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AMANDA LOUISI DOS SANTOS GALVÃO

VALORAÇÃO DE ÁREAS VERDES URBANAS: UMA ANÁLISE DA PERCEPÇÃO PÚBLICA SOBRE OS BENEFÍCIOS PARA A SAÚDE

Bauru
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Orientador: Prof. Dr. Adriano Bressane

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Aos 22 dias do mês de novembro do ano de 2023, às 14:00 horas, por meio de Videoconferência, realizou-se a defesa de DISSERTAÇÃO DE MESTRADO de AMANDA LOUISI DOS SANTOS GALVÃO, intitulada **VALORAÇÃO DE ÁREAS VERDES URBANAS: UMA ANÁLISE DA PERCEPÇÃO PÚBLICA SOBRE OS BENEFÍCIOS PARA A SAÚDE.** A Comissão Examinadora foi constituida pelos seguintes membros: Prof. Dr. ADRIANO BRESSANE (Orientador(a) - Participação Virtual) do(a) Departamento de Engenharia Ambiental / Universidade Estadual Paulista UNESP Instituto de Ciência e Tecnologia de São José dos Campos, Prof. Dr. FELIPE HASHIMOTO FENGLER (Participação Virtual) do(a) Engenharia Agronômica / Centro Universitário FACENS, Profa. Dra. ELISA ESPÓSITO (Participação Virtual) do(a) Departamento de Ciência e Tecnologia / Unifesp – Universidade Federal de São Paulo. Após a exposição pela mestranda e arguição pelos membros da Comissão Examinadora que participaram do ato, de forma presencial e/ou virtual, a discente recebeu o conceito final: APROVADA. Nadamais havendo, foi lavrada a presente ata, que após lida e aprovada, foi assinada pelo(a) Presidente(a) da Comissão Examinadora.

Prof. Dr. ADRIANO BRESSANE

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RESUMO

A importância das áreas verdes para saúde da população urbana está cada vez mais evidente nos estudos científicos. Por outro lado, há poucas evidências sobre a percepção pública quanto a esta importância, especialmente em países não desenvolvidos como o Brasil. Apesar do reconhecimento científico, a abordagem do tema limitada a países desenvolvidos impossibilita uma compreensão abrangente. Este estudo tem como objetivo suprir essa lacuna e analisar a disposição a pagar para manutenção das áreas verdes urbanas e sua correlação com a percepção dos benefícios para saúde da população. A coleta de dados foi realizada por meio de pesquisa on-line, com tamanho amostral de 2.597 entrevistados (nível de confiança de 95%, poder de teste de 80% e uma diferença mínima detectável de 7%). A pesquisa foi composta por um formulário baseado na escala Likert de 5 pontos e no método de valoração contingente. A análise empregou a ANOVA de Welch e o índice de Cohen para medir os tamanhos dos efeitos. Os entrevistados demonstraram ter consciência dos benefícios das áreas verdes urbanas para saúde pública, principalmente para saúde mental (estresse e ansiedade) e física (respiração). Em contrapartida, associaram a situações de falta de segurança pública. Além disso, ficou evidente a disponibilidade a pagar pela manutenção das áreas verdes urbanas, influenciada principalmente pela renda. Como resultado, o estudo destaca o papel importante das áreas verdes urbanas para saúde pública e a disposição a investir na manutenção e conservação destas áreas. Por fim, novas pesquisas podem aprofundar sobre a associação entre renda e disposição a pagar, apoio público para melhorias na segurança e estratégias para acessibilidade e, assim, contribuir para futuras iniciativas de planeamento urbano.

Palavras-chave: infraestrutura urbana; áreas verdes; saúde; percepção pública.

