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The public perception of urban vegetation in metropolitan regions of Costa Rica

Jose Ali Porras-Salazar [a,*], Jan-Frederik Flor [b,c], Sergio Contreras-Espinoza [d], Melissa Soto-Arce [e], Rene Castro-Salazar [e]

[a] School of Architecture, University of Costa Rica, San Pedro de Montes de Oca, Costa Rica
[b] Faculty of Architecture and Ekistics, Universiti Malaysia Kelantan, Bachok, Malaysia
[c] School of Architecture, Building and Design, Taylor's University, Subang Jaya, Malaysia
[d] Department of Statistics, University of Bio-Bio, Bio-Bio, Chile
[e] Independent researcher, San Jose, Costa Rica

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ABSTRACT

Urban vegetation makes cities more liveable, provides essential ecosystem services, and is relevant for sustainable development. We investigated the public perception of urban vegetation in the metropolitan area of Costa Rica, Central America. Through an online survey, we collected 1264 responses from Costa Rican residents on their attitudes and opinions towards urban vegetation's environmental services and disservices. After selecting those participants residing in the Greater Metropolitan Area and applying a data cleaning process, we derived 811 valid responses. Poststratification techniques were employed to fit the sample to the general population distribution. We found that the majority viewed urban vegetation favorably, with 80 % believing that urban greenery contributes more benefits than negative effects to air quality, shading, and wildlife. In contrast, up to 20 % think urban greenery is harmful, asserting that it encourages crime, promotes pests, and damages infrastructure. Perceptions changed according to demographic variables such as gender, age group, and education level. We compared our results to a previous study in Singapore, Southeast Asia, which showed similar trends despite cultural and economic differences. This paper offers a starting point for priority-setting and decision-making in city planning by delivering insights into how people in the tropics perceive urban vegetation.

1. Introduction

The concentration of human population in cities has led to numerous benefits for society, including greater access to resources, services, and job opportunities, as well as cultural and intellectual interchange. Over 57 % of the world's population (4.7 billion people) currently lives in urban environments such as towns and cities, with more than two-thirds expected to do so by 2050 (United Nations, 2018). Unfortunately, while cities are rising in size and population, ecosystems and forests within or near them are shrinking in extension and diversity (Li et al., 2022). Therefore, most of the ecosystem services (ES) consumed in cities are generated by ecosystems located outside of the cities themselves, often far away and not easily accessible (Rees and Wackernagel, 1996). This is also the case of Costa Rica (The State of the World's Forest 2020, FAO, p. 40). Furthermore, population concentration in metropolitan environments —dominated by technology, built infrastructure, and individuals spending most of their time in enclosed settings with little or no interaction with nature— has propagated the idea of an urban society that is independent and disconnected from ecosystems (Ausubel, 1996). The physical and mental barrier between urban consumers and the ecosystems that support them masks the ecological consequences of their everyday choices (Rees and Wackernagel, 1996; Folke et al., 2011). In contrast, individuals who reside in rural regions or near forests are more conscious of ES than their urban peers (Abram et al., 2014; Muhamad et al., 2014). Given the alarming rates of terrestrial ecosystem degradation, increasing ES awareness and perceptions, as well as the value placed on these services by local residents, is critical. Scholars and politicians have consequently been drawn to the need to better link urban residents to the natural world (Folke et al., 2011).

* Corresponding author.
E-mail address: jose.porrassalazar@ucr.ac.cr (J.A. Porras-Salazar).

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1.1. Theoretic framework

Historically, the economic and ecological disciplines have driven the defining framework of ES, searching for a concept that would link human activities with natural systems. Ehrlich and Ehrlich (1981) introduced the concept of ES in 1981. They hypothesized that assigning a monetary value to the deteriorating environment would help ensure that economic decision-making considers the total cost of environmental degradation, resulting in more sustainable and equitable outcomes. Costanza et al. (1997) were the first to assess ES in economic terms and assign a monetary value to global ecosystems. According to their approach, ES was defined as the "benefits that human populations obtain from ecosystem functions" (Costanza et al., 1997). Although much of previous research has focused on economic analysis, a parallel field investigated the impact of ES on human wellbeing, a concept crucial to defining its benefits in the public perception. The Millennium Ecosystem Assessment investigated the changes human activities have inflicted on ecosystems, threatening biodiversity, and the sustainability of human living standards, also in urban environments (Watson et al., 2005). The report was fundamental in describing ecosystem services as benefits closely related to human needs at different levels of well-being, such as security, health, social relations, and the provision of essential materials such as shelter, food, and goods. To integrate previous studies on ES, Braat and de Groot (2012) affirmed that recognizing the value of ecosystems and the services they provide might be sufficient at the individual level. However, a transparent and clear assignment of costs might be more appropriate for business and policy-making institutions. Research has shown that, despite growing awareness, environmental damages, particularly in the global south, are increasing as land uses change due to short-term economic interests, affecting ecological functions and the provision of ES. This trend indicates that societies and territorial governance still need to fully acknowledge and account for ES and raises the question of how the relationship between the city and nature can be rebalanced and better integrated (Yeo et al., 2016). According to Mckenzie et al. (2014), knowing more about ES will eventually improve conceptual, strategic, and instrumental decision-making processes. Changing the way ES are framed and talked about while providing detailed information required for planning and policymaking could contribute to this process (Posner et al., 2016); furthermore, the long-term benefits of such knowledge-based decision-making should always focus on biodiversity and human well-being (Haines-Young and Potschin, 2010).

1.2. Urban vegetation and ecosystem services

Unmistakably, the provision of ecosystem services essential to human well-being is jeopardized due to increasing urbanization and fragmentation of green spaces, resulting in a general decline in vegetation coverage in urban areas (Yeo et al., 2022). Vegetation is an essential component of terrestrial ecosystems, significantly contributing to environmental regulation. In an urban setting, vegetation provides numerous and diverse benefits related to human activity. Plants and trees improve the livability of cities and provide ES that directly impact on human health and well-being. A study by Balvanera et al. (2017) established that ES emerge from the interactions between ecosystems and societies, forming a quasi-socio-ecological system. In this regard, urban vegetation (UV) can provide opportunities for city dwellers to become stewards of ES (Andersson et al., 2014), which in turn can provide regulating services, such as green infrastructure, that moderate local temperatures in cities and mitigate the heat island effect. UV also offers habitat for other species, such as animals and insects, which provide secondary ES like seed dispersal, pollination, and pest control. ES also encompass all material products derived from ecosystems, such as food and water for human consumption. While there appears to be general agreement among scholars that all of these ES can be considered useful to humans (La Notte et al., 2017), part of the public opinion holds that UV can have negative consequences, such as destroying the functional use and life of structures and posing a threat to people's health and safety (Drillet et al., 2020). Consequently, ecosystem disservices have been defined as "ecosystem functions perceived as negative for human well-being" (Lyytimäki and Sipilä, 2009). Considering that some aspects of UV are sometimes perceived as problematic, careful attention is required to avoid a narrow focus on ES with a positive impact only. While different types of UV may provide a variety of ES, it is also necessary to ask which of the various ES are of immediate importance and which are of more fundamental importance to the health and well-being of the urban population. Fig. 1 depicts a graphic representation of various elements of UV, along with the associated ES relevant to urban living and well-being.

1.3. Perception of urban vegetation

The definitions and categories the previous body of research establishes with respect to the relationship between ES and the benefits humans obtain are very relevant to this study. However, one aspect that previous studies may have overlooked is the human factor of perception, which influences how much value people assign to any specific ecosystem service. This study, therefore, aims to investigate more deeply how urban residents perceive UV.

People's perception of UV can vary considerably depending on several factors. Socioeconomic determinants such as location, education, gender, ownership status of residence, and income all influence how vegetation in an urban setting is perceived (Atif et al., 2018; Buchel and Frantzeskaki, 2015; Mathey et al., 2018). The specific design and management of green spaces and whether these were planned or grew spontaneously also plays a role (Atif et al., 2018). As a result, UV types are not perceived equally, and furthermore, perceptions of the services and disservices they provide may vary depending on the factors mentioned above (Drillet et al., 2020).

Understanding the public perception of ES provided by UV is critical to the task of promoting its acceptance and support within the urban population, with local authorities in many cities worldwide coming under pressure to find innovative ways to maintain and increase green infrastructure as part of urban planning and design (Gomez-Baggethun et al., 2013). Furthermore, recognizing people's preferences and motivations for the inclusion of vegetation in their urban surroundings could help to improve urban quality (Camacho-Cervantes et al, 2014). Local governments and planners can then make informed decisions that respond to the needs and values of the community. This can increase public engagement and support, leading to more successful and sustainable green infrastructure initiatives. Therefore, in the present study we aim (i) to examine Costa Rican urban residents' perception of UV as a provider of ecosystem services and disservices; (ii) to compare the results from Costa Rica with those acquired by Drillet et al. (2020) in Singapore to examine if public perception of UV across the tropical belt varies due to cultural, economic, and historical differences; and, (iii) to determine whether factors such as gender, age and educational level influence the perception of UV and the ecosystem services it provides.

