruhe, the highest visitation was on weekends (34.96 %), and the lowest was on weekday mornings (12.03 %). In Suwon, 28.08 % of respondents visited UGS on holidays and 25.03 % on weekday evenings. In Karlsruhe, 23.1 % visited on holidays and 30 % on weekday evenings. Graphic figures on the timings of visits to UGS in Suwon and Karlsruhe are presented in Fig. 4.

The interaction between age and place of residence for the time spent in green spaces was statistically significant ($\beta = 0.05$, $SE = 0.01$, $z = 4.18$, $p < .001$). In Karlsruhe, younger people spent more time in UGS than older people ($\beta = 0.03$, $SE = 0.01$, $z = 2.61$, $p = .009$), whereas in Suwon, older people spent more time in UGS than younger people ($\beta = 0.03$, $SE = 0.01$, $z = 3.35$, $p = .001$). Spearman correlation analysis supported these findings, showing a negative correlation between age and time spent in UGS in Karlsruhe ($\rho = -0.134$, $p = .027$) and a positive correlation in Suwon ($\rho = 0.199$, $p < .001$). While both correlations were statistically significant, the strength of the relationships was relatively weak, particularly in Karlsruhe, as shown in Fig. 5.

The interaction between gender and place of residence for time spent in green spaces was statistically significant ($\beta = 0.55$, $SE = 0.28$, $z = 1.98$, $p = .048$). Female respondents spent more time in UGS than male respondents in Karlsruhe, while there was no statistically significant difference in time spent in UGS by gender in Suwon. For the frequency of visiting UGS, the interaction between gender and place of residence was statistically significant ($\beta = 0.57$, $SE = 0.27$, $z = 2.07$, $p = .038$). This indicates that the frequency of visits varied by gender between Karlsruhe and Suwon. In Karlsruhe, women tended to visit UGS more often, whereas in Suwon, men showed a higher frequency of visits. However,

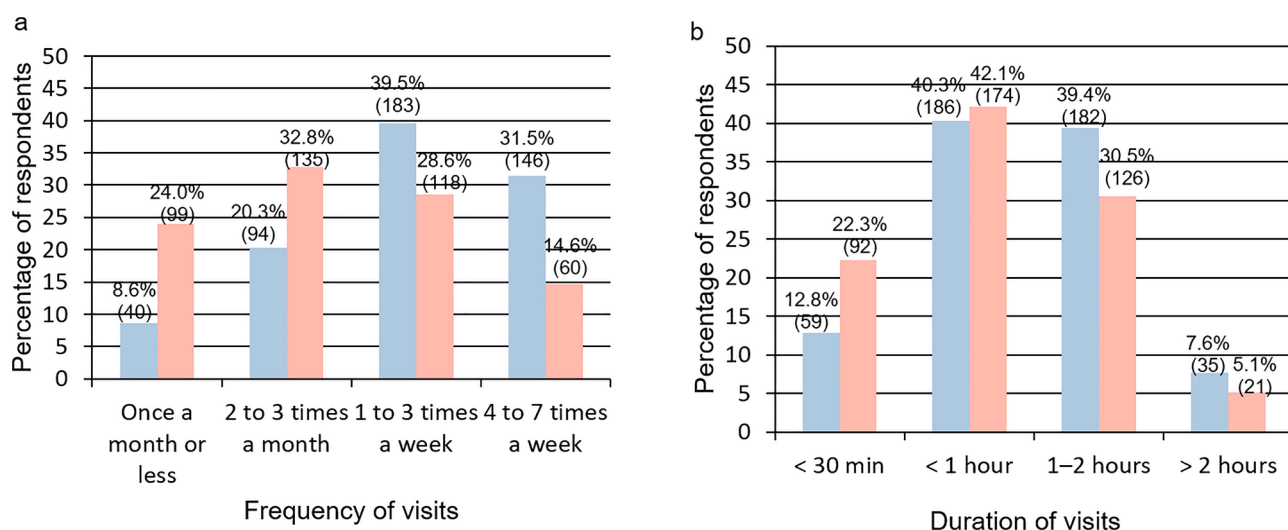


Fig. 3. a. Frequency of visits to green spaces by respondents in Karlsruhe (blue; $n = 463$) and Suwon (red; $n = 412$). b. Duration of visits to green spaces by respondents in Karlsruhe (blue; $n = 462$) and Suwon (red; $n = 413$).

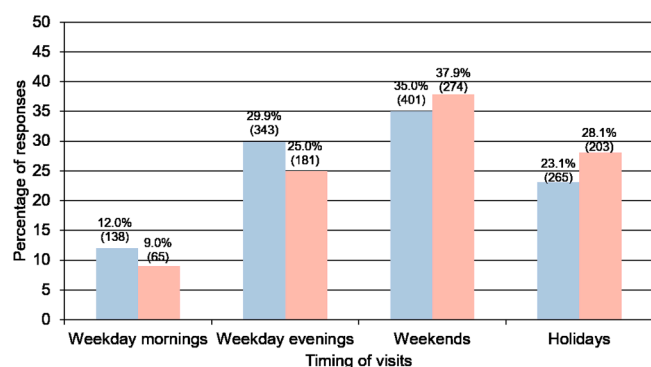


Fig. 4. Timing of visits to green spaces. Blue indicates Karlsruhe respondents, red indicates Suwon respondents.

within each city, there was no statistically significant difference in the frequency of visits between genders (Karlsruhe: $\beta = -0.29$, $SE = 0.19$, $z = -1.55$, $p = .122$; Suwon: $\beta = 0.28$, $SE = 0.20$, $z = 1.42$, $p = .155$).

Significant outcomes of the logistic regression analysis, examining the influence of demographic factors on the frequency and duration of UGS visits, are presented in Tables 2 and 3.

Activities and companions

Karlsruhe residents undertook a broader range of activities in UGS than Suwon residents, with an average of 2.3 different activities per person compared to 1.6 in Suwon. Karlsruhe had higher percentages for a variety of activities, such as socializing (21.9 %), watching/observing animals/plants (17.6 %), and commuting (10 %), while Suwon showed higher percentages in mainly exercising (33.8 %) and relaxing/meditating (31.7 %). Specifically, a significantly higher rate of people in Suwon (33.8 %) used green spaces for exercising than in Karlsruhe (18.6 %). Watching/observing animals/plants was more popular in Karlsruhe (17.6 %) than in Suwon (11.9 %). People in Karlsruhe socialized more in UGS (21.9 %) than in Suwon (9 %). A higher percentage of people in Karlsruhe used UGS for commuting (10 %) compared to Suwon (3.7 %). Walking the dog was more common in Suwon (6 %) than in Karlsruhe (2.8 %). Both cities had a high percentage of people using UGS for relaxing or meditating, with 31.7 % in Suwon and 22.5 % in Karlsruhe.

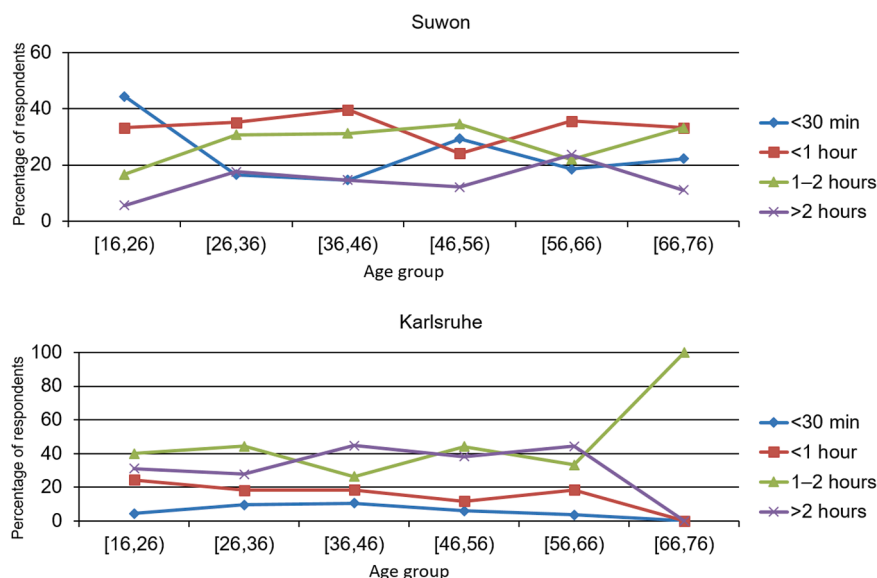


Fig. 5. Influence of age on time spent in urban green spaces by respondents in Karlsruhe and Suwon.

Table 2

Regression outcome for frequency of visits to green spaces by the demographic variables. Lists only those models that are significant between the additive and interaction models.