ABSTRACT

Urban green spaces (UGS) offer health benefits, yet public perception, particularly in non-developed countries like Brazil, remains underexplored. Despite scientific recognition of UGS health benefits, limited research addresses public willingness-to-pay (WTP) in non-developed countries, hindering comprehensive understanding. This study addresses the research gap by analyzing WTP for UGS in Brazil, focusing on the association with perceived public health benefits. A primary survey collected data from 2597 respondents through online surveys. Analysis employed Welch's ANOVA and Cohen's index to measure effect sizes. Respondents demonstrated strong awareness of UGS health benefits, notably in mental and respiratory health. Despite tax concerns, significant WTP for UGS maintenance was evident, predominantly influenced by income. The study underscores UGS's vital role in public health and the public's willingness to invest in their conservation. Urban planners and policymakers should prioritize UGS conservation, considering multifaceted benefits and addressing safety concerns. Strategies to ensure UGS accessibility across income groups warrant exploration. Further research can delve into income-WTP dynamics for UGS and assess the effectiveness of awareness programs in bolstering public support. Evaluating strategies to enhance UGS accessibility for all income groups is crucial for future urban planning initiatives.

Keywords: urban infrastructure; green spaces; health benefits; public perception.

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LISTA DE SIGLAS E ABREVIATURAS

AVU – Áreas Verdes Urbanas

BHD – Breast Height Diameter

CGA – Condition of Green Areas

CVM – Contingent Valuation Method

DAP – Disposição a Pagar

DEN – Density

DGA - Dimensions of green area

FCQ – Forest Cover-based Quality

FES – Fuzzy Expert System

FSQ – Forest Stage-based Quantity

PGA – Percentage of green area

UGS – Urban Green Spaces

WTP – Willingness-to-pay

SUMÁRIO

1 INTRODUÇÃO

A urbanização é um desafio global emergente. Em diversas partes do mundo, o número de pessoas vivendo em cidades já supera a população rural. Estima-se que 68% da população mundial residirá em áreas urbanas até 2050 (NAÇÕES UNIDAS, 2018).

A urbanização pode proporcionar avanços importantes em vários setores. Melhores condições de habitação, saneamento, educação, transporte e serviços de saúde, são alguns dos benefícios associados as áreas urbanas (WANG et al., 2021).

Por outro lado, quando a expansão das áreas construídas resulta na supressão de áreas naturais, o processo de urbanização pode comprometer a qualidade de vida e saúde da população nas cidades (RAMELI; RAMLI; SALLEH, 2019). Além da perda de biodiversidade, os impactos sobre a saúde pública estão entre os seus principais efeitos negativos (XU et al., 2018; LEDDA; DE MONTIS, 2019; YANG; TANG; YANG, 2021).

Nesse cenário, a existência de áreas verdes no ambiente urbano tem sido cada vez mais reconhecida pela comunidade científica, como necessária para o alcance de cidades saudáveis (RIGOLON et al., 2018). Assim, a manutenção destas áreas se tornou uma diretriz, definida pelas Nações Unidas, como estratégia para alcançar objetivos de desenvolvimento sustentável (KROLL; WARCHOLD; PRADHAN, 2019).

Na literatura podem ser encontradas diversas definições de áreas verdes. Nesse projeto, assumimos que as áreas verdes urbanas podem assumir diferentes graus de naturalidade, mas que em geral correspondem aos espaços livres de edificações, com presença de cobertura vegetal, e que podem ser dotados de infraestrutura para lazer e recreação (NIEUWENHUIJSEN et al., 2021).

As áreas verdes podem constituir uma alternativa estratégica para gestão do solo urbano, sobretudo, devido à sua capacidade multifuncional. Ao mesmo tempo em que contribuem para funções ecológicas, como a conservação da biodiversidade e recursos naturais, também podem ser espaços para lazer e recreação, desempenhando função social relevante (KLOMPMAKER et al., 2018; HANSEN et al., 2019; ENSSLE; KABISCH, 2020).

Diversos estudos têm demonstrado efeitos positivos das áreas verdes urbanas (AVU) sobre a saúde pública. Como são áreas frequentemente usadas para prática de atividades físicas e interação social, geram benefícios associados a melhoria da pressão arterial (YANG et al., 2019), da qualidade do sono (XIE et al., 2020) e do sistema respiratório (WU et al., 2021), a redução de doenças cardiovasculares (LIU et al., 2021), do estresse (CROUSE et al., 2021), da depressão e ansiedade (LIAO et al., 2020).

Tian et al. (2020) apontam que os planejadores urbanos têm dado cada vez mais atenção à percepção pública e à demanda por espaços verdes urbanos (AVU). Os autores conduziram uma extensa pesquisa com residentes de três grandes cidades da China sobre a disposição a pagar (DAP) para conservação de AVU. O estudo constatou que as percepções dos serviços ecossistêmicos da AVU tiveram impactos na DAP, que também foi diretamente proporcional ao status socioeconômico dos residentes.