1.4. Case study background

Costa Rica, located at 9.6°N, 84°W, is a Central American country with an area of 51,100 km^2 and a population of 5.2 million people. It has a tropical climate with high humidity (monthly mean 82–87 %), consistent temperature (monthly mean 26.4–28.3 °C), and abundant rainfall (monthly mean 115–320 mm). These climatic conditions make it one of the most biodiverse territories on the planet (Mittermeir et al., 2004). It is seen as a world leader in environmental conservation thanks to its solid conservation area system that protects nearly a quarter of the country's territory. Costa Rica is a pioneer in payment for environmental services (PES) (Cordero-Pinchansky and Castro-Salazar, 2002), establishing itself as one of the few countries in the world with a forest cover

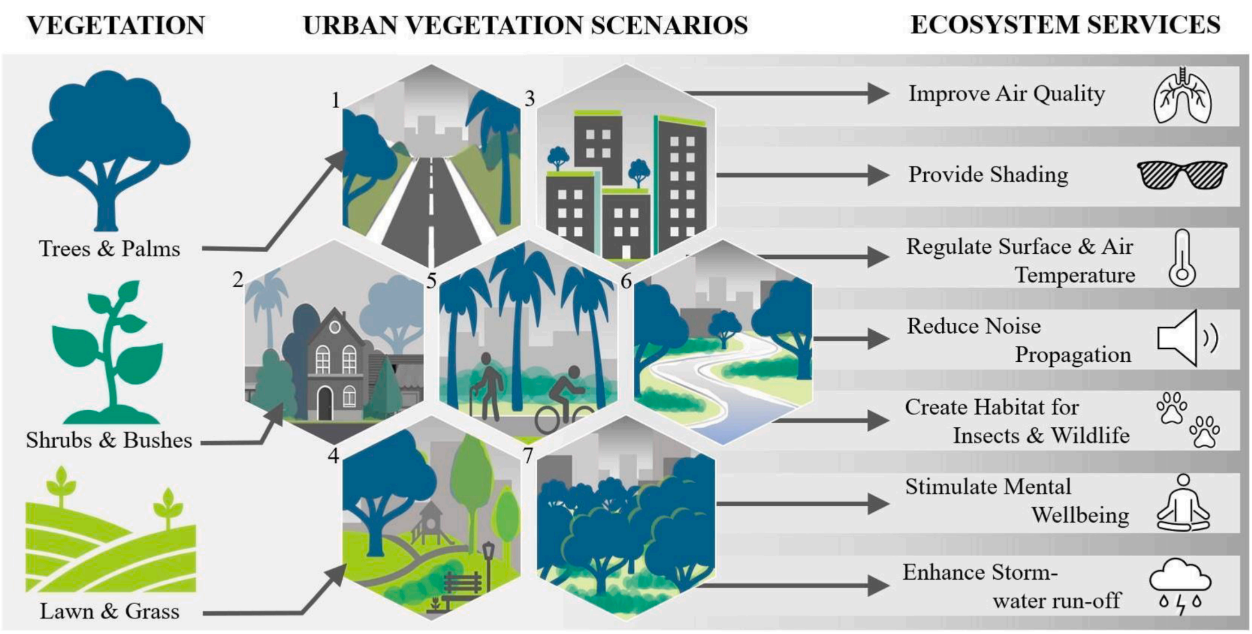

Fig. 1. Urban vegetation and associated ecosystem services: (1) Vegetation along streets or railways; (2) Front gardens and private gardens; (3) Roofs and green facades; (4) Urban and children's parks; (5) Greenways and corridors (walking/biking paths); (6) Vegetation along rivers and streams; (7) Urban forests.

that has increased from 20 % to 60 % in the last 30 years (Castro-Salazar et al., 2021). However, government attention to natural areas has been unbalanced, focusing primarily on rural environment conservation while ignoring cities and their green spaces (Alvaro-Navarro, 2016; UNDP, 2021).

Since migrating quickly from agricultural to urban regions in the latter half of the 20th century, today 60 % of Costa Ricans reside in the Greater Metropolitan Area (GMA), which represents only 4 % of the country's total land area (Plan GAM 2013, 2013). Consequently, the premontane humid forest that was once prevalent in this area is now the country's second most altered and reduced type of forest, with only 1.75 % of its original cover remaining (Sanchez-Azofeifa, 1996). The canton of San Jose is the most populous region in the GMA and the country. Only 12 % of its territory is not yet urbanized, which corresponds primarily to high-slope areas and riverbanks with limited development due to urban rules and environmental restrictions (Municipalidad de San Jose, 2014). Furthermore, according to the local government, this region has only 8.1 m^2 of public green, sports, and recreational areas per inhabitant (Municipalidad de San Jose, 2014), whereas the United Nations Environment Programme estimates that the ratio of green area is 2 m^2/hab (2010). This is much lower than the 9 to 15 m^2 recommended by the World Health Organization to cover the population's social needs. This makes it one of the cities with the lowest ratio of green areas per inhabitant in Latin America (PNUMA, 2010). Unfortunately, as Morales-Cerdas et al. (2018) show, the scenario is similar in other GMA cantons, too. To reverse this trend, Costa Rica's Ministry of Environment established the Urban Natural Parks (PANU) category in 2021 (Decree No. 42742-MINAE) to conserve at-risk ecosystems and forests in cities while improving people's physical and mental well-being.

While increasing urban green areas in Costa Rica has proven difficult, this same task has met with more success in other parts of the globe, raising the question of how this was accomplished, what factors contributed to its success, and whether the public perception of UV played a role. Singapore has achieved the re-greening of its urban environment. Given that both countries are situated in the tropical rainforest climate zone and share a similar latitude (Singapore: 1.2°N, 103.5°E), it is possible that the vegetation patterns in regions with similar altitudes originally had similar traits. Singapore, however, is a highly urbanized city-state with one main island and many smaller islands within its territorial boundaries totaling only 724 km^2. With a population comparable to Costa Rica living in an area 72 times smaller, much of its original vegetation has been destroyed due to the rapid urbanization process that began following the country's independence in 1965. As a result, protected nature reserves cover only 4.5 % of Singapore's total land area, and primary forest accounts only for 0.28 % (Yee et al., 2011). However, 49 % of the city-state is covered by introduced and cultivated species (Gaw et al., 2019), with managed vegetation accounting for more than half of this (Edwards et al., 2020). This has been made possible by different government initiatives to promote green spaces (Edwards et al., 2020). Singapore launched the *Garden City* programme shortly after independence to make the country a highly liveable, green city (MEWR and MND, 2014). Flowering trees and shrubs were planted, a network of park connectors linked parks, and skyrise vegetation was encouraged (Singapore Green Plan 2030, n.d.). Later, the *Green Plan* was launched in 1992, with a new edition executed in 2002 and a relaunch in 2021 aiming to guide Singapore's sustainability agenda through 2030 (Singapore Green Plan 2030, n.d.). Included among the goals are to increase the proportion of park space per 1000 people to 0.8 ha, the length of park connectors by 32 %, the length of natural ways by 165 %, and the proportion of households within a 10-minute walk of a park to 90 % (MEWR and MND, 2014).

The dichotomy between Costa Rica, a world leader in the conservation of wilderness areas that is nonetheless struggling to introduce green spaces in cities, and Singapore, a country conserving only a minor proportion of its original wild areas but becoming one of the greenest cities in the world, makes it worthwhile to compare the results of the inhabitants' perceptions of UV in both countries. The question that emerges from this inquiry is whether socioeconomic, historical, or other variables play a role in the perception of UV, as found in similar non-urban studies on wilderness valuation, which showed that landscape preferences are heavily influenced by cultural heritage (Buijs et al., 2009). Table 1 provides additional background data on the country-specific key parameters for this case study.

2. Methods

In this study, we aimed to investigate the perception of UV. Traditionally, questionnaires or interview surveys have been employed to

Table 1
Key country parameters of Costa Rica and Singapore.

Country parameter	Costa Rica	Singapore
Location (latitude, longitude)	9.93, −84.08	1.28, 103.83
Territory Area (km^2)	51,100	724
Population density (People per km^2)	85	7804
Language	Spanish	English, Chinese, Malay, and Tamil
Gross Domestic Product (USD per capita) (World Bank Open Data, n. d.-a)	12,472	72,794
Climate (Köppen–Geiger classification)	Tropical climate (Aw, Af, and Am)	Tropical rainforest climate (Af)
Temperature (Annual Mean, °C)**	24.9	27.7
Precipitation (Annual Mean, mm) (World Bank Open Data, n.d.-b)	2926	2497
Forest area cover (% of land area) (World Bank Open Data, n.d.-c)	59.4	21.7

acquire information on public perception of natural elements and conditions (Bird, 2009). For this study, we used an online self-selecting survey approach. The questionnaire design was based on a set of questions developed by Drillet et al. (2020) for a survey in Singapore that we compared our results with. Our study followed best practice guidelines for online questionnaires, ensuring participant consent, anonymity, and secure data storage. In continuation, we outline the survey design and the statistical methods employed in the data analysis.

2.1. Participant recruitment and sample design

We recruited participants for the survey using announcements posted on the authors' Facebook and LinkedIn social media accounts. Several posts were made during the recruitment period. In the announcements, we asked potential readers to answer our survey and share the posts with other social media users to start a snowball recruitment process. This distribution method was used because it allowed us to reach a large group of respondents without conducting face-to-face interviews, which were restricted during the COVID-19 pandemic. Furthermore, this allowed the study to be conducted with a minimal budget. As an additional advantage of this approach, we presumed that personal perception patterns would be easier to disclose via anonymized internet media. Participation requirements stated that candidates must have lived in Costa Rica for at least one year and be of legal age, 18 years or older, to participate. Through self-selection, eligible individuals choose whether to participate without any control by the authors, implying that the sample was not defined using a probability sampling method. However, we used statistical post-stratification techniques to counteract the effect of any undesired under- or over-representation. We explain more details on this matter in Section 2.6.