Predictor	Estimate (β)	Std. Error	z-value	p-value	95 % Confidence Interval	
					Lower bound	Upper bound
Age						
Age	0.009	0.006	1.563	.118	−0.002	0.021
Gender						
Gender: Male	0.288	0.199	1.442	.149	−0.103	0.679
City: Karlsruhe	1.400	0.199	7.032	<0.001	1.010	1.790
Gender: Male \times City: Karlsruhe	−0.566	0.273	−2.070	.038	−1.100	−0.031
Education						
Education: Low	−0.049	0.139	−0.356	.722	−0.322	0.222
Income						
Income: Low	0.125	0.104	1.208	.227	−0.078	0.328

Table 3

Regression outcome for duration of visits to green spaces by the demographic variables. Lists only those models that are significant between the additive and interaction models.

Predictor	Estimate (β)	Std. Error	z-value	p-value	95 % Confidence Interval	
					Lower bound	Upper bound
Age						
Age	0.028	0.008	3.450	.001	0.012	0.044
City: Karlsruhe	2.696	0.526	5.128	<0.001	1.670	3.730
Age \times City: Karlsruhe	−0.052	0.013	−4.180	<0.001	−0.077	−0.028
Gender						
Gender: Male	0.040	0.201	0.198	.843	−0.355	0.435
City: Karlsruhe	0.757	0.195	3.876	<0.001	0.375	1.140
Gender: Male \times City: Karlsruhe	−0.548	0.277	−1.976	.048	−1.090	−0.005
Education						
Education: Low	−0.097	0.140	−0.693	.488	−0.372	0.177
Income						
Income: Low	−0.133	0.105	−1.264	.206	−0.339	0.073

Regarding companions, the highest response in both Suwon (29.2 %) and Karlsruhe (32.9 %) was that people usually go to UGS alone. This is closely followed by a similar response percentage for visiting UGS with their partners in Suwon (28.9 %) and Karlsruhe (26.8 %). A higher percentage of people in Karlsruhe (28.3 %) visited green spaces with friends than in Suwon (19.7 %), but visiting UGS with children was more common in Suwon (15.1 %) than in Karlsruhe (8.4 %). More people in Suwon (7 %) visited green spaces with pets compared to those in Karlsruhe (3.5 %). Graphical figures on activities and company during UGS visits in Suwon and Karlsruhe can be found in Figs. 6a and 6b

Influence of COVID-19 on visits to urban green spaces

The median responses in both cities indicate that COVID-19 did not change how often the respondents visited UGS, with 69.57 % in Karlsruhe and 56.02 % in Suwon reporting no change. The percentage of respondents who visited green spaces more often than before COVID-19 was relatively similar in both cities, with Karlsruhe at 27.46 % and Suwon at 26.54 %. However, the pandemic negatively impacted UGS visits in Suwon, where a higher percentage of respondents (17.44 %) reported visiting UGS less often than before, compared to Karlsruhe (2.97 %). However, when analyzing the full sample, we found a statistically significant difference in COVID-19's influence on UGS visits between Karlsruhe and Suwon, with Karlsruhe residents spending more time in UGS after COVID-19 than Suwon residents ($\beta = 0.53$, $SE = 0.13$, $z = 4.16$, $p < .001$). A graphical figure on the impact of COVID-19 on UGS visits in Suwon and Karlsruhe can be found in Fig. 7.

After COVID-19, younger people visited UGS more often than older people in both cities ($\beta = 0.01$, $SE = 0.01$, $z = 2.07$, $p = .038$). The interaction between education and place of residence for the role of COVID-19 was statistically significant ($\beta = 0.94$, $SE = 0.33$, $z = 2.89$, $p = .003$). In Suwon, residents who were attending university or held a university degree spent more time in UGS after COVID-19 than those who did not ($\beta = 0.51$, $SE = 0.24$, $z = 2.14$, $p = .033$). However, there

was no statistically significant difference in the influence of education (university education or not) on the impact of COVID-19 on Karlsruhe residents ($\beta = -0.35$, $SE = 0.21$, $z = -1.66$, $p = .098$). Outcomes of the logistic regression analysis examining the influence of demographic factors on COVID-19's impact on UGS visits can be found in Table 4.

Qualities of urban green spaces

Respondents were asked to evaluate the importance of various qualities of UGS. Statistically significant differences between Karlsruhe and Suwon residents were found in evaluating safety, facilities, cleanliness, maintenance, less pollen, and biodiversity. The only UGS quality that did not show a statistically significant difference between the two cities was quietness, where the medians of both cities were “Important” ($p = .123$). Beyond biodiversity, Suwon residents rated all other UGS qualities—safety, facilities, cleanliness, maintenance, and less pollen—as more “Important” than Karlsruhe residents did (Fig. 8). These differences were statistically supported by Mann-Whitney U tests and ordinal logistic regression (see detailed results below). Cleanliness stood as the only quality with a median rating of “Very important” in both cities, indicating a shared priority. Meanwhile, less pollen was the only quality rated as not important by a notable portion of respondents, particularly in Karlsruhe, as shown in Fig. 8.

Suwon residents rated safety significantly higher than Karlsruhe residents ($\beta = 1.15$, $SE = 0.14$, $z = 8.37$, $p < .001$). Similarly, facilities were rated more highly in Suwon ($\beta = 1.90$, $SE = 0.14$, $z = 13.27$, $p < .001$), as were cleanliness, maintenance, and less pollen. In contrast, biodiversity was rated more highly in Karlsruhe ($\beta = 0.80$, $SE = 0.13$, $z = 6.17$, $p < .001$). No significant difference was found for quietness ($p = .123$).

While Karlsruhe residents valued biodiversity more highly than Suwon residents ($\beta = 0.80$, $SE = 0.13$, $z = 6.17$, $p < .001$), a higher percentage of respondents in Suwon rated UGS biodiversity as “Not important at all” (9.01 %) or “Not important” (29.1 %) compared to

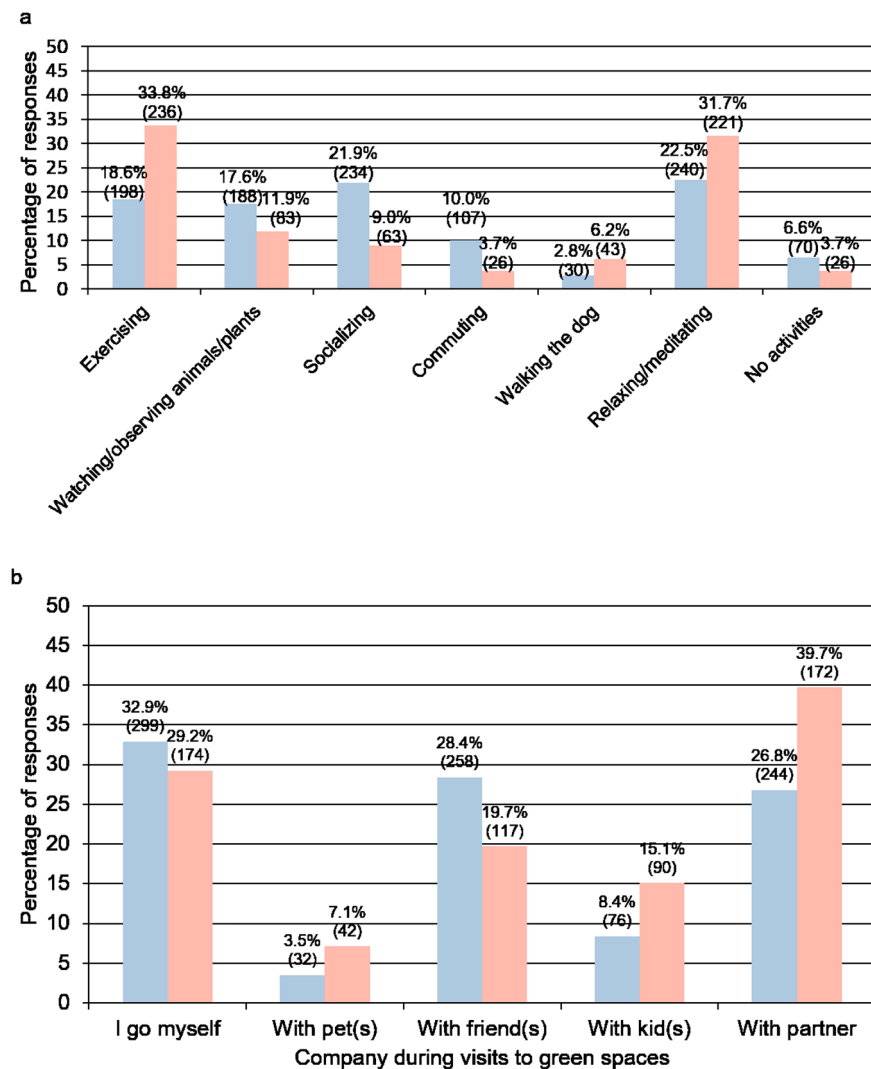


Fig. 6. a. Activity while visiting green spaces. b. Company during visits to green spaces. Blue indicates Karlsruhe respondents, red indicates Suwon respondents.