De acordo com Chen et al. (2020), muitos países em desenvolvimento ainda carecem de conscientização pública sobre as AVU e seus benefícios. Os autores argumentam que nesses países a relação entre benefícios AVU e a DAP não foi amplamente investigada. Avaliando a cidade de Guangzhou (China) como um estudo de caso, os resultados mostraram que as oportunidades de educação, entretenimento e benefícios de saúde fornecidos pela AVU tiveram a maior influência na DAP.

Para Zhang et al. (2020), conhecer a percepção do público sobre a AVU é importante para a tomada de decisão. Concentrando-se em três pequenas AVU, os autores avaliaram a DAP dos residentes para a manutenção de infraestruturas verdes (cobertura, parede e faixa verde). O estudo constatou que os benefícios percebidos da melhoria da qualidade do ar geraram maior DAP, que também foi maior nos jovens em comparação aos idosos.

Sabyrbekov et al. (2020) argumenta que o valor da AVU raramente é reconhecido nos processos políticos e de planejamento, principalmente nos países em desenvolvimento. O estudo desenvolvido pelos autores em Bishkek, Quirguistão, mostrou que uma alta afinidade natural não leva necessariamente a uma maior DAP para melhorar a provisão pública de AVU, pois a DAP é limitada por outros fatores, como renda e educação.

Dinda e Ghosh (2021) destacam que as AVU proporcionam benefícios multifuncionais (ambientais, sociais e recreativos) e que uma melhor compreensão das preferências dos cidadãos contribui para sua gestão. Para isso, os autores avaliaram a DAP em diferentes perfis sociodemográficos na Índia. O estudo revelou que diversos fatores sociodemográficos, principalmente gênero, idade, escolaridade e situação econômica influenciam as preferências e, consequentemente, a DAP para AVU.

Mamani et al. (2021) determinou a DAP para recuperação e conservação de AVU existentes para uso público na cidade de Juliaca, Peru. Os resultados revelaram que os principais fatores influenciadores na DAP incluem renda familiar, escolaridade e proximidade residencial a espaços verdes, além da frequência de visitas à AVU.

Idris et al. (2022) descrevem que a cidade de Padang, na Indonésia, iniciou a construção de uma AVU para aumentar a qualidade ambiental e proporcionar oportunidades de lazer para moradores e visitantes. Para subsidiar a gestão local, o estudo avaliou a DAP pela AVU. Os resultados mostraram que o DAP é afetado pela percepção do público, conhecimento das funções da AVU e estado civil do respondente. Por outro lado, a renda não teve efeito significativo. Considerando que o conhecimento sobre as funções da AVU teve um efeito significativo, o estudo sugeriu programas de conscientização.

Luo et al. (2022) indicam evidências emergentes para sugerir que o AVU contribui para múltiplos benefícios de saúde para residentes urbanos. A partir de uma pesquisa realizada na China, os autores descobriram que mais da metade dos entrevistados relataram ter DAP por AVU em áreas residenciais, o que consideraram mais benéfico para a saúde mental do que para a saúde física e social. De maneira geral, os autores concluíram que os benefícios percebidos à saúde tiveram um impacto positivo na DAP, e que tal constatação pode melhorar a eficácia dos planejadores urbanos na tomada de decisões capazes de construir comunidades saudáveis.

Cheung et al. (2022) discutem que a AVU fornecem múltiplos benefícios, mas também podem causar impactos negativos. Ao investigar a DAP dos residentes de Hong Kong para melhorar a oferta de AVU, os autores constataram que as percepções de benefícios positivos e impactos negativos influenciaram a DAP, que foi diretamente proporcional ao nível de escolaridade, mas inversamente proporcional à faixa etária dos respondentes.

Pelo exposto, a importância das áreas verdes no meio urbano, tanto para a conservação ambiental, quanto para a qualidade de vida dos seus habitantes, está cada vez mais evidente nos estudos científicos (DEROSE et al., 2021; CHENG et al., 2021; CHALMIN-PUI et al., 2021). Por outro lado, há menos evidências sobre a percepção pública quanto a está importância, sobretudo em países em desenvolvimento (ZHANG et al., 2019; LYNCH, 2021), como é o caso do Brasil.