2.2. Questionnaire development and testing

We based our questionnaire on the first section of a survey developed by Drillet et al. (2020), which included 15 ecosystem services and ten ecosystem disservices commonly associated with green urban areas. The first part gathered data on participant demographics, including questions about age, gender, occupation, educational level, and residence location based on Costa Rica's territorial divisions of province and canton. The second part focused on the perception of UV, classifying the 25 assertions into ecosystem services and ecological disservices. We asked participants to rate each statement on a five-point Likert scale, from *strongly disagree* to *strongly agree*. Except for statement S14 (*It provides food or useful materials*), which is a provision service, all other statements fall within the regulating and cultural dimensions. At the beginning of the second part of the survey, we introduced the concept of UV and provided several contextualized examples. By providing these examples participants were expected to gain a better understanding of the object of study to which we referred in the statements. Some of the examples provided for common locations of UV are listed below:

(1) Vegetation along streets or railways; (2) Front gardens and private gardens; (3) Roofs and green facades; (4) Urban and children's parks; (5) Greenways and corridors (walking/biking paths); (6) Vegetation along rivers and streams; (7) Urban forests.

Unlike Drillet et al. (2020), we did not use images as examples of UV in the questionnaire to avoid participants judging the ecosystem services of UV based on what the pictures revealed rather than how people remembered and experienced them. Since the original questionnaire was written in English, we translated it into Spanish, Costa Rica's official and most widely spoken language. To gain feedback on question order, translation, readability, and comprehension, beta versions of the Spanish questionnaire were circulated to a group of 20 Costa Ricans fluent in English and Spanish. The comments received from this first pilot group of participants were incorporated into the final version of the questionnaire. The statements included in the online survey and the original English version are listed in Table 2.

2.3. Data collection protocol

The data collection period for this survey was from March 5th to March 14th, 2021. The time required to complete the survey was approximately 10 minutes. Responses were collected in the Google Forms platform. Answers were automatically saved into a .csv file and then imported to R software for data cleansing and processing. All participants conceded their informed consent to participate in the study. Participants received no direct payment or other rewards for participating in the survey, and their participation was entirely voluntary. The experimental protocol was granted an exemption from review by the Ethics Scientific Committee of the University of Costa Rica (No CEC-507-2023).

2.4. Data quality checks

During the data collection period, we received a total of 1,264 responses. To obtain a high-quality data set we applied a data cleansing process. Since we targeted the perception of Costa Rican residents living in urban areas, i.e., regions where constructed infrastructure covers a significant fraction of the land surface or where people reside in high densities (Pickett et al., 2001), we removed all answers from participants residing in cantons that, according to the limits of the GMA (Plan GAM 2013, 2013), are outside its boundaries. While other cantons outside the GMA may include other minor cities, their classification needs to be revised because they combine urban and rural features. For the residents of these regions, the proximity to rural areas implies frequent contact with nature, which might impact their perception. A total of 298 participants (24 %) reported residing outside the GMA. Therefore, we excluded them from the respondents' data set. Participants who did not indicate in which canton they resided were also excluded. To reduce the possibility of including non-residents, we asked participants in the demographics section to indicate the province and canton where they lived and how many years they had resided in Costa Rica. Two individuals who reported less than a year of residence were automatically discarded. Six participants that did not answer this question were also omitted. Finally, we also removed all 147 participants from the data set who did not respond to all 25 statements. After the data cleansing process, the sample used for the weighting and analysis steps was of 811 individual response sets. Fig. 2 illustrates the distribution of our sample by gender, age group, and education level. Appendix A of the supplemental material (SM) contains tables indicating the number of people in each group.

Table 2
Statements included in the original and online (translated) questionnaire with the associated environmental services and disservices that were addressed. The order below follows the presentation order in the Spanish questionnaire.

ID no.	Original statement (English)	Translated statement (Spanish)	Ecosystem service type
Ecosystem services statements:			
S01	It improves air quality	Mejoran la calidad del aire	Regulating
S02	It provides me with shade	Me brindan sombra	Regulating
S03	It supports wildlife that I enjoy	Sostienen vida silvestre que sí disfruto	Cultural
S04	It is pleasing for me to look at	Me es grato observarlas	Cultural
S05	It encourages me to spend time outdoors	Me animan a pasar tiempo al aire libre	Cultural
S06	It provides opportunities for me to learn more about nature	Me brindan oportunidades para aprender más sobre la naturaleza	Cultural
S07	It possesses spiritual or religious value	Poseen un valor espiritual o religioso	Cultural
S08	It provides me with a good place for socializing	Me proporcionan un buen lugar para socializar	Cultural
S09	It provides me with inspiration for art, creativity, and photography	Me proporcionan inspiración para el arte, la fotografía o crear	Cultural
S10	It makes me feel better (e.g., improves my longevity, relieves my feelings of stress, allows me to relax, etc.)	Me hacen sentir mejor (Ej., me desestresa, me relaja)	Cultural
S11	It reduces surrounding noise levels	Reducen los niveles de ruido circundante	Regulating
S12	It stores carbon	Almacenan carbono	Regulating
S13	It controls the effects of heavy rainfall and flooding	Ayudan a controlar los efectos de los grandes aguaceros y previenen inundaciones	Regulating
S14	It provides food or useful materials	Proporcionan alimentos y/o materiales útiles	Provision
S15	It increases my interaction with wildlife	Aumentan mi interacción con la vida silvestre lo cual sí disfruto	Regulating
Ecosystem disservices statementss:			
D01	It encourages the presence of general pests (e.g., mosquitoes, rats, etc.)	Fomentan la presencia de plagas (Ej., mosquitos, ratas, etc.)	NA
D02	It looks messy	Desmejoran la estética urbana (Ej., basura, hojas caídas, zacates altos)	NA
D03	It is a safety hazard to people and personal property	Son un peligro para la seguridad de las personas y la propiedad privada	NA
D04	It is strong-smelling	Provocan malos olores	NA
D05	It poses a crime risk	Presentan un riesgo para la seguridad (Ej., escondite para el hampa)	NA
D06	It makes me feel uneasy	Me hacen sentir incómodo	NA
D07	It poses a risk of spreading mosquito-borne diseases (e.g., dengue)	Presentan un riesgo de propagación de enfermedades transmitidas por mosquitos (Ej., dengue)	NA
D08	It is damaging to sidewalks	Dañan las aceras, las calles y otros elementos de la infraestructura	NA
D09	It supports wildlife that I do not enjoy	Sostienen vida silvestre que NO disfruto	NA
D10	It increases my interaction with wildlife that I do not enjoy	Aumentan mi interacción con la vida silvestre lo cual NO disfruto	NA

2.5. Demographics data analysis

In our analysis, we employed the Chi-square (χ^2) test of independence to explore the relationship with demographic factors, namely age, gender, and education. By examining these factors, we aimed to shed light on the intricate connections between demographic profiles and the perception and experience of ecosystem services and disservices. The Chi-square test allowed us to assess whether there was a statistically significant association between these demographic variables and the patterns of response towards ecosystem services and disservices. We checked for correlation between gender, age, and education and the responses given by the participants in each of the ecosystem services and disservices.

Furthermore, we conducted a multigroup study using Structural Equation Modeling (SEM), which allowed us to investigate if the structural correlations between variables alter across multiple groups. It is useful for testing group differences and determining model invariance across different subgroups. The analysis was performed in the *R* software using the *lavaan* package. A statistical significance set at p-value <0.05 was used with all the tests. The fit of the structural equation models were evaluated by the Root Mean Square Error of Approximation (RMSEA). In general, RMSEA values less than 0.05 are good, values between 0.05 and 0.08 are acceptable, values between 0.08 and 0.1 are marginal, and values greater than 0.1 are poor (Fabrigar et al., 1999).

2.6. Data weighting

There is evidence that the distributions of self-selected samples from Internet-based surveys deviate from those of the general population (Bethlehem, 2010). To ensure that our sample was representative, we compared its distribution to that of the general population. For this, we used the demographic information collected in the first part of the questionnaire, specifically gender, age, and education level. To determine the distribution of the selected variables among the overall population, we used data from the latest Costa Rican national census, executed by the National Institute of Statistics and Censuses in 2011. Although our sample comprises five individuals under the age of 20, we chose only those over 20 for comparative purposes because census data does not differentiate between people aged 15 and 19. Compared to the census statistics (see Table 3), young people were underrepresented in our sample, with 19 % fewer in the 20–29-year age group. By contrast, there were 16 % more senior participants in the 60–69 age group, who were thus overrepresented compared to the general population. Regarding educational levels, the population with a university degree was overrepresented in the sample —83 % vs. 22 % in the Costa Rican population—, whilst the group with primary or less education was notably underrepresented —2 % vs. 43 % in the population. Gender disparities were not detected.

Due to the distribution differences and the correlation of age group and educational level detected, we decided to use a post-survey correction technique known as poststratification (Bethlehem, 2010; Biffignandi and Bethlehem, 2021). By using auxiliary data, this technique applies some weightings to the sample as an attempt to correct for over- or under-representation of specific groups and to reduce the coverage bias. Auxiliary variables are those that are measured in the survey and for which information on the distribution of the population is available. The correction for the estimation of the proportions can be made for one or more variables, if the information to perform the calculations is available (Biffignandi and Bethlehem, 2021). Since the Costa Rican census provides detailed information on the population by age group and educational level, we used this information as auxiliary variables.

Therefore, the population was divided into 24 strata that were the result of multiplying four education levels by six age groups (see Table 4). To avoid having too few responses in one of the categories, we collapsed the 5-point Likert scale to three: *agree* (*slightly agree* and *strongly agree*), *neutral* (*neither disagree nor agree*), and *disagree* (*slightly* and *strongly disagree*). According to Bethlehem (2010), the strata of the population, e.g. U, are denoted by the subsets $U_1, U_2, \ldots, U_{24}$, and the number of target population elements in stratum U_h is denoted by N_h, for $h = 1, 2, \ldots, 24$. The population size N is equal to $N = N_1 + N_2 + \cdots + N_{24}$.