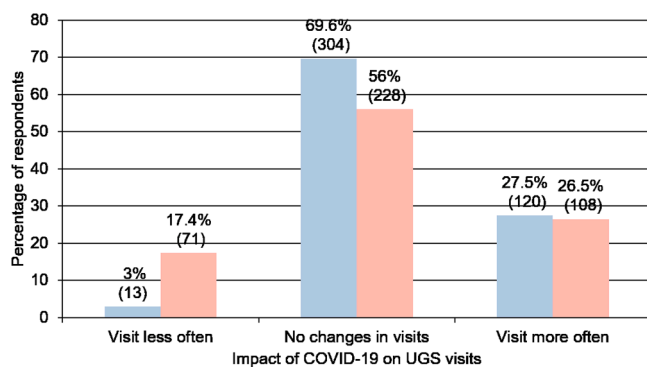


Fig. 7. Impact of COVID-19 on visits to urban green spaces in Karlsruhe (blue; $n = 437$) and Suwon (red; $n = 407$).

Karlsruhe (3.79 % and 18.74 %, respectively). Conversely, a greater proportion of respondents in Karlsruhe rated biodiversity qualities as “Important” (41.89 %) or “Very important” (30.32 %) compared to Suwon (38.34 % and 16.63 %, respectively).

Age was a statistically significant variable which influenced biodiversity valuation in both cities, where older people valued biodiversity more highly than younger people ($\beta = 0.03$, $SE = 0.01$, $z = 4.43$, $p <$

Table 4

Regression outcome for the influence of COVID-19 on urban green space visits by the demographic variables. Lists only those models that are significant between the additive and interaction models.

Predictor	Estimate (β)	Std. Error	z-value	p-value	95 % Confidence Interval	
					Lower bound	Upper bound
Age						
Age	−0.014	0.007	−2.071	.038	−0.028	−0.001
Gender						
Gender:	−0.058	0.153	−0.378	.705	−0.357	0.242
Male						
Education						
Education:	0.658	0.269	2.537	.011	0.148	1.170
Low						
City:	0.999	0.233	4.280	<0.001	0.542	1.460
Karlsruhe						
Education:	−0.943	0.327	−2.886	.004	−1.580	−0.301
Low × City:						
Karlsruhe						
Income						
Income:	−0.041	0.116	−0.349	.727	−0.268	0.187
Low						

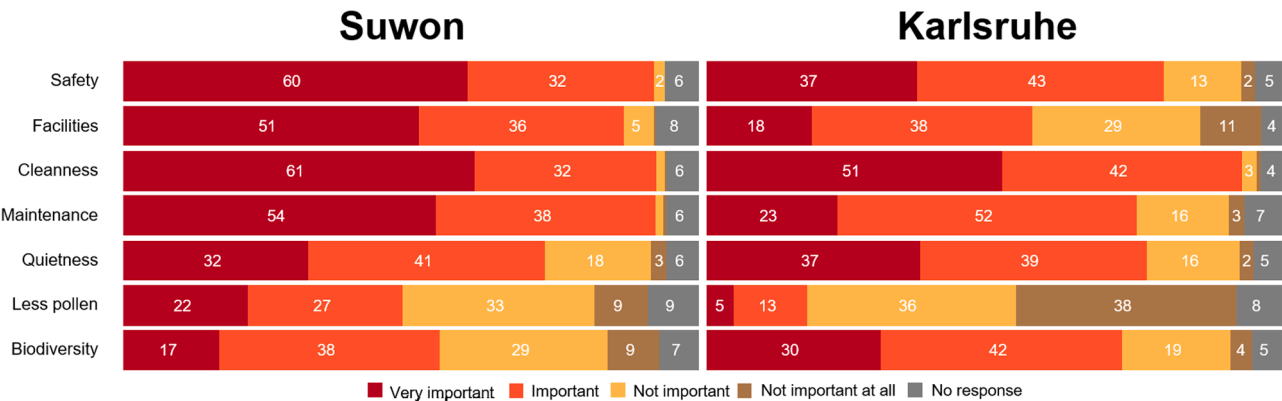


Fig. 8. Qualities of urban green spaces (%).

Table 5
Regression outcome for biodiversity evaluation of green space qualities by the demographic variables. Lists only those models that are significant between the additive and interaction models.

Predictor	Estimate (β)	Std. Error	z-value	p-value	95 % Confidence Interval	
					Lower bound	Upper bound
Age						
Age	0.027	0.006	4.426	<0.001	0.015	0.040
Gender						
Gender: Male	−0.308	0.140	−2.207	.027	−0.582	−0.035
Education						
Education: Low	−0.150	0.145	−1.037	.300	−0.435	0.134
Income						
Income: Low	−0.691	0.162	−4.276	<0.001	−1.010	−0.376
City: Karlsruhe	0.467	0.152	3.073	.002	0.170	0.765
Income: Low × City: Karlsruhe	0.762	0.215	3.543	<0.001	0.341	1.180

.001). Female respondents valued biodiversity more highly than male respondents in both cities ($\beta = 0.31$, $SE = 0.14$, $z = 2.21$, $p = .027$). The interaction between income and place of residence for people’s evaluation of biodiversity was statistically significant ($\beta = -0.76$, $SE = 0.22$, $z = -3.54$, $p < .001$). Suwon residents with a gross monthly income less than 3 million won (approximately €1,898 as of June 27, 2025) valued biodiversity more highly than those earning more than 3 million won ($\beta = 0.70$, $SE = 0.17$, $z = -4.26$, $p < .001$), but there was no

statistically significant difference in the valuation of biodiversity in Karlsruhe between residents with an income of less than €3,000 per month and those who earn more ($\beta = 0.07$, $SE = 0.14$, $z = 0.50$, $p = .621$). Outcomes of the logistic regression analysis examining the influence of demographic factors on biodiversity evaluation of UGS qualities can be found in Table 5.