2 OBJETIVOS

2.1 Objetivo Geral

Esse projeto tem como objetivo analisar a disposição a pagar para implantação e(ou) manutenção de áreas verdes urbanas, e sua correlação com a percepção pública dos benefícios para saúde e o perfil sociodemográfico da população.

2.2 Objetivos específicos

Como objetivos específicos, podem ser destacados:

(i) identificar quais são os benefícios das áreas verdes urbanas sobre a saúde mais percebidos pela população;

(ii) verificar se há correlação entre a percepção destes benefícios, o perfil sociodemográfico e a disposição a pagar (DAP) pela implantação e (ou) manutenção das áreas verdes;

(iii) avaliar quantitativamente a influência dos benefícios percebidos sobre a DAP por áreas verdes urbanas.

3 APRESENTAÇÃO

A relevância das áreas verdes urbanas para a saúde pública tem se tornado cada vez mais evidente nos estudos científicos. No entanto, ainda que haja um crescente consenso no meio científico sobre o tema, a percepção da população em relação a essa relevância, sobretudo em países em desenvolvimento como o Brasil, é pouco estudada. Desta forma, o propósito deste trabalho é preencher essa lacuna. Este trabalho é estruturado em dois artigos que compõe a pesquisa de maneira correlata.

O primeiro artigo, já publicado, é resultado de um estudo realizado em 2021 pelo grupo de pesquisa, em que a ênfase para o tema urbanização ocorre através da propositura de uma metodologia para determinação das proporções ideais de áreas verdes urbanas por habitante, considerando também a qualidade desses ambientes.

O segundo artigo, desenvolvido neste trabalho, traz a ênfase da pesquisa para como viabilizar economicamente a manutenção e conservação das áreas verdes urbanas, através da proposta de contribuição da população por meio da disposição a pagar por essa infraestrutura e analisando também a percepção da população sobre os benefícios para saúde pública.

Ressalta-se que os artigos foram elaborados de forma independentes e compartilham do mesmo tema central da pesquisa.

4 ARTIGO PUBLICADO

A fuzzy-based methodological proposal for analysing green areas in urban neighborhoods

Abstract

The reduction of the green areas due to the growth of the built-up areas has affected the environmental quality in cities. Nevertheless, some uncertainties remain about the adequate amount of such areas in the urban landscape. This study aims at introducing a methodology to support analysis of green areas in urban neighborhoods. The methodological proposal was based on a fuzzy expert system (FES), a soft computing approach capable of dealing with uncertainties in complex multiple-criteria decision-making. As empirical research, some case studies to introduce and validate the proposed methodology were performed. An agglomerative hierarchical clustering, followed by a Kruskal-Wallis test and multiple pairwise comparisons using the Conover-Iman procedure (significance 0.05), demonstrated that the FES was able to provide outcomes consistent with hypothetical situations, simulated as ideal and critical conditions of green areas. In conclusion, our findings indicate that the methodological proposal based on FES is a promising tool for complex case-by-case analysis in urban neighborhoods.

Keywords: land use, sustainable cities, expert system, decision model.

Introduction

According to the World Urbanization Prospects report, the urban population corresponds to 3.9 million people, about 54 % of the total world population, and may reach 66% by 2050 (DESA United Nations 2015). Urbanization is a global trend that oftentimes leads to soil sealing, deforestation and habitat fragmentation, requiring integrated management of anthropic and natural issues to achieve healthy and sustainable cities (Adler and Tanner 2015, Aronson et al. 2017, Bressane et al. 2017b, Ribeiro et al. 2018, Bressane et al. 2019). It is widely acknowledged that green areas not only contribute to biodiversity conservation but that they also provide environmental quality in urban landscapes (Zhou and Wang 2011, Sperandelli et al. 2013, Andersson et al. 2014, Kabisch and Haase 2014, Gavrilidis et al. 2017, Meerow and Newell 2017, Bressane et al. 2018b, Rocha and Mussury 2020).