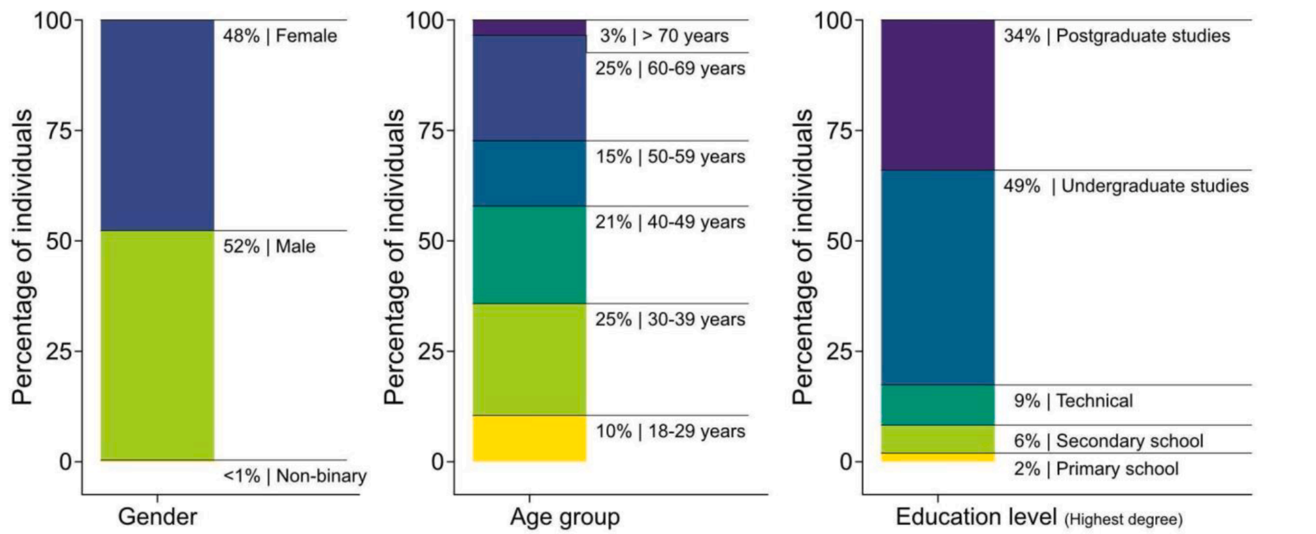

Fig. 2. Distribution of cleansed participants sample (*N*: 811) according to gender, age group, and education level.

Table 3
Comparison of the Costa Rican population with the sample population over the age of 20 by age group and educational level.

	Costa Rica: population >20 years-old	Percentage (%)	Sample: number of participants >20 years-old	Percentage (%)	Percentage difference (%)
Total	2,715,262	100	806	100	–
Age groups (years)					
20–29	776,106	28.6	80	9.9	−18.7
30–39	604,437	22.2	205	25.4	3.2
40–49	534,594	19.7	179	22.2	2.5
50–59	402, 006	14.8	120	14.9	0.1
60–69	222,876	8.2	194	24.1	15.9
70+	175,243	6.5	28	3.5	−3.0
Education level					
Primary or lower	1,161,022	42.8	15	1.9	−40.9
Secondary	809,036	29.8	46	5.7	−24.1
Technical	145,242	5.3	74	9.2	3.8
University or higher	599,962	22.1	671	83.2	61.1

Table 4
Percentage of Costa Ricans above the age of 20 categorized by age group and education level. The absolute number of participants in each category is shown in brackets.

Age groups (years)	Education level (Highest degree) Primary school or lower (Elementary school)	Secondary school (High school)	Technical / Vocational School (Para-university)	Undergraduate studies or higher (University)
20–29	7.9 (0)	11.3 (19)	1.9 (14)	7.5 (52)
30–39	8.9 (5)	6.7 (10)	1.1 (12)	5.5 (178)
40–49	8.9 (3)	5.7 (3)	1.1 (14)	4.0 (159)
50–59	7.03 (3)	3.8 (7)	0.7 (12)	3.0 (98)
60–69	5.0 (3)	1.6 (11)	0.3 (19)	1.4 (161)
70+	4.7 (1)	0.8 (1)	0.2 (3)	0.8 (23)

Finally, if a random sample of size n is selected from population U, the number of elements chosen from category h is denoted by n_h and $n = n_1 + n_2 + \cdots + n_{24}$. Since in this case we were interested in estimating the proportions, we used the estimator given by Eq. (1), where $\widehat{p_h}$ is the estimate of the observed proportion in stratum h and $W_h = \frac{N_h}{N}$ is the relative size of the stratum h.

$$\widehat{p} = \sum_{h=1}^{L} W_h \widehat{p}_h \tag{1}$$

3. Results

3.1. Costa Ricans' perception of UV associated with ecosystem services

From the data presented in Fig. 3, it is apparent that responses to statements regarding ecosystem services were overall positive. Approximately two-thirds of the participants agreed *(agree* and *strongly agree*) with the statements about the ES provided by UV. The only exception was the statement *It possesses spiritual or religious value* (S07), which had a different answer pattern: 41 % of the overall population agreed with the statement that UV has a spiritual value, while 30 % disagreed, and 29 % of the votes were neutral. 85 % of the participants confirmed that UV *is pleasing for me to look at* (S04), *it makes me feel better* (S10), and *it improves air quality* (S1). For another three statements (S02, S03, and S05), the percentage of agreement was over 80 %. Given that S03, S04, S05, and S10 correspond to the provision of cultural services, and S01 and S02 belong to regulatory services, Costa Ricans strike a solid balance between the utilitarian rewards associated with health and comfort and the less tangible cultural benefits of UV.

The more surprising aspect of the data is within the group of participants who disagreed with some of the statements presented in the questionnaire (Fig. 3). Overall, except for S07 and S14 (*spiritual value, food provision*), the percentage of participants who disagreed was generally low and remained less than 20 % throughout (mean = 17.7 %, sd = 2.1). However, the decrease in the proportion of agreement for some statements did not imply an increase in disagreement, as one might expect, but rather an increase in the percentage of participants voting

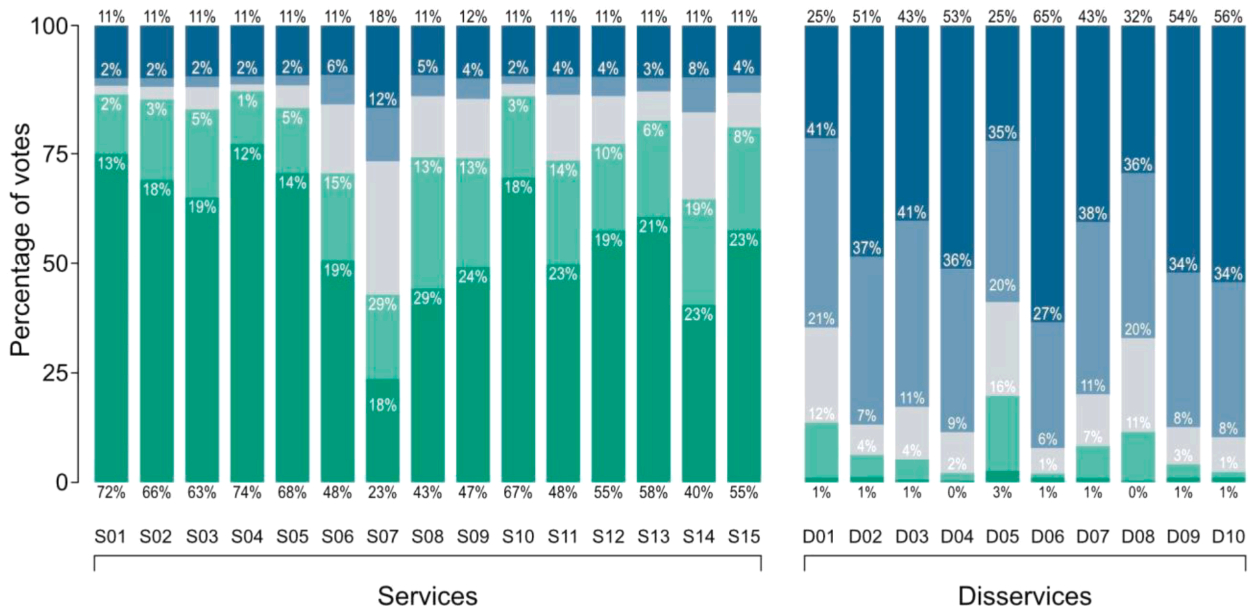

Fig. 3. Stacked proportion barplots showing Costa Ricans' perception of selected UV ecosystem services and disservices (*N*: 811). Colors correspond to the following answers: (i) Green, *strongly agree*; (ii) light green, *agree*; (iii) gray, *neutral* (*neither disagree nor agree*); (iv) light blue, *disagree*; and (v) blue, *strongly disagree.* The corresponding statements are listed in Table 1.(For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

neither agree nor disagree.