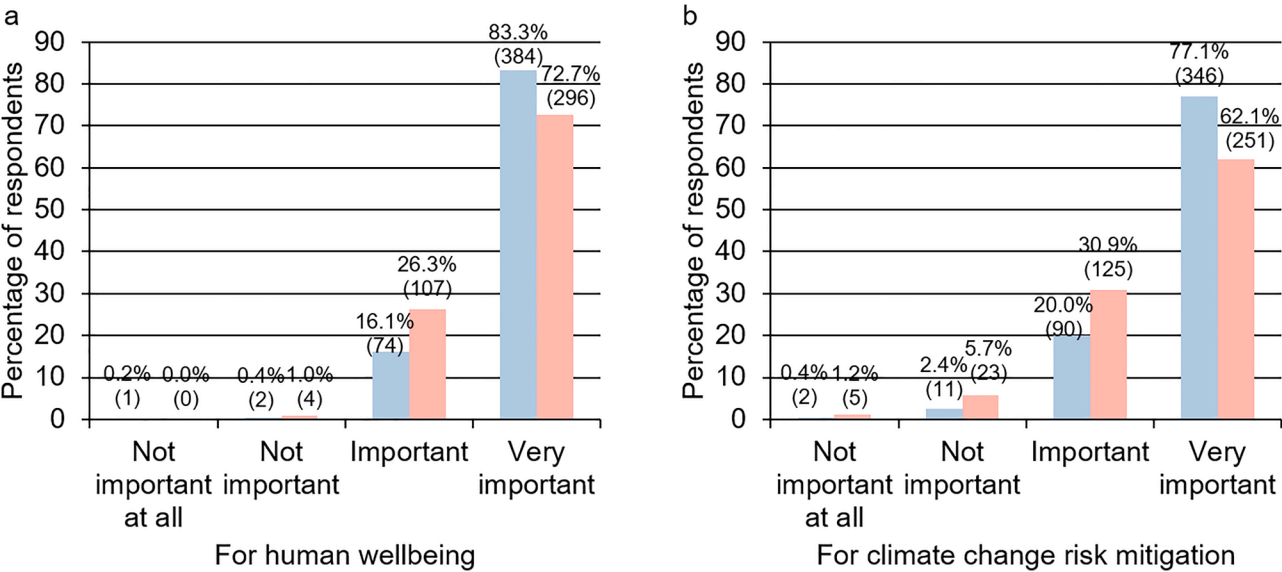
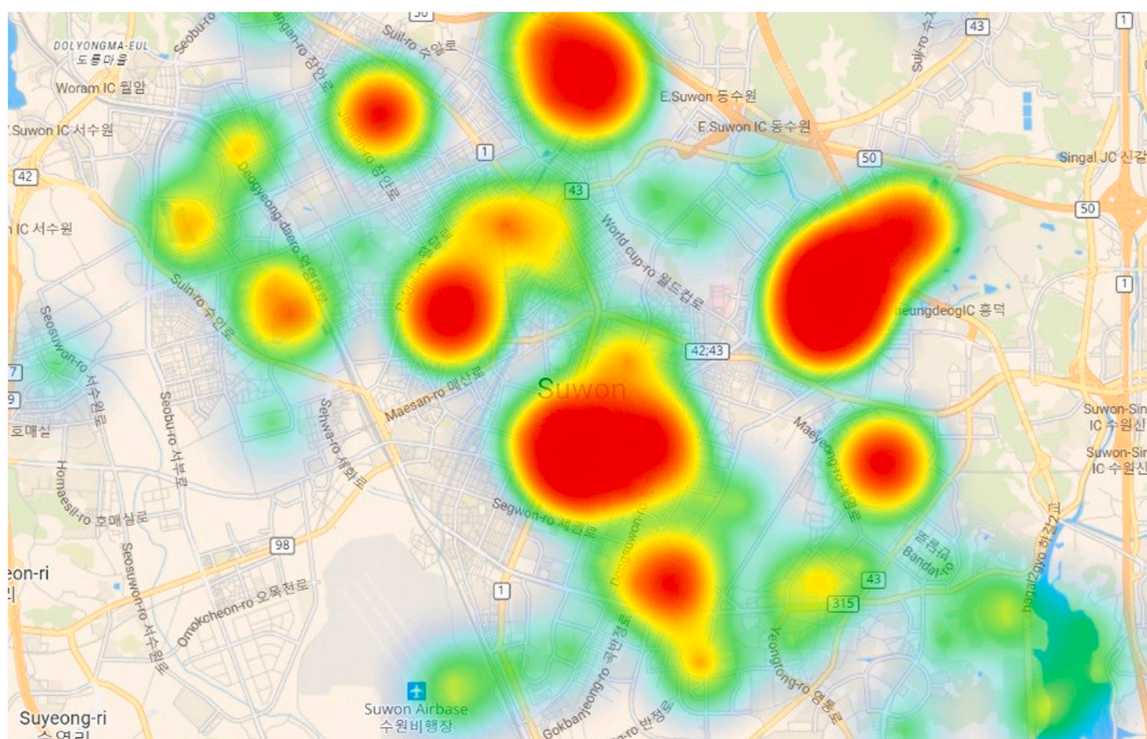
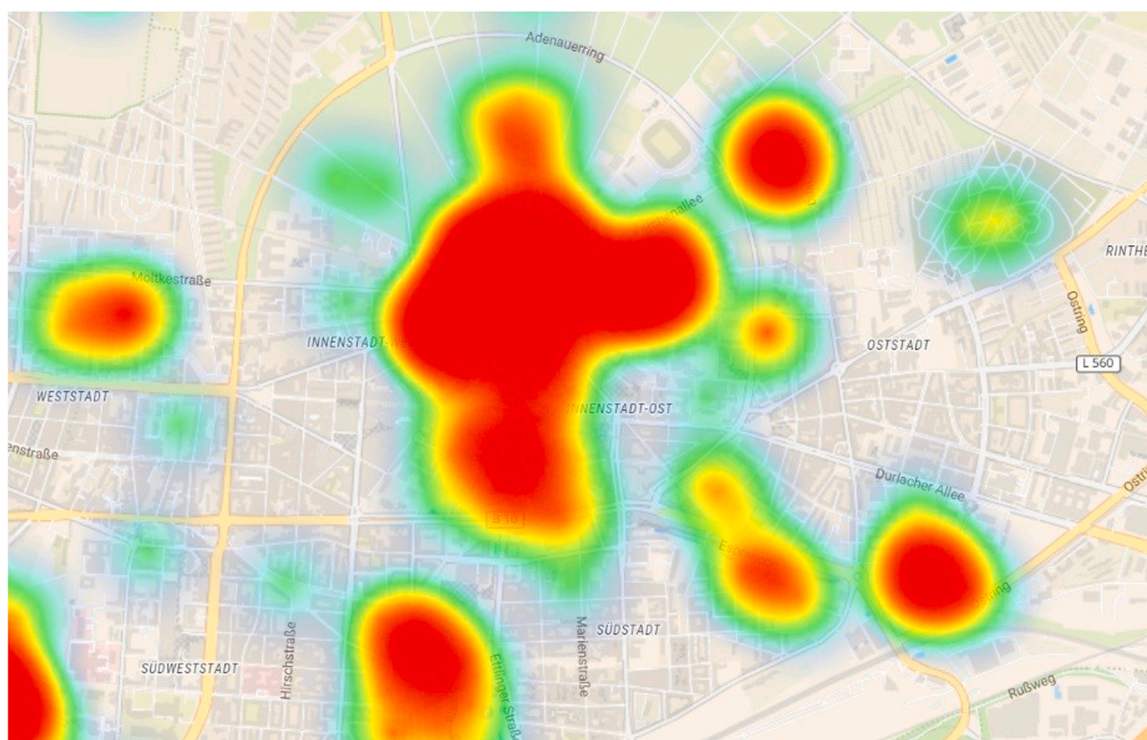


Fig. 9. a. Importance for human wellbeing of urban green space in Karlsruhe (blue; $n = 461$) and Suwon (red; $n = 407$). b. Importance of urban green spaces for reducing risks from the effects of climate change in Karlsruhe (blue; $n = 449$) and Suwon (red; $n = 404$).



(a) Suwon



(b) Karlsruhe

Fig. 10. Heatmaps of cultural ecosystem services in Suwon and Karlsruhe. Different colors in the heatmap represent varying densities of preferred UGS, with red indicating the highest density and light green indicating the lowest density.

Importance of urban green spaces

The majority of respondents in both cities responded that UGS are “Very important” for human wellbeing and climate change mitigation. However, although only 1 % in Suwon and 0.4 % in Karlsruhe answered that UGS are “Not important”, and only 0.2 % in Karlsruhe answered

they are “Not important at all” for human wellbeing, a higher percentage of respondents answered that UGS are “Not important” (5.7 % in Suwon, 2.5 % in Karlsruhe) or “Not important at all” (1.2 % in Suwon, 0.5 % in Karlsruhe) for climate change mitigation. Graphic figures on the perceived importance of urban green spaces for human wellbeing and

reducing risks from the effects of climate change in Suwon and Karlsruhe can be found in Figs. 9a, and 9b

Exploring preferences and mapping of urban green spaces

Spatial distribution of cultural ecosystem services

Utilizing the built-in heatmap visualization tools on the Maptionnaire platform, the map-based responses from the survey were visualized to show the spatial distribution of UGS in each city where the public indicated CES (Fig. 10). In Suwon, 268 locations were identified as the most preferred UGS due to their CES, with an additional 51 locations marked as the nearest UGS if the most preferred UGS was not the closest to their home. In contrast, in Karlsruhe, 471 locations were marked as the most preferred UGS, with 207 as the nearest UGS. The visualization shows a distinction between the two cities' distributions. In Karlsruhe, preferred UGS were more centralized around Karlsruhe Palace, which is one of the main attractions in the city, while in Suwon, preferred sites were distributed across the city.

Types of urban green spaces

In both cities, parks were the most favored type of UGS among respondents, with 65.8 % in Suwon, and 48 % in Karlsruhe expressing this preference. In Suwon, a hiking trail (13.3 %) was the next most chosen option, while other UGS types were less favored: natural reserves (5 %), riverfront (4.7 %), garden (4.7 %), landscaping around buildings (4.3 %), institutional or corporate grounds (1.3 %), and education campus (1 %).

In Karlsruhe, besides the park, other types of UGS chosen as favorites included gardens (12.5 %), nature reserves (11.9 %), hiking trails (10 %), landscaping around buildings (7.5 %), and riverfront (6.6 %). Educational campus (2.1 %), and institutional or corporate grounds (1.8 %) were less favored. The graphic figure on the type of favorite UGS in Suwon and Karlsruhe can be found in Fig. 11.