Although green areas are one of the most important elements to be considered for urban planning (Attwell, 2000), the adequate quantity of theses green areas is still under investigation around the world (Maryanti et al. 2016). Discussion of the ideal percentage of canopy cover in urban areas is not recent, but it has not reached consensus in the scientific literature (Mell et al. 2017). For instance, the World Health Organization (WHO 2012) recommends a minimum of 9 m^2 of green space should be available per individual. In Brazil, while local studies recommend that residential areas with low verticalization should have 50% of vegetation, of which 25% are trees and shrubs, areas with high urban verticalization should have 30%, and industrial areasones, 20% (Nucci and Presotto 2009). State legislation requires a minimum of 20% of green areas and recreational space in urban neighborhoods in São Paulo (Resolution SMA 72: São Paulo 2017).

The lack of consensus creates uncertainties that make the treatment of green areas more complex. To deal with these uncertainties, this paper introduces a fuzzy-based methodological proposal, as a tool for analysing the condition of green areas (CGA) in urban neighborhoods. Thereby, the proposed model aims to support decisions that seek to conciliate the expansion of built-up areas with the adequate conservation of green areas. In particular, the model can contribute to the determination of the minimum percentages of green areas based on the integrated analysis of local attributes on a case-by-case basis.

Fuzzy set theory is a soft computing approach that has been widely applied in the building of complex decision support systems, due to its ability to approximate expert reasoning, to equate parameters of a dissimilar nature, to deal with subjectivity and other issues associated with uncertainties (Barros et al. 2017, Bressane et al. 2020, Ewbank et al. 2020, França et al. 2020). Whilst in classical logic elements either do or do not belong to a given set (hard boundary), in fuzzy logic membership can be partial (soft boundaries), as well as assuming linguistic values (Bressane et al., 2018a, Roveda et al., 2018). Thus, as green area analysis can be complex due to the uncertainties involved, fuzzy modelling can provide a promising alternative. Comparison with other methods will be carried out in the continuity of the research.

It is noteworthy that currently, there is no justification for determining percentages of green areas in the process of occupation of urban land (allotments). The percentages used by different municipalities are variable and without any technical justification. The proposed model analyses and recommends percentages of green area based on variables related to existing natural attributes and their potential to promote environmental services. As empirical research, case studies were performed in a medium-sized city in Brazil, in order to validate the proposed methodology.

Materials and Methods

Fuzzy-based tool

In a hard computing approach, membership (φ) of an element in a set is evaluated in a Boolean fashion (classical set theory or type-0 fuzzy set), so that the element assumes value 0 (not pertinent) or 1 (pertinent). In turn, in soft computing based on fuzzy sets theory (type-1 fuzzy sets), the partial membership of an element in several linguistic values becomes possible, assuming a certainty factor in an interval [0,1] (Figure 1).

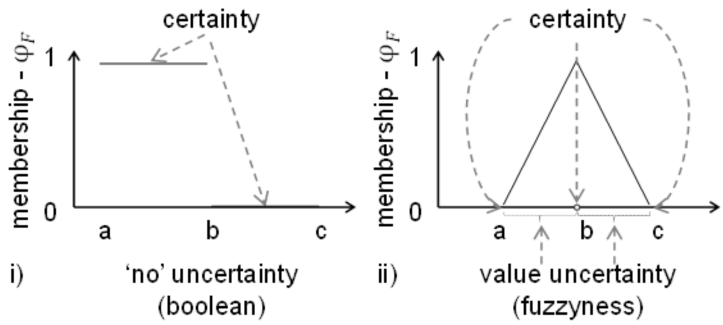

Fig 1. Regions of certainty, with membership equal to 1 or 0, and uncertainty, with transition between conditions of pertinence and non-pertinence: (*i*) classical (type-0 fuzzy set), and (*ii*) type-1 fuzzy set. Source: Bressane et al. (2020).