3.2. Costa Ricans' perception of UV associated with ecosystem disservices

Turning now to the responses on ecosystem disservices, we found (see Fig. 3) that more than two-thirds of the sample disagreed with suggested environmental problems UV causes. The disservice that individuals mostly disagreed with was *It makes me feel uneasy* (D06), which is consistent with the answers given when asked if *It makes me feel better* (S10), to which 85 % agreed. Other statements on disservices that received nearly a 90 % rejection rate (*disagree* and *strongly disagree*) were: *It looks messy* (D02), *It is strong-smelling* (D04), *It supports wildlife that I do not enjoy* (D09), and *It increases my interaction with wildlife that I do not enjoy* (D10).

Overall, what stands out is that the percentage of respondents who agreed with the disservices was far smaller than the percentage who disagreed with the services. For this set of statements, we also noted a general increase among undecided respondents voting *neither agree nor disagree*. However, for two specific statements, the proportion of respondents who agreed that UV causes adverse effects was substantially

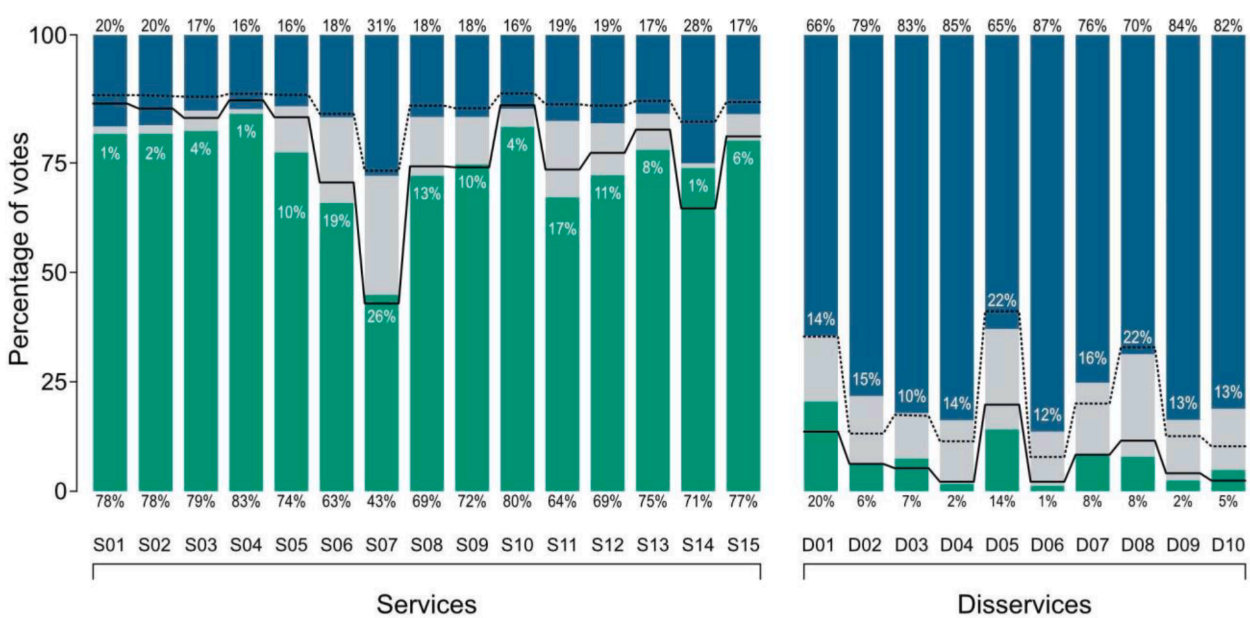

Fig. 4. Stacked proportion barplots showing Costa Ricans' perception of selected UV ecosystem services and disservices (N: 811) after data weighting. We grouped responses into *agree* (*agree* and *strongly agree*. Green bars in the plot), *neutral* (*neither disagree nor agree*. Gray bars in the plot) and *disagree* (*disagree* and *strongly disagree.* Blue bars in the plot). Solid black lines correspond to the percentage of agreement before data weighting, while dashed black lines correspond to the percentage of disagreement (Fig. 3). The corresponding statements are listed in Table 1.(For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

higher: 13 % agreed that *It promotes the existence of general pests* (D01), and 19 % agreed that *It poses a criminal risk* (D05), (see Fig. 5). Furthermore, 8 % believe that *It poses a risk of spreading mosquito-borne diseases* (D07) such as dengue, and 11 % that *It is damaging to sidewalks* (D08).

3.3. Costa Ricans' perception of selected UV ecosystem services and disservices after data weighting

Fig. 4 shows the results of Costa Ricans' UV perception after data weighting (see Section 3.1). Compared to the results obtained before the stratification, the trend is very similar: most of the participants had a positive perception of urban vegetation, agreeing with the ecosystem services it provides and disagreeing with the harms. However, when focusing on the individual statements, we were able to observe a more nuanced picture.

First examining the ecosystem services, we found that the absolute average difference on the agreement side of the scale was 3.6 %. Except for the statement *It provides food or useful materials* (S14), for which the positive perception increased by 9 % agreement, all other statements decreased or plateaued at the same level. Statements S01 and S11 contrasted with the other statements, showing a more pronounced decrease in positive perception of approximately 7 %. On the disagreement side (*disagree* and *strongly disagree*) the absolute average difference was 4 %, and an increase in negative perception for almost all statements. Interestingly, the highest increase in disagreement was also found for statement S14, with a 9 % difference. A decrease of 7 % in positive perception was detected for statements S01 and S02.

With regards to the disservices, we found that the absolute average difference between the responses that agreed with the statements was only 2.3 %. The statements that showed a more pronounced variation were D01, with an increase of 7 % in agreeing responses, while the agreeing responses for D05 were reduced by 5 %. With regards to responses showing disagreement, at 4.1 %, the average difference was slightly higher. However, responses showing disagreement decreased, particularly for D02 and D10, which changed by 9 % and 8 % respectively. A comprehensive table with the summarized results showing the specific numeric differences of the results before and after data weighting can be found in Appendix B in the SM.

3.4. Perception of Costa Ricans and Singaporeans of UV associated with ecosystem services and disservices

To obtain a better understanding of the perceptive differences along the tropical belt, we compared our survey results with those from a previous study. After the poststratification processing we juxtaposed our weighted results with those from Singapore (Fig. 5). Overall, the response patterns in both countries agreed well and corroborate the findings of previous work on ES. Most of the individuals agreed that urban greenery has certain benefits and disagree about its potential harms. Surprisingly, despite cultural and religious differences, people's perception of the spiritual value (D05) that UV may have were nearly equivalent. This statement was simultaneously the one with which the fewest people agreed and that which generated the most significant number of neutral votes. Unsurprisingly, those harms caused by UV that are associated with the prevailing tropical climatic conditions in both territories, such as contributing to the presence of pests such as mosquitoes and rats (D01) and incurring the risk of the spread of diseases transmitted by mosquitoes (D07), are also among the disservices most agreed upon by both Costa Ricans and Singaporeans. Despite the similarities, there are also some differences. Across all ES, we found a higher percentage of agreement in Costa Rica, except for the first two statements: *improves air quality* (S01) and *provides shade* (S02). This distinguished higher approval rate is more evident in the percentage of participants agreeing with the statements on disservices. The average in Singapore was 17.8 % (sd = 5.6), while in Costa Rica it was only 7.2 % (sd = 5.7).

3.5. Inference of demographic profile on ecosystem services and disservices

3.5.1. Chi-square test of independence

From Table 5 we can see that age is the demographic factor that most influences the responses with a clear correlation evidenced by X^2 being consistently larger than the critical value. More precisely, the responses given for all services except *it possesses spiritual or religious value* (S07) and six disservices (D01, D02, D05, D06, D07, and D08) showed correlation with the participants' age. Gender was identified as the second most important factor in showing correlation with ecosystem services (four), yet was less correlated with responses towards disservices (one).

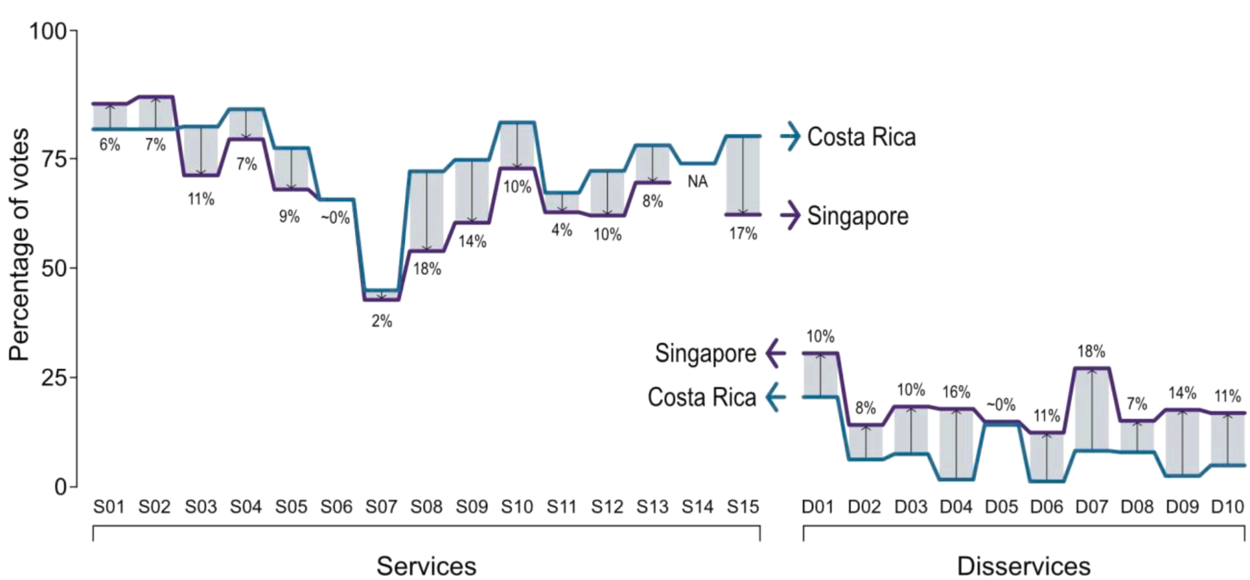

Fig. 5. Differences in the percentage of agreement between Costa Rica (blue) and Singapore (purple) for the same services and disservices. Arrows going up means a higher percentage of agreement in Singapore, while arrows going down mean the opposite. The magnitude of the difference is reported in percentages. Singaporean data was drawn from Drillet et al. (2020). Corresponding statements can be read in Table 1.(For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 5
Independence test of participants' responses on ecosystem services and disservices with respect to gender, age group, and education level. *P* value <0.05 indicates a significant impact of the variable on participants' perception of UV. $N = 811$.