Distance from preferred urban green spaces to respondent's residences

The median distance to the favorite UGS for both cities was 500 m (m) to 1 km (km). In Suwon, 34.9 % of respondents reported that their favorite green space was located more than 1 km from their home, while 27.1 % reported that it was within 300 m, and 22.9 % indicated it was within 500 m to 1 km. Additionally, 15.1 % reported it was within 300 m to 499 m. Furthermore, 75.7 % of Suwon residents stated that their favorite UGS was the nearest to their home, while 24.3 % said otherwise. Among them, 37.9 % reported that their nearest UGS was more than 1 km away, 19.5 % answered it was 500 m to 1 km, 16 % indicated it was 300 m to 499 m, and 26.4 % said it was less than 300 m.

In contrast, 45.9 % of respondents in Karlsruhe stated that their

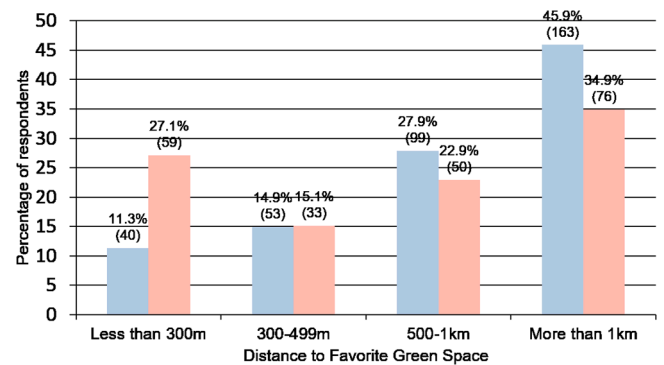


Fig. 12. Distance to favorite green spaces in Karlsruhe (blue; $n = 355$) and Suwon (red; $n = 218$).

favorite UGS was more than 1 km away, a higher percentage than Suwon. Additionally, 27.9 % reported that it was within 500 m to 1 km, 14.9 % said it was 300 m to 499 m away, and only 11.3 % indicated it was less than 300 m. Moreover, 67.4 % of the Karlsruhe respondents mentioned that their favorite UGS was not the closest one. Among them, 42.6 % answered that it was within 300 m, 21.3 % reported it was 300 m to 499 m, 23.2 % lived within 500 m to 1 km, and 12.9 % answered it was more than 1 km away. All distances mentioned in this section are based on respondents' self-reports. A graphic figure on the distance to favorite UGS can be found in Fig. 12.

Reasons for liking urban green spaces

Respondents were asked to indicate their reasons for liking UGS. Descriptively, the majority of respondents in both Suwon and Karlsruhe "Agreed" on the importance of aesthetics, ease of socializing, emotional attachment, health benefits, and quietness. In addition, both groups "Strongly agreed" that ease of access is crucial. Conversely, respondents in both cities generally "Disagreed" that cultural heritage is a reason for liking UGS.

To statistically evaluate these differences, Mann-Whitney U tests were conducted. The findings revealed significant variations between the two cities in reasons chosen, including recreation, sense of place, environmental education, health benefits, proximity to water ($p < .001$), as well as inspiration for creativity ($p = .002$) and cultural heritage ($p = .015$). No notable differences emerged for aesthetic appeal, ease of socialization, spiritual and religious values, quietness, or accessibility.

These findings align with the descriptive trends. For example, most Suwon respondents agreed on the importance of proximity to water and environmental education, while most Karlsruhe respondents "Disagreed". Mild differences were also observed in recreation (Suwon:

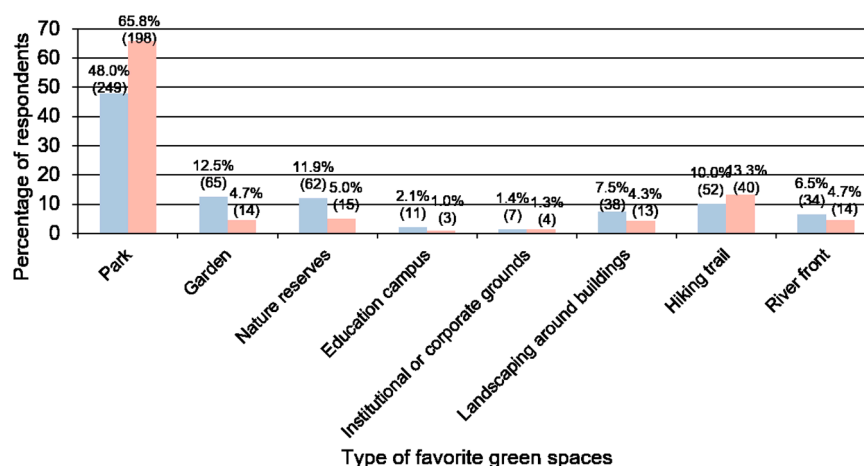


Fig. 11. Type of favorite urban green space. Blue indicates Karlsruhe respondents, red indicates Suwon respondents.

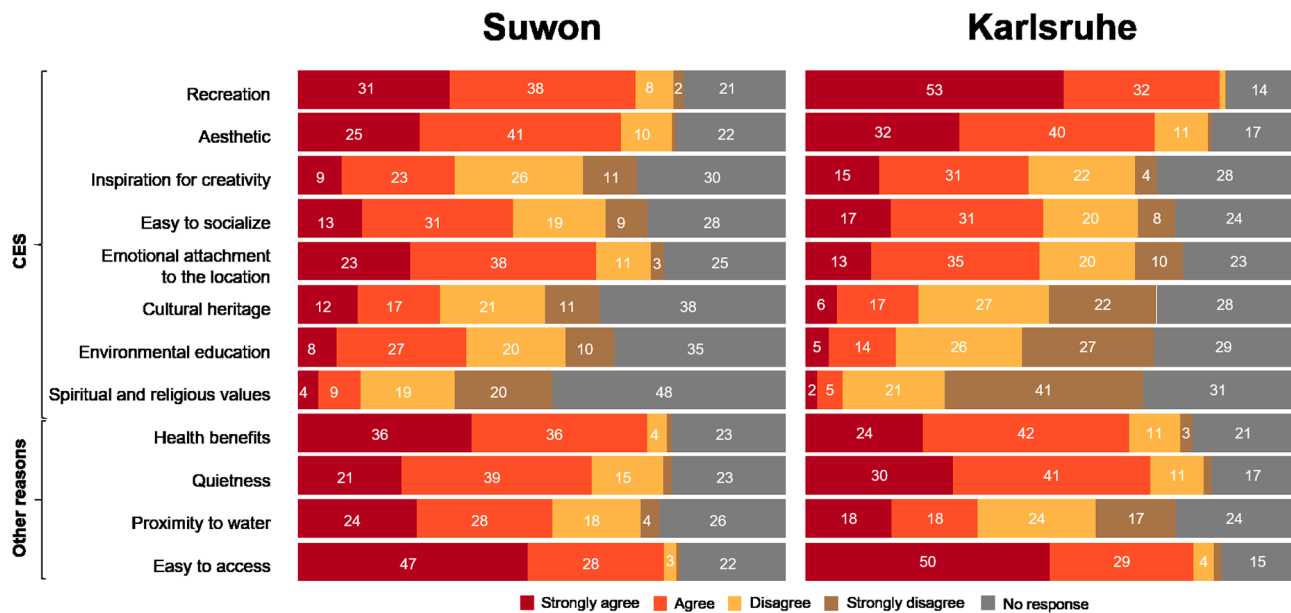


Fig. 13. Preferences for cultural ecosystem services (CES) and other contributing factors (%). Respondents selected reasons they liked their favorite urban green space after marking it on a map. CES include non-material benefits, while other reasons reflect practical motivations.

“Agreed”, Karlsruhe: “Strongly agreed”) and inspiration for creativity (Suwon: “Disagreed”; Karlsruhe: “Agreed”) which were confirmed as statistically significant. For spiritual and religious values, both cities showed low agreement (Suwon: “Disagreed”, Karlsruhe respondents: “Strongly disagreed”), though this difference was not statistically significant (Fig. 13).

Discussion

Convergence and divergence in public perceptions of urban green space qualities

This study investigated public perceptions of CES from UGS in Suwon and Karlsruhe using a PPGIS survey. Both cities’ residents valued recreation, aesthetics, socializing, emotional attachment, health benefits, and quietness in UGS, with ease of access being a crucial factor. However, cultural heritage, spiritual, and religious values were generally less emphasized. While many of these perceptions were shared, statistical analysis revealed that some of these differences were significant, highlighting nuanced variations in how UGS are valued across different cultural contexts. UGS were considered “Important” for wellbeing and climate change mitigation. The median distance to respondents’ favorite UGS was 500 m to 1 km, and parks were the most favored UGS type in both cities. The next preferred UGS types were gardens and nature reserves in Karlsruhe, with similar percentages, whereas in Suwon hiking was the most chosen option after parks, with other types chosen less than 5 %.