In Figure 1, (*i*) shows the classical case (type-0 fuzzy set), where parameter 'b' is a crisp value that defines a hard boundary between sets, assuming that there is no uncertainty. In the case of (*ii*) the type-1 fuzzy set, there is uncertainty about the real value of a variable (fuzzyness), which will be quantified as a 'value around b'. While the, threshold parameters provide a gradual transition between sets (soft boundaries), the 'a' and 'c' parameters are rigid, real, and well-known numbers. The membership functions of an element in linguistic values can be trapezoidal, triangular, sigmoidal, Z-shaped, or generalized bell-shaped, among others. In the present study, type-1 fuzzy sets were used, and fuzzification of variables was performed using triangular and trapezoidal membership functions, given by:

$$\varphi_F(x) = \left\{ \left\{ \frac{x-a}{b-a}\ , 1, \frac{c-x}{c-b'} \right\}\ , 0 \right\} \quad (1)$$

where $\varphi_F(x)$ measures the membership of x in the linguistic value modelled by fuzzy set *F*; a, b, b' and c are scalar parameters defined by experts for delimiting regions of certainty and uncertainty, so that for triangular-shaped functions, the parameter b is equal to b'.

Figure 2 presents the tool architecture based on fuzzy expert system (FES), introduced above. Firstly, modelling consisted of the fuzzification of variables, by means of pertinence functions associated to linguistic values, i.e. sets with soft boundaries. The model inputs were indicators of 'density (DEN)', 'quality (FSQ)' and 'quantity (FCQ)' of green areas in urban neighborhoods. In turn, the output from the FES is the condition of green area (CGA).

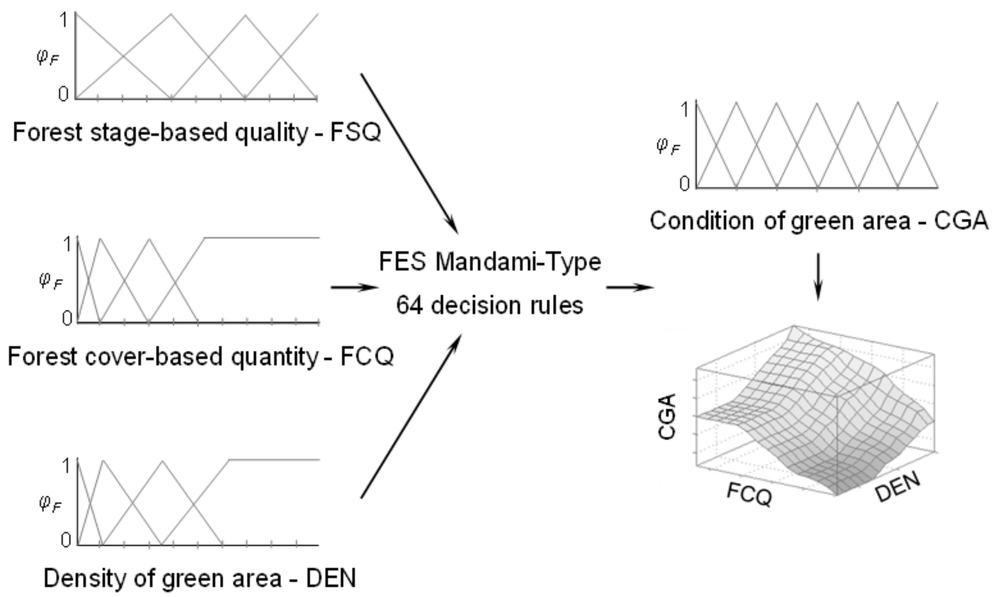

Fig 2. Architecture of the fuzzy-based tool.

Taking into account the different nomenclatures found in the literature (FAO 2016) green areas were designated as areas of collective use in which buildings are not allowed. 'Quality' of green area was based on the forest succession stage (FSQ), so that more advanced stages were considered to be of higher quality (Brown et al. 2015, Cohen-Cline et al. 2015, Klemm et al. 2015, Middel et al. 2015, Berland et al. 2017, Derkzen et al. 2017, Fanelli et al. 2017, Gunawardena et al. 2017, Jayasooriya et al. 2017, Meerow and Newell 2017, Sanusi et al. 2017, Graça et al. 2018, Mota et al. 2019). The fuzzification of this variable is shown in Figure 3a.