Statement	Gender				Age				Education level			
Ecosystem services statements:												
	χ^2	df	Critical value	*p*-value	χ^2	df	Critical value	*p*-value	χ^2	df	Critical value	*p*-value
S01	4.25	8	15.51	0.834	45.43	20	31.41	**0.001**	10.01	12	21.03	0.615
S02	10.76	8	15.51	0.216	41.44	20	31.41	**0.003**	8.39	12	21.03	0.754
S03	14.10	8	15.51	0.079	58.34	20	31.41	**<0.001**	14.91	12	21.03	0.246
S04	15.29	8	15.51	0.054	49.24	20	31.41	**<0.001**	16.69	12	21.03	0.162
S05	10.29	8	15.51	0.245	54.36	20	31.41	**<0.001**	29.44	12	21.03	**0.003**
S06	6.56	8	15.51	0.585	93.90	20	31.41	**<0.001**	15.57	12	21.03	0.212
S07	8.12	8	15.51	0.422	32.27	20	31.41	**0.041**	8.70	12	21.03	0.728
S08	13.31	8	15.51	0.102	48.46	20	31.41	**<0.001**	13.12	12	21.03	0.360
S09	23.09	8	15.51	**0.003**	44.93	20	31.41	**0.001**	9.32	12	21.03	0.675
S10	11.06	8	15.51	0.198	62.86	20	31.41	**<0.001**	15.68	12	21.03	0.206
S11	12.59	8	15.51	0.127	49.85	20	31.41	**<0.001**	10.96	12	21.03	0.532
S12	21.87	8	15.51	**0.005**	37.39	20	31.41	**0.011**	12.00	12	21.03	0.446
S13	12.54	8	15.51	0.129	60.96	20	31.41	**<0.001**	8.68	12	21.03	0.730
S14	16.73	8	15.51	**0.033**	45.91	20	31.41	**0.001**	18.69	12	21.03	0.096
S15	19.16	8	15.51	**0.014**	68.44	20	31.41	**<0.001**	7.86	12	21.03	0.796
Ecosystem disservices statements:												
D01	6.14	8	15.51	0.632	24.25	20	31.41	0.232	12.92	12	21.03	0.375
D02	7.59	8	15.51	0.474	42.57	20	31.41	**0.002**	28.24	12	21.03	**0.005**
D03	12.49	8	15.51	0.131	21.97	20	31.41	0.342	10.04	12	21.03	0.613
D04	15.76	8	15.51	**0.046**	30.41	20	31.41	0.063	22.62	12	21.03	**0.031**
D05	13.90	8	15.51	0.084	27.47	20	31.41	0.123	11.01	12	21.03	0.528
D06	6.87	8	15.51	0.551	63.69	20	31.41	**<0.001**	37.10	12	21.03	**<0.001**
D07	10.91	8	15.51	0.207	28.46	20	31.41	0.099	12.37	12	21.03	0.416
D08	5.62	8	15.51	0.690	47.42	20	31.41	**0.001**	20.69	12	21.03	0.055
D09	6.13	8	15.51	0.633	31.21	20	31.41	0.052	15.08	12	21.03	0.237
D10	4.21	8	15.51	0.838	36.13	20	31.41	**0.015**	21.28	12	21.03	**0.046**

We found that educational level was more correlated with disservices (four) and less correlated with services (one).

Consequently, we proceeded to analyze the distribution of the sample and the groups for each demographic variable to detect whether the group that adversely viewed UV shared demographic traits such as gender, age, and education level. We found that among all statements, except for S07 and S14, older people (>50 years old) tended to disagree more with the statements associated with ecosystem services, and people with technical education agreed more than participants with a university degree. Furthermore, males disagreed in a higher proportion than females to statements S07 and S14 —which were the statements with the highest percentage of disagreement (See Fig. 6(A) and (B)). Tables C1 to C6 in Appendix C of the SM show the detailed results.

We analyzed the demographic characteristics of the group that negatively perceived UV in greater detail and found that younger people (18–39 years old) agreed more with the statements associated with the aforementioned ecosystemic disservices (See D01 and D05 in Fig. 7(A) and (B)) than older people. Another noteworthy trait is the higher proportion of females who agreed with the assertion that UV *poses a crime risk* (D05) or *poses a risk of spreading mosquito-borne diseases* (D06). In contrast, the statement *It is damaging to sidewalks* (D07), referring to the physical condition of urban infrastructure, was more agreed upon by males. Among these respondents, those with technical education tended to agree more with D07 than participants with a university degree (See Fig. 7(B)). Regarding the sensorial aspects we touched upon in the survey, even though only a minority of respondents agreed that UV has a strong odor (D04, *n*: 17) and makes people *feel uneasy* (D06, *n*: 16), it is worth noting that females made up 82 % of those who agreed on the former and 62 % of those who agreed on the latter.

3.5.2. Multigroup analysis using structural equation modeling (SEM)

Table 6 presents the outcomes of the multigroup analysis, revealing that participants' perception of ecosystem services provided by UV varies based on different combinations of age group and educational level, as well as age group and gender. As previously discussed, age emerges as the most influential factor in shaping the responses. Although there is also some influence from the interaction between these factors on the perception of disservices, it is relatively weaker due to a smaller number of significant findings. Additionally, the interaction between gender and educational level affects participants' perception of disservices, but not of services, as no significant correlations were observed in the latter. For an illustrative example of how responses vary across questions based on age group and educational level, please refer to Appendix D.

Taken together, these results suggest that there is a correlation between age, gender and educational level that affects the perception of UV on an individual scale and that manifests in trends towards the recognition of the benefits of ecosystem services among larger population groups. However, it is crucial to recognize that the evaluation of model fit using the Root Mean Square Error of Approximation (RMSEA) values should be employed to moderate the interpretation of our results. In particular, it is noted that a few of the significant models show RMSEA values that are higher than the usual cutoffs for an acceptable fit. While our findings provide insight into the correlations between the variables under examination, the restrictions imposed by a less-than-optimal model fit highlight the need for cautious interpretation and additional research.

4. Discussion

While many cities worldwide benefit from the ecosystem services provided by UV, political and financial support for planning, planting, and upkeep is not always guaranteed. Our study, on the other hand, reveals the largely favorable opinion and high-value urban residents place on greenery in their surroundings. The findings show that the majority of survey participants agreed with the statements associated with ecosystem services provided by UV and disagreed with the ones related to drawbacks. As a result, the overall impression of urban greenery was favorable among urban residents in Costa Rica. Only approximately 18 % (sd = 2.1) of the sample population disagreed with the benefits provided by urban greenery, whereas 7 % (sd = 5.6) agreed with the negative aspects. We also observed that Costa Ricans valued