The preferred UGS type could have been influenced by different local factors. For example, although it is not in Karlsruhe, the well-known and easily reachable Black Forest National Park could have contributed to Karlsruhe residents indicating nature reserves as their third favorite UGS type after parks and gardens. In Suwon, the Suwon Hwaseong Fortress Loop, which surrounds the UNESCO heritage fortress, is popular for hiking. Additionally, Gwanggyosan, a mountain on the border of Suwon, offers a challenging trail with rocky paths and stunning views from the top. These factors could have contributed to Suwon respondents indicating hiking trails as the next most chosen option after parks.

Although we did not collect respondents’ residential location data, we gathered information on their nearest and favorite UGS, along with their perceived distance. Interestingly, most Suwon respondents’

favorite UGS was the nearest UGS to their home, while a significant number of respondents in Karlsruhe stated that their favorite UGS was more than 1 km away. This suggests that in Karlsruhe, factors such as the attractiveness, size, or amenities of more distant green spaces may outweigh proximity in shaping user preferences. For example, the Schlossgarten—a large, centrally located park adjacent to the Karlsruhe Palace—is not only historically significant and well-equipped for recreation, but also highly accessible due to the city’s unique fan-shaped street layout radiating out from the Palace. It is also possible that individuals choose different green spaces on their specific needs, visiting larger or more naturalistic UGS located in suburban or fringe areas when seeking particular experiences. While we could not systemically compare urban core versus suburban UGS usage due to data limitations, this distinction is likely relevant and should be explored in future research using spatially explicit data.

Transportation access may help explain why a higher proportion of Karlsruhe respondents reported UGS located more than 1 km from their homes. As of 2023, Karlsruhe had 458.4 passenger cars per 1000 inhabitants, a level similar to Suwon’s estimated 469.5 per 1000 (The Federal Returning Officer, 2025; Statistics Korea, 2025; Suwon Special City, 2025). While this indicates comparable car ownership rates, Karlsruhe’s strong cycling culture may also enhance mobility. Karlsruhe was ranked among the top three large German cities for cycling friendliness in 2024, reflecting its strong cycling infrastructure and public support for sustainable mobility (Stadt Karlsruhe, 2025). This likely facilitates access to more distant UGS. In contrast, Suwon’s bicycle mode share was only 2.6 % in 2021, and although the city has received national recognition for its cycling policies, public bike usage remains relatively low, with just 215 public bikes rented 14,495 times in 2023 (The province of Gyeonggi, 2021; Ministry of the Interior & Safety, 2024). These differences suggest that Karlsruhe residents may have more flexible mobility options, which could partly explain their willingness to travel farther to reach preferred green spaces.

Our studies rely on self-reported distance respondents’ favorite UGS, rather than objectively measured proximity. Recent research demonstrates that perceived access to green space is a stronger predictor of physical activity and visitation frequency, often more so than objective measures (e.g. Jeppesen et al., 2014; Phillips et al., 2023; Xu et al., 2024). For example, Jeppesen et al. (2014) found that in Denmark, individuals who reported easy access to neighborhood green space were

more than three times as likely to be physically active in those spaces, with this association being even stronger among individuals with higher educational level. Moreover, trajectory-based analyses in China suggest that while frequent park users are sensitive to perceived distance—visiting less often as perceived distance increases—occasional visitors may prioritize other factors such as park size, amenities, or uniqueness (Xu et al., 2024). These findings align with those of Cardinali et al. (2024), who demonstrate that while proximity is important, the characteristics and quality of UGS significantly influence their use across Denmark, Bulgaria, Portugal, and France.

In addition, socio-demographic factors and perceptions of crowding influence how individuals evaluate accessibility and usability of UGS, highlighting the importance of addressing both physical and psychological barriers in urban planning, as shown in research from Belgium (Phillips et al., 2023). While our reliance on self-reported distances introduces some measurement uncertainty, it offers insights into respondents' lived experiences and psychological accessibility, which may be more directly linked to behavior, satisfaction, and well-being than spatial metrics alone. Future research could benefit from both perceived and objective measures to better understand their respective roles in shaping UGS management.

In denser cities like Suwon, UGS may be more heavily used and thus more highly valued for their recreational, social, and psychological benefits. In contrast, Karlsruhe's lower density might allow for more tranquil and spacious UGS, possibly shaping different expectations and experiences. Prior research has shown that perceptions of UGS are closely tied to local social-ecological contexts, including population density and land use patterns, as reported in studies from Spain, the USA, and Germany (Quintas-Soriano et al., 2018; Riechers et al., 2019; Mittermüller et al., 2021). These urban form differences may help explain some of the divergence in UGS preferences and perceived benefits between the two cities.

Key divergences included Karlsruhe residents visiting UGS more frequently and valuing biodiversity more highly, while Suwon residents prioritized safety, facilities, cleanliness, maintenance, and less pollen. Suwon residents valued proximity to water and environmental education, while Karlsruhe residents valued inspiration for creativity; all of these differences were statistically significant. Both cities' medians were considered "Important" for evaluating biodiversity. Interestingly, biodiversity was the only UGS quality that was rated more "Important" by Germans than Koreans. This aligns with the survey by the Ministry of Environment (2023) in Korea, which indicates that while many Koreans are aware of biodiversity, few understand it well. Literature shows that public awareness increases the value placed on biodiversity and this awareness may be influenced by the baseline biodiversity endowment of a city—places with richer or more visible biodiversity may naturally foster greater appreciation among residents. This pattern has been reported in studies from Sweden and Portugal, as well as in a broader literature review covering 22 other countries (Gunnarsson et al., 2017; Bernardo et al., 2021; Bele & Chakradeo et al., 2021). According to the 2024 Environmental Performance Index (Block et al., 2024), Germany ranks 4th globally in Biodiversity and Habitat, while Korea ranks 139th, suggesting a substantially higher national-level biodiversity endowment in Germany. However, this index does not provide city-level data, so local biodiversity levels in Karlsruhe and Suwon may differ from national trends. Enhancing awareness and citizen participation, alongside biodiversity-rich urban planning, could further support future biodiversity efforts. Future studies could benefit from the global adoption of city-level biodiversity indicators, such as the Singapore Biodiversity Index (Chan et al., 2021). Such indicators would enable more precise cross-city comparisons and support more targeted urban biodiversity planning worldwide.

Another unexpected result was that Suwon residents with an income of less than 3 million won (approximately €1,898 as of June 27, 2025) valued biodiversity more highly than those earning more than 3 million won. While there is limited literature on the relationship between

income levels and biodiversity valuation in Asian contexts, including Korea, a willingness-to-pay survey by Choi et al. (2017) in Korea showed that low- and middle-income households were more willing to pay for aquatic biodiversity conservation programs than higher-income households. This is because improvements in water quality and aquatic ecosystem conditions through such programs can reduce costs for drinking water purification and recreational activities for low- and middle-income households. In contrast, high-income households, as reported in studies from Korea and Bangladesh, are better positioned to find alternatives, as they can afford the cost of purification and traveling further for recreational activities (Shin et al., 2016; Khan & Fenner, 2024). While these studies provide some context on lower-income groups valuing biodiversity more highly than higher-income groups in the Asian context, more research is needed to reach firm conclusions.

Karlsruhe residents favored Schlossgarten, while Suwon's preferred sites were more distributed. These differences in site preference may be partly explained by how demographic factors—such as age, gender, and income—influenced perceptions and usage of UGS in each city. For example, our study shows that women tended to visit UGS more often in Karlsruhe, whereas in Suwon, men showed a higher frequency of visits. Various research on gender differences in UGS visitation shows varying results depending on the city. A study from Poland shows that women tend to visit UGS closer to home, prefer UGS within the city center, and most likely walk to UGS compared to men. In contrast, men often prefer larger, more natural spaces located farther away, but this does not necessarily indicate higher visitation rates for women (Bąkowska-Waldmann & Piniarski, 2023). In Spain, women visited peri-urban and natural parks less frequently than men (Farias-Torbidoni et al., 2024).

In Beijing, a study found that men spent more time and visited UGS more frequently than women (Huang et al., 2024b). In Chengdu, while there were more older males than females observed in the park, they were less physically active than females (Li et al., 2022). Female visitors were more likely to visit UGS than male visitors in Shanghai (Ullah et al., 2020). In Hanoi, women stayed for a shorter time and visited UGS less frequently than men (Pham et al., 2019). As there are no significant conclusions on visiting patterns between genders between Asian and European contexts, including Korea and Germany, further research on gender differences in UGS with more case studies and between cross-cultural studies may be needed to draw conclusions.