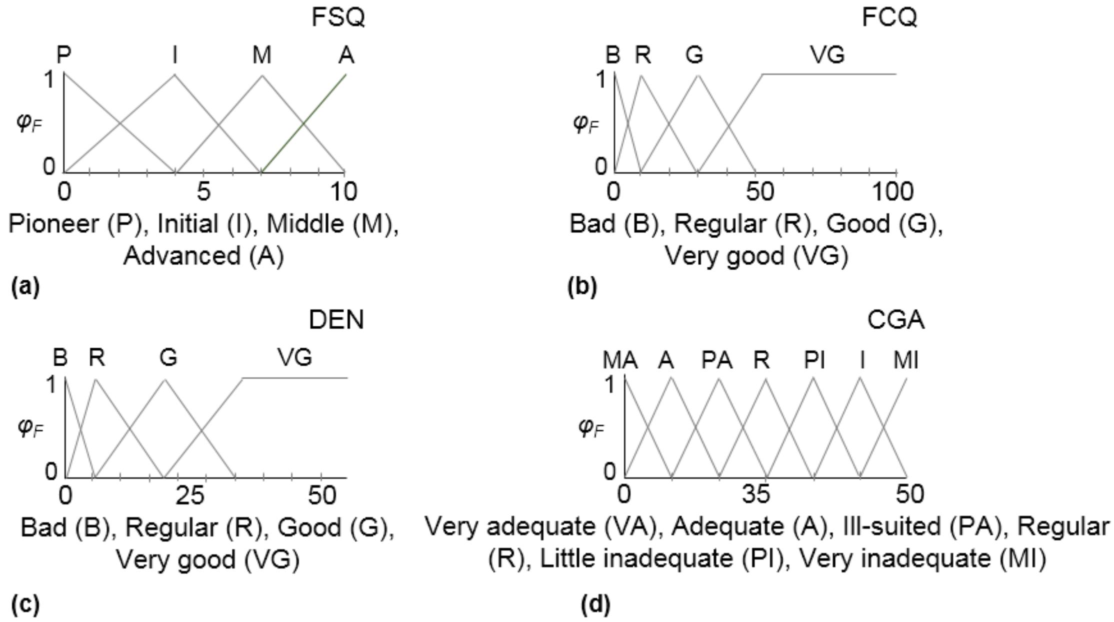

Fig. 3. Model variables fuzzification: a) Forest Stage-based Quality (FSQ), b) Forest Cover-based Quantity (FCQ), c) Density (DEN), and d) Condition of Green Area (CGA).

Data for FSQ variable were collected using the Bitterlich method, which consists of evaluating the trees in a 360° rotation, whose breast height diameter (BHD) is equal to or greater than the angular aperture of selected individuals (Bitterlich 1948). Trees were measured systematically in transects that crossed large vegetation patches. 'Quantity' evaluates the percentage of green areas occupied by forest cover (Forest Cover-based Quantity - FCQ) in relation to the total green area. As a reference value, 50% of the area to be occupied by forest cover were considered (Nucci and Presotto 2009; Figure 3b). Forest cover was inventoried using satellite images and field work.

In turn, ‘density’ (DEN) expresses the relation between a green area and the estimated human population size of an urban neighbourhood. For this, the number of plots was multiplied by the average number of household residents (according to the IBGE census of 2015). Then, density was calculated as the ratio between total green area divided by the estimated population. Taking into account the lack of a global or regional density number the fuzzification shown in Figure 3c were adopted. After the fuzzification step, a rule base was constructed, which consisted of a set of conditional propositions defined by the form “IF – THEN” (Bressane et al., 2016). In the proposed model, 64 *modus ponens* rules were created, combining linguistic values of input variables, such as in:

if ‘FSQ’ is ‘middle’ and ‘FCQ’ is ‘good’ and ‘DEN’ is ‘optimum’
then ‘GCA’ is ‘adequate’.

For the mathematical treatment of rule base propositions, a Mamdani-type fuzzy inference system was used, adopting the ‘max-min’ relational composition (Mamdani and Assilian, 1975). Using the architecture presented in Figure 2, modelling produces recommended ratios for green areas, varying from 20% to 50%. The conversion of fuzzy outputs to a crisp value was performed by the centroid method (Barros et al. 2017, Bressane et al., 2017a). Figure 3d presents the fuzzification of this output, normalized to range $[0, 50]$.