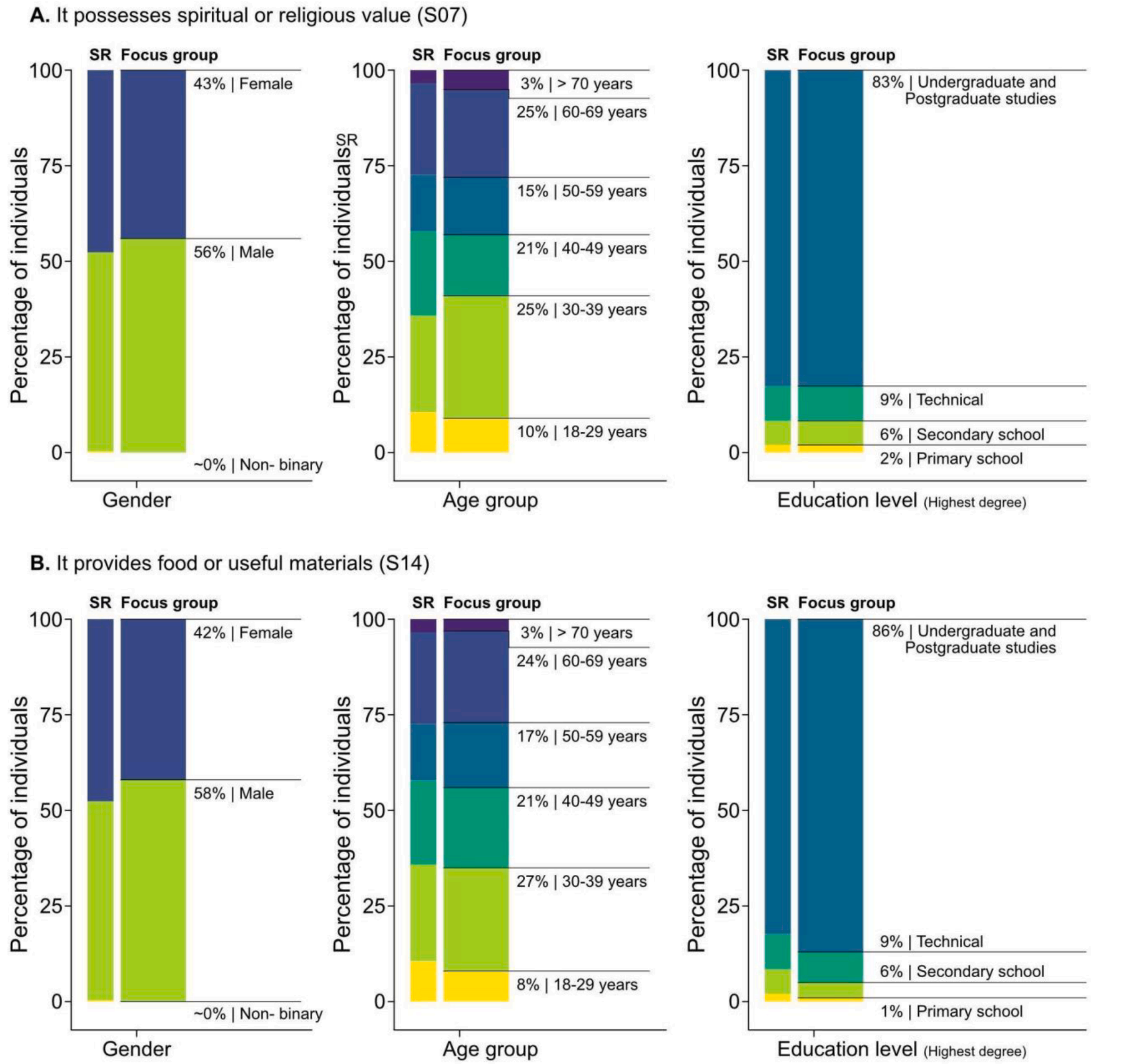

Fig. 6. Stacked proportion barplots comparing gender, age group, and educational level distribution of the sample (SR) and of the participants who disagreed (Focus group) with the services A. *It possesses a spiritual or religious value (S07)*, and B. *It provides food or useful materials*. Appendix C in the SM presents detailed tables including all services.

cultural and regulating services similarly, which is interesting to note because it reflects the multidimensional complexity of environmental perception.

This favorable perception of the ecosystem services provided by UV is evident both before and after implementing the poststratification technique. Nevertheless, it is worth mentioning that after applying data weighting, the level of positivism slightly decreases. This suggests that participants from underrepresented groups, who carry a higher weight after weighting, exhibit a less optimistic perception.

Overall, the results of this survey are in good agreement with the findings of previous studies. Weber et al. (2014) conducted a study in Berlin and Cologne and found that urban roadside vegetation was highly approved by city dwellers. However, planted and maintained vegetation was slightly more preferred. The findings of a study conducted in Morelia, west-central Mexico, by Camacho-Cervantes et al. (2014) revealed that, even when people believe that trees in urban environments can cause damage, they are more interested in their benefits and believe that more trees should be planted in cities. Equally, Drillet et al. (2020) found that nearly two thirds of Singaporeans believe that UV provides ecosystem services and should therefore be considered an essential element of the urban environment.

The disservices that people mostly agreed upon in our study were *It promotes the existence of general pests* (D01, 20 % agreement), and *It poses a criminal risk* (D05, 14 % agreement). This could be related to the fact that disease vectors, notably mosquito-transmitted dengue, Chikungunya and Zika viruses, are a serious health concern in Costa Rica (Gutiérrez Albenda, 2018). It must also be noted that Costa Ricans generally take a dim view of the security situation in their country, with 69 % of the population perceiving that it is unsafe (Mora-Izaguirre et al., 2020), a factor that might have influenced the response rate towards potential crime risks associated with UV.

In many of the responses concerning ecosystem disservices, however, participants were undecided. For some statements the percentage of people who voted *neither agree nor disagree* surpassed 20 %. Many

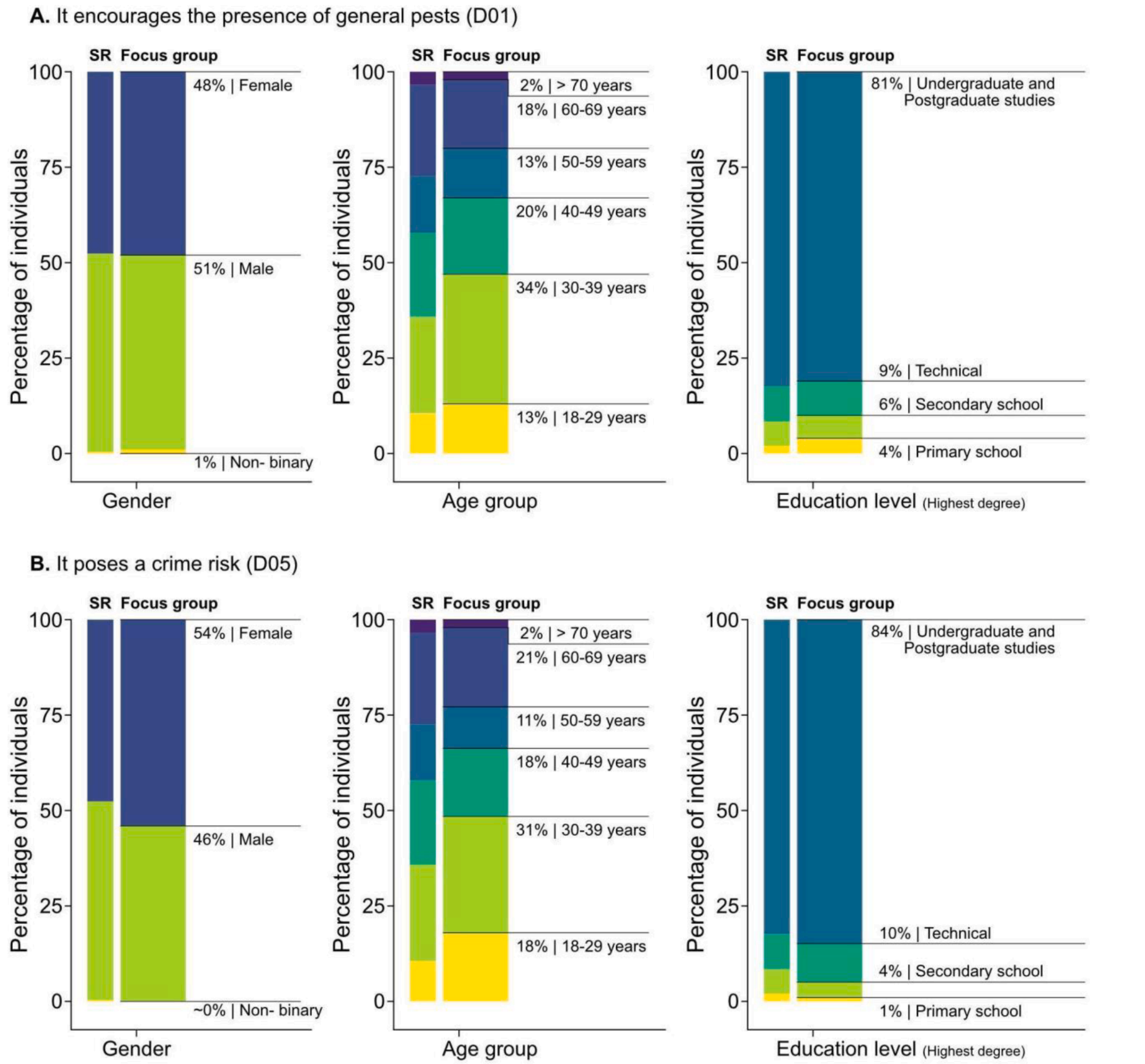

Fig. 7. Stacked proportion barplots comparing the gender, age group, and educational level distribution of the sample (SR) and of the participants who agreed (Focus group) with the disservices A. *It encourages the presence of general pests* (D01) and B. *It poses a crime risk* (D05). Appendix C in the SM presents detailed tables including all disservices.

neutral votes could be attributed to participants' beliefs that the mere presence of UV does not guarantee benefits. Other factors could have altered people's perceptions as well. Several studies have demonstrated that manicured grass is preferred over unkempt vegetation (Özgüner and Kendle, 2006; Weber et al., 2014; Poškus and Poškienė, 2015), indicating that the public favors urban landscapes that show care, control, and tidiness and are adequately managed. This is coherent with the answers the participants gave when asked if UV poses a crime risk or if it damages sidewalks, underpinning the *it depends* hypothesis. 22 % voted *neither agree nor disagree*, which could suggest that it depends on the vegetation type (e.g., grasses, shrubs, trees), where it is planted, or how well it is managed. Our findings suggest that people prefer to live closer to nature, but only in ways that appeal to the human need for control over nature. Although evaluating whether people's impressions differ depending on the type of vegetation or its state of upkeep falls outside the scope of this study, it should be investigated further in future research.

Given the highly positive perception of the ecosystem services provided by UV, it should be emphasized that when completing the questionnaire, participants might not have been aware that some issues related to UV could affect them directly in the future —trees in front of their residences that can damage sidewalks or drop leaves— and influence their perception of UV. These changes in attitude due to personal experiences have been seen before, where ecologic initiatives widely supported at first are later rejected by those who perceive themselves to be directly affected (Scott et al., 2016). We suggest that more research is needed to investigate this phenomenon in depth and to evaluate whether it may affect the perception of UV and require changes in policy or planning practices.

Another topic participants needed to be made aware of is the upkeep costs associated with urban greenery, which could mean, for example, increased taxes. The willingness to pay for these costs to obtain the benefits of ES in the future is, however, linked to the perception of UV; a causal nexus to solve that will require more attention in future research.