Safety, maintenance, and facilities such as drinking water, toilets, playgrounds, and benches were considered "Very important" by Suwon residents and "Important" by Karlsruhe residents, while cleanliness was rated as "Very important" for both cities; these findings align with international research showing that perceived safety, particularly fears of crime after dark, affects UGS visitation in Australia, Belgium, Sweden, and Hong Kong (James & Embrey, 2001; Van Herzele & Widemann, 2003; Rahm et al., 2021; Mak & Jim, 2022), and that basic facilities and clean areas are highly valued in Pakistan, Vietnam, Germany (Schetke et al., 2016; Palliwoda & Priess, 2021), with well-managed UGS enhancing benefits for people and nature as reported in Kenya and across multiple countries in literature reviews (see Jabbar et al., 2022; Paudel & States, 2023; Odhengo et al., 2024).

Interestingly, despite Suwon reporting significantly fewer crime (64 total crimes in 2023; Gyeonggi Province, 2024) than Karlsruhe (42,398 total crimes in 2024, including 25,349 in the urban district and 17,058 in the rural district; Polizeipräsidium Karlsruhe, 2025), Suwon residents rated safety as more important—suggesting that perceived safety does not necessarily align with actual crime statistics, a pattern supported by studies from Italy and multi-country literature reviews showing that perceptions of safety are shaped by factors beyond crime rates, including maintenance, accessibility, quality, aesthetics, and social connectedness within green spaces (Mancus & Campbell, 2018; Syption, 2023; Navarrete-Hernandez & Afarin, 2023). In this context, Suwon residents may perceive even minor risks as significant, while Karlsruhe residents may have adapted to a higher baseline of urban crime.

Additionally, Suwon respondents were older on average (43.5 years vs. 35.9 years in Karlsruhe), and older individuals often express greater concern about safety in public spaces. This trend has been observed in studies from Sweden, Canada, as well as in literature reviews covering the UK, Netherlands, Hong Kong, Portugal, Australia, Italy (Ceccato & Bamzar, 2016; Ottoni et al., 2021; Figueiredo et al., 2023), highlighting the importance of considering both objective crime data and subjective perceptions shaped by cultural, demographic, and environmental factors in UGS planning.

Our findings show that quietness is similarly valued in both cities, with no significant difference in its importance. Noise mitigation—one of the key benefits of UGS—supports biodiversity, human wellbeing, and climate change adaptation, as demonstrated in studies in India and Greece (Pathak et al., 2011; Votsi et al., 2014; Krause & Farina, 2016). Negative perceptions of noise increase the demand for quietness, while positive perceptions reduce it, as shown in a study from the Netherlands (Booi & Berg, 2012) and supported by broader conceptual work on soundscape perception (Mookiah, 2023). Additionally, studies from the UK and US show that noise complaints tend to rise with urban density (Tong & Kang, 2021; Chen et al., 2024). Given the ongoing urbanization, findings from Singapore and China suggest a growing need for quiet public spaces (Wang et al., 2023; Ren et al., 2024), aligning with the World Health Organization (2007) recommendation for clean and quiet environments.

Our study also revealed differing perceptions of pollen: while most respondents in Karlsruhe rated less pollen as “Not important”, Suwon residents considered it “Important”. This contrast aligns with regional differences in pollen seasons; Germany experiences a longer pollen period, typically from March to late summer, whereas Korea’s pollen season spans from February to November with peaks in spring and fall (Oh et al., 2012; Damialis et al., 2019; Bergmann et al., 2023).

Future research should broaden the scope of cross-cultural studies on CES from UGS, incorporating a wider range of cities and socio-ecological contexts. This would help clarify the understanding drivers of convergence and divergence in public perceptions. Building on the findings of this study, further exploration of how gender, income, and cultural background shape UGS visits and biodiversity valuation is essential. Incorporating qualitative methods, such as interviews, will be helpful in providing deeper insights into the contextual background and underlying reasons behind the public perceptions. Additionally, studying how practitioners understand public perceptions and integrate these perceptions into UGS planning and management could bridge the gap between user needs and policy. As cities become more internationalized, considering the diverse needs and perceptions influenced by cultural differences will be crucial in urban planning.

COVID-19 and cultural influences on green space visits

Understanding extreme events such as COVID-19, and their impact on people’s perception of nature is crucial for future cross-continental comparative studies. Regarding the impact of COVID-19 on UGS visits, some Koreans expressed uncertainty about the “post-COVID-19” period. Despite the WHO declaring the end of the COVID-19 emergency on May 5, 2023, and Korea lifting all COVID-19 measures from June 1, 2023, cautious perspectives persisted, and respondents expressed doubts about the end of COVID-19. This cautiousness aligns with the observation that several Korean respondents reported visiting UGS less frequently after the pandemic, while this was less so among German respondents, indicating a more significant impact on UGS visitation in Korea.

Interestingly, a study by Beckmann-Wübbelt et al. (2021) found that Karlsruhe residents visited UGS more often during the COVID-19 pandemic. However, in our study, the majority of the respondents (52.7 % in Suwon and 64 % in Karlsruhe) indicated that COVID-19 did not change how often they visit green spaces. We assume that although Karlsruhe residents increased their UGS visits during the pandemic, their habits have eventually returned to normal. Research from Berdejo et al.,

(2021) also reported that while 36 % of participants increased their UGS use, 26 % reduced their visits during the pandemic, showing variability in UGS visits patterns across society.

This variability may be influenced by the main purpose or activity associated with UGS visits, which could differ between cities. In this study, the most frequently chosen activity in Suwon was exercising, whereas socializing was most frequently chosen in Karlsruhe. Although the survey did not examine how the purpose of UGS use changed before and after COVID-19, this contrast suggests a potential avenue for further investigation. Contextual factors may also play a role; for instance, having a large UGS like Schlossgarten—centrally located and near the university—may contribute to its popularity as social gathering place, particularly for meeting with friends.

While it can be seen as a precaution that Koreans limited their social activities with friends even after COVID-19 restrictions were lifted, the shorter duration and lower frequency of their UGS visits compared to Germans can be attributed to cultural factors. According to the OECD (2023), Koreans work longer than Germans, with an average of 1901 h per year per person compared to 1347 h in Germany. Commuting time is also longer in Korea compared to Germany, with national averages around 57 min in Korea and 28 min in Germany (OECD, 2021). Although these figures are based on national-level data, they offer valuable insights into general lifestyle patterns that likely influence time availability across different regions. Extended working hours and lengthy commutes reduces the time available for social interaction, family activities, and healthy lifestyle practices such as exercise, as supported by studies from the US and Sweden, as well as literature reviews and theoretical work (Van der Hulst, 2003; Geurts & Sonnentag, 2006; Christian, 2012; Mattisson et al., 2015; Lee et al., 2024). These factors likely contribute to higher frequency and longer duration of UGS visits among Karlsruhe residents. This is further supported by our finding that older respondents in Suwon—who may have more discretionary time—spent more time in UGS than younger people.

Both countries experience four distinct seasons and have similar annual mean temperatures, but summer in Korea is hotter and more humid than in Germany (Kong et al., 2022). Thus, spring and autumn are preferred for outdoor activities due to the thermally comfortable conditions (Kang, 2021).

While only 20 % of homes in Europe have air conditioners, and only 3 % in Germany (Hockenos, 2022) due to the relatively mild European climate (European Commission, 2023), Korea is one of the top three countries for high household air conditioner ownership rates, along with Japan and the US, with over 85 % of households owning air conditioners (International Energy Agency (IEA) 2023). The hotter, more humid summers and the everyday use of air conditioners in Korea contribute to people staying indoors longer. Additionally, the perception of “nice weather” for outdoor activities may differ between Koreans and Germans.

Germany receives significantly less sunlight in other seasons other than summer—485 h in spring, 392 h in autumn, 160 h in winter—compared to 707.6 h in summer (Deutscher Wetterdienst, 2023a, 2023b, 2024a, 2024b). In contrast, Korea has relatively high sunlight across all four seasons (661.3 h in spring, 554.1 h in summer, 566.8 h in autumn, and 449 h in winter) (Statistics Korea, 2024). This might lead Koreans to place less value on sun exposure during summer, as it is not a scarce resource. This behavioral and perceptual differences are supported by studies from Germany, the US, and Brazil, which shows that individuals raised in different countries often have different perspectives on nature, influencing their recreational preferences (Jay & Schraml, 2009; Floyd & Stodolska, 2019; Rosa et al., 2023). These findings underscore the importance of considering cultural contexts, as well as social, environmental, and external factors such as pandemics, in UGS planning and management to cater to both universal appreciation and the diverse needs of city residents.

Implications of this work for sustainable urban green space planning and policy

The findings highlight the need for locally tailored UGS planning. The lower frequency and duration of visits to green spaces by Suwon residents suggest that urban planners should consider lifestyle factors such as working hours and thermal comfort. For example, designing more shaded areas and cooling features in parks can ensure that UGS are enjoyable year-round, addressing barriers that might otherwise limit nature experiences. The influence of socio-demographic backgrounds on the perception and use of UGS underscores the need for inclusive planning that addresses diverse demographic needs within the city. Ensuring accessibility and safety, including basic facilities such as drinking water, toilets, playgrounds, and benches, is crucial, as these amenities are highly valued by residents. Utilizing tools like PPGIS can gather local perceptions, facilitating better planning and management.

In addition, planning that considers gender-inclusivity and the needs of economically disadvantaged groups is essential to ensure that UGS can meet the diverse needs of the community. Providing safety and accessibility features for women, and offering free recreational opportunities and accessible UGS for low-income groups should be addressed. Older adults also benefit from inclusive UGS features such as benches, shaded areas, and easy-to-navigate paths. These considerations align with principles of environmental justice, which emphasize fair access to ecological benefits and decision-making for all social groups, particularly in urban contexts where green space access is often uneven (Kim et al., 2022; Yang et al., 2022; Kumar et al., 2023). These efforts contribute to achieving the Sustainable Development Goals, particularly Goal 11 (Sustainable Cities and Communities) and Goal 10 (Reduced Inequalities), by promoting inclusive, safe, and accessible urban environments for all (United Nations, 2015).

The research supports the goals outlined in the International Guidelines on Urban and Territorial Planning by UN-Habitat (2018), which emphasize the need for culturally sensitive and environmentally sustainable urban planning practices. By addressing cultural, social, and demographic factors, this study can influence local, national, and international policies. For local policies, the study offers insights into residents' preferences, enabling adjustments to better meet community needs. For national policies, it contributes valuable context on second-tier cities, highlighting their unique requirements and ensuring that policies are inclusive of diverse urban contexts. Cross-cultural studies on CES from UGS can provide a broader evidence base, helping international policymakers to understand public perceptions, and ensuring that urban environments are designed to meet the diverse needs of global populations. Additionally, local and national policymakers can learn from international practices, adapting successful strategies to their specific contexts.

Human-nature relationships in urban green space use

Our comparative analysis of Suwon and Karlsruhe offer insights from various interdisciplinary perspectives that enhance our understanding of how humans interact with nature within urban settings. The Gaia theory (Lovelock, 1972; Lovelock & Margulis, 1974, 1979) considers UGS as crucial parts of a self-sustaining planetary system, where human health and ecological balance are closely linked. Additionally, the increased desire to spend time outdoor after COVID-19 supports the biophilia hypothesis (Wilson, 1984), which posits that humans have an innate, cross-cultural tendency to seek out natural environments.

From a social ecology perspective, green spaces fulfill both ecological and social roles, serving as venues for community interactions, psychological renewal, and fostering social cohesion (Pickett et al., 1997, 2016; Elmqvist et al., 2018; Mehring et al., 2021). This is evident in differing usage patterns and preferences seen in Suwon and Karlsruhe, which is influenced by local cultural norms, perceptions of safety, and recreational needs. Additionally, insights from environmental

psychology shed light on how subjective experiences—such as feelings of safety, cleanliness, and appreciation for biodiversity—affect emotional reactions and active engagement with green spaces (e.g. Kaplan & Kaplan, 1989; Cameron et al., 2020; Gong et al., 2024).

Although Suwon and Karlsruhe share similar economic conditions, their cultural and demographic makeups vary, which affects how residents engage with and perceive green spaces. These findings highlight the need to incorporate ecological, psychological, and cultural factors into UGS research and planning. By recognizing the diversity of human experiences and expectations, cities can create inclusive green spaces that benefit both biodiversity and the well-being of different urban populations.

Limitations of the study

While the authors endeavored to choose the most suitable cities for a comparative study between Korea and Germany, inherent differences between the two countries cannot be ignored.

Suwon and Karlsruhe serve as distinct case studies, each with unique characteristics, providing valuable insights into two different cultural and urban contexts. Although both cities are classified as second-tier, Suwon's significantly larger population may have influenced residents' perceptions of UGS, introducing a contextual limitation to the comparability of results.

Despite efforts to ensure accurate translation and cultural equivalence in the survey (translated into Korean, German, and English), achieving perfect translation and cultural alignment remains challenging. For example, some questions that involved components not common in the other country were removed; Germans are accustomed to low-rise buildings with gardens, while many high-rise apartments in Korea have verandas. Some lifestyle differences made it difficult to translate questions, including those related to accessible home components, leading to their removal from the questionnaire.

Due to limitations in the recruitment of some subcategories in the demographic profile, some groups were excluded from statistical analysis or combined with others to ensure sufficient sample sizes for meaningful interpretation. For example, in gender category, responses other than "female" or "male" were excluded due to very low response rates (e.g., no non-binary responses in Suwon, and only 6 responses in Karlsruhe), which made subgroup analysis statistically unreliable. Similarly, and income responses were re-categorized into two groups: those earning more or less than €3,000 per month. Educational levels were also simplified into university attended or not attended categories. Additionally, the limited number of participants with nationalities other than Korean or German restricted the analysis of nationality differences. These decisions were made solely to maintain statistical validity and do not reflect the importance or relevance of any demographic group.

Conclusion

Our findings reveal significant differences in how residents of Suwon and Karlsruhe use and value green spaces, influenced by socio-demographic factors and cultural contexts. Karlsruhe residents visited UGS more frequently and for longer durations, engaging in a broader range of activities compared to Suwon residents. This suggests different lifestyles and social contexts can influence nature interactions. In addition, the increased time spent in UGS by Karlsruhe residents after COVID-19, compared to Suwon residents, indicates that the impact of extreme events on nature interactions can vary based on the socio-cultural context.

Karlsruhe residents placed a higher value on biodiversity, while Suwon residents prioritized safety, facilities, cleanliness, maintenance, and less pollen. This highlights the influence of cultural context on how people evaluate and prefer different qualities of UGS. The use of PPGIS revealed spatial preferences, with dispersed UGS in Suwon versus centralized ones in Karlsruhe, which is crucial for tailored city design

and future UGS planning.

As the first study comparing CES between second-tier cities in Korea and Germany, this research provides a broader evidence base on diverse public perceptions across different contexts. It underscores the importance of considering social, cultural, and demographic factors in UGS planning. Inclusive planning that addresses gender, income, and age-related needs is crucial to ensure that UGS meet the diverse needs of all residents. Further studies are needed to explore more diverse case studies, understand the reasons behind these differences, and address the varied needs of residents through urban planning. Additionally, integrating local cultural, social, and environmental conditions, and external factors like pandemics into UGS planning and management will ensure that UGS cater to both universal appreciation and the diverse needs of city residents.

These findings enhance our understanding of human-nature interactions in urban environments, reinforcing theories like the biophilia hypothesis, social ecology, and environmental psychology. They emphasize the need to consider ecological, spatial, cultural, emotional, and demographic psychology. By leveraging these interdisciplinary insights, urban planners and policy makers can develop green spaces that are inclusive, culturally aware, and ecologically beneficial, enhancing biodiversity and the well-being of diverse city populations.

CRediT authorship contribution statement

Jaewon Son: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Yunjeong Lee:** Visualization, Formal analysis. **Caroline Kramer:** Writing – review & editing, Supervision, Conceptualization. **Somidh Saha:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

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.

Acknowledgments

This work was supported by the Research Grants-Doctoral Programs in Germany from the German Academic Exchange Services (DAAD) [57588370], and by the National Research Foundation of Korea (NRF) funded by the Korean government (Ministry of Science and ICT) (No.RS-2023-00254343). Field data collection was financially supported by the Institute for Technology Assessment and Systems Analysis (ITAS). The authors appreciate the respondents for their invaluable participation, and various institutions and individuals for their support in translation, feedback, and promotion of the questionnaire including the ITAS, Karlsruhe Institute of Technology (KIT), Leibniz Institute for the Social Sciences (GESIS), the Park and Green Zone division of Paldal-gu office in Suwon, and the alumni of the Global Environmental Leaders Program (GELP). We thank the open access fund of the library of Karlsruhe Institute of Technology for sponsoring the open access publication fees. We also sincerely acknowledge two anonymous reviewers and editors for providing us with critical reviews and suggestions that significantly improved the paper.

Data availability statement

The full privacy notice and questionnaire can be found in the supplementary document.

Supplementary materials

Supplementary material associated with this article can be found, in

the online version, at [doi:10.1016/j.baee.2025.08.002](https://doi.org/10.1016/j.baee.2025.08.002).

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