Table 6
Outcomes of the multigroup analysis. The interaction of three combinations of variables were examined: Gender- Educational level, Gender-Age group, and Age group-Educational level. A *p*-value <0.05 indicates a statistically significant difference in the perception of UV ecosystem services and disservices among the various groups formed by combining the different demographic variables. RMSEA values below 0.05 were considered indicative of a good fit, while values below 0.08 were deemed acceptable. $N = 811$.

Statement	Gender/education level			Gender/age group			Age group/education level		
Ecosystem services statements:									
	χ^2	*p*-value	RMSEA	χ^2	*p*-value	RMSEA	χ^2	*p*-value	RMSEA
S01	6.28	0.393	0.015	26.12	**0.004**	0.109	28.432	**0.002**	0.117
S02	6.34	0.386	0.016	28.32	**0.002**	0.116	36.025	**<0.001**	0.139
S03	7.42	0.284	0.034	22.33	**0.014**	0.095	26.555	**<0.001**	0.111
S04	8.37	0.212	0.044	26.57	**0.003**	0.111	29.683	**<0.001**	0.121
S05	10.10	0.121	0.058	27.62	**0.002**	0.114	34.101	**<0.001**	0.133
S06	6.98	0.323	0.028	10.77	0.376	0.023	17.525	0.064	0.074
S07	2.09	0.911	0.000	25.02	**0.005**	0.105	31.354	**<0.001**	0.125
S08	6.23	0.398	0.014	24.61	**0.006**	0.104	29.544	**<0.001**	0.120
S09	5.88	0.437	0.000	24.05	**0.008**	0.102	28.775	**<0.001**	0.117
S10	7.82	0.252	0.039	27.40	**0.002**	0.113	32.497	**<0.001**	0.129
S11	4.31	0.634	0.000	12.61	0.247	0.043	18.836	**0.042**	0.080
S12	8.67	0.193	0.047	12.44	0.257	0.042	18.161	0.052	0.077
S13	5.56	0.474	0.000	24.44	**0.007**	0.103	29.776	**<0.001**	0.120
S14	9.90	0.129	0.056	7.864	0.642	0.000	10.311	0.414	0.015
S15	6.37	0.383	0.017	17.44	0.065	0.074	20.741	**0.023**	0.089
Ecosystem disservices statements:									
D01	14.00	**0.030**	0.081	21.78	**0.016**	0.093	18.95	**0.041**	0.081
D02	17.65	**0.007**	0.097	7.667	0.661	0.000	11.87	0.294	0.037
D03	13.54	**0.035**	0.078	10.61	0.389	0.021	10.954	0.361	0.026
D04	25.62	**<0.001**	0.127	19.25	0.037	0.082	20.46	**0.025**	0.087
D05	6.955	0.325	0.028	24.35	**0.007**	0.103	22.29	**0.014**	0.095
D06	17.29	**0.008**	0.096	36.58	**<0.001**	0.140	26.19	**0.003**	0.109
D07	14.38	**0.023**	0.085	11.72	0.304	0.035	15.01	0.132	0.060
D08	14.62	**0.023**	0.084	20.34	0.026	0.087	17.51	0.064	0.074
D09	15.25	**0.018**	0.087	8.30	0.599	0.000	11.058	0.353	0.028
D10	17.06	**0.009**	0.095	20.32	**0.026**	0.087	15.819	0.105	0.066

Moving on now to consider the perception of urban vegetation in a wider context, upon comparing our findings from Costa Rica with those from Singapore, it is surprising to observe a striking similarity in people's perceptions despite the economic, cultural, and religious disparities between the two countries. Both Costa Ricans and Singaporeans expressed concern about the negative impacts associated with the tropical climate, such as the presence of mosquitoes, which pose a risk of spreading mosquito-borne diseases. However, Singaporeans appeared to be more apprehensive about this issue, potentially due to regular dengue prevention campaigns and the public display of monthly dengue case numbers in each neighborhood.

The most notable difference was Costa Ricans' generally more favorable attitude towards UV, particularly with regards to the disservices. We propose two possible explanations for these disparities: Firstly, a more relaxed perception of the harms that UV may generate could be associated with the higher level of "wilderness" in Costa Rica, while Singapore is a densely populated city-state with most of its vegetation planted and regulated. Costa Rica is less urbanized, and its residents have a greater exposure to nature, which may lead to a higher tolerance of its potential hazards. This hypothesis is supported by previous studies, stating that people who live in rural areas or near forests are more aware of ES than those who live in cities (Abram et al., 2014; Muhamad et al., 2014).

Secondly, responses in Costa Rica may have been influenced by the COVID-19 global pandemic. While Singaporeans were surveyed before the pandemic (September 2018), in Costa Rica, the survey was deployed after a long period of stay-at-home restrictions. It could be argued that isolation and social distancing have affected the survey participants' perception of green infrastructure as has been reported for other countries (Haasova et al., 2020; Morse et al., 2020). It is important to consider the possible bias this might have caused. However, the overwhelming similarity between positive perception responses among both countries' populations despite cultural, social, and economic differences is difficult to outweigh.

4.1. Limitations and future work

One of the study's major limitations is that we used a self-selection sample rather than one derived from a probability sampling method. Consequently, our sample presented a coverage bias, because certain people in the population of interest were underrepresented. To tackle this issue, we used a poststratification technique. Yet, given that the final sample of 811 participants only contained 15 subjects who had not completed high school while this group represented almost half of all Costa Ricans, the weight applied to their answers was very high. Therefore, these results should be interpreted with caution and a study including a higher number of participants from that specific group is highly recommended.

Another limitation we encountered was the fact that some regions of Costa Rica's GMA are still less developed. Although they are categorized as urbanized territory within the official cartographic layout, some of these regions maintain a rural character with a rudimentary infrastructure. We anticipated that the perception of UV might vary for the sample representatives of these regions. However, we were unable to account for this variance adjusting the weightage for the answers from this group. Therefore, it cannot be outruled that some participants living in semi-rural areas might have self-reported as urban residents while responding in the questionnaire to preferences for UV with a bias resulting from the context in which they live.

Finally, it must be noted that the 2011 national census was used because it was the most recent version accessible. Costa Rica conducted a new census in 2022, the results of which have yet to be disclosed. The estimated proportions in Table 2 could be revised once these are revealed. It is expected, if the recent trend continues, that there will be more people with a university degree and fewer people with only a primary education.

5. Conclusions

The main goal of the current study was to investigate Costa Rican urban residents' perceptions of urban vegetation (UV) as a provider of ecosystem services and disservices. To do so, we deployed a web survey and received 1264 responses from people living in Costa Rica. After selecting those participants residing in the Greater Metropolitan Area and applying a data cleaning process, we obtained 811 valid responses. To determine whether public perception of urban vegetation varies across the tropical belt we compared our results from Costa Rica with those of a previous study in Singapore. Our results show that Costa Ricans have overwhelmingly positive views on urban vegetation and clearly perceive the services they provide as beneficial. They also complement those of earlier studies in Singapore, confirming the positive perception of urban vegetation and ecosystem services in cities with tropical climates, despite differences in green space planning and management.

In relation to respondents' demographic variables, our findings indicate that age emerged as the most influential factor, with a significant impact on ES perception. Additionally, gender had a greater influence on the perception of services, whereas education level played a more significant role in shaping the perception of disservices. The perception of most urban vegetation ecosystem services was influenced by various combinations of age and gender, as well as age and educational level. Additionally, nearly half of the disservices were affected by these combinations. Furthermore, the interaction between gender and educational level specifically influence the perception of disservices. While positive views on urban vegetation are shared on a broad basis, negative perception demonstrates a more varied response pattern. Older participants, in general, tend to disagree more with the services, while younger respondents agreed more with the disservices. Females were more likely to affirm the perceived association of urban vegetation with risk and negative impacts on health, in contrast to males who were more aware of possible damage to infrastructure. However, while these findings provide insight into the correlations between UV perception and the demographic variables, the restrictions imposed by a less-than-optimal model fit highlight the need for cautious interpretation and additional research.

Harmful effects related to tropical conditions, such as pests and diseases, are equally negatively perceived among Costa Ricans in Central America and Singaporeans in Southeast Asia, suggesting a shared perceptive sensitivity towards urban vegetation. The results of this study are significant for future urban planning practices. By providing insights into how urban vegetation is perceived by people in tropical regions, this research serves as a foundation for setting priorities and making informed decisions. Local governments and planners can use this information to respond to the needs and values of their communities, which can increase public engagement and support for green infrastructure initiatives. Ultimately, this can lead to more successful and sustainable urban planning efforts.

Declaration of generative AI and AI-assisted technologies in the writing process

Statement: During the preparation of this work the authors used machine learning powered typing assistants (Grammarly), paraphrasing tools (QuillBot AI), and translation tools (Google Translate) to improve language and readability. After using these tools/services, the authors reviewed and edited the content as needed and they take full responsibility for the content of the publication.

CRediT authorship contribution statement

Jose Ali Porras-Salazar: Conceptualization, Methodology, Investigation, Software, Formal analysis, Writing – original draft, Visualization, Writing – review & editing, Project administration. **Jan-Frederik Flor:** Writing – original draft, Visualization, Writing – review & editing. **Sergio Contreras-Espinoza:** Formal analysis, Writing – review & editing. **Melissa Soto-Arce:** Data curation. **Rene Castro-Salazar:** Conceptualization, Investigation, Writing – review & editing.

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.

Data availability

Data will be made available on request.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.envadv.2023.100422.

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