Case Studies and data collection

As empirical research, case studies were performed to validate the methodological proposal. For that, the developed methodology were applied to analyse green areas in urban neighborhoods of a middle-sized city (Sorocaba), São Paulo State, Brazil. Sorocaba occupies an area of 448.9 km^2 and has an estimated population of 644,919 inhabitants (IBGE 2015). The municipality is located in a transitional ecoregion between the Atlantic Forest (mostly Semideciduous Seasonal Forest) and the Cerrado (Brazilian Savanna). The sample size was calculated based on the total urban area, using the population proportion method (Montgomery and Runger 2011), this resulted in including 70.4% of municipal territory. Thus, seeking a confidence level of 95% and an error margin of 2%, the resulting sample size was 1,597 ha. To select the neighborhoods approval plans for the urban development project were analysed and then only urban neighborhoods larger than 30 ha were selected. So the sample dataset included 30 urban neighborhoods (Table I and Figure 4), with a total area of 1630.73 ha (a larger area than the minimum, described above). A field survey was carried out in the first half of 2018. Based on on-site observations, the green area of each urban neighbourhood was delimited on a map, and then forest cover was measured using aerial images acquired in 2018.

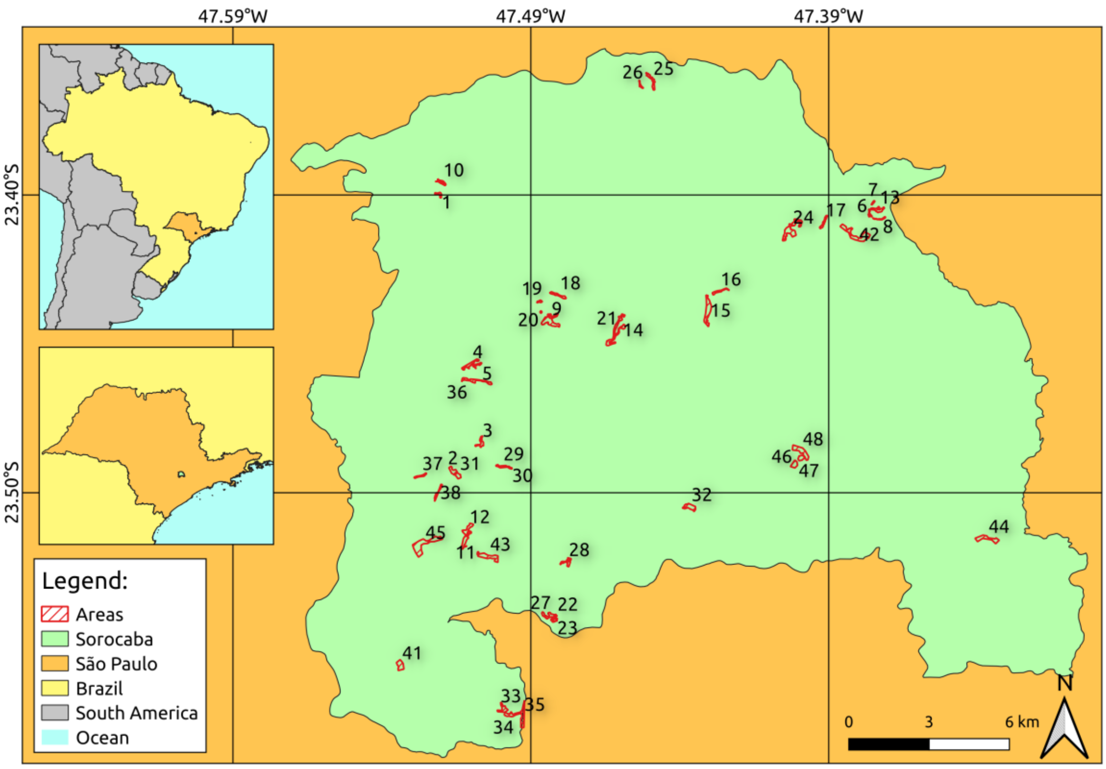

Fig. 4. Urban neighborhoods analysed as case studies.

Tab. 1. Urban neighborhoods selected for the sample dataset.

Index**	Urban neighborhoods	TA (ha)	NL (un.)	PGA (%)	DGA (m^2)	DEN (m^2/inh)
31	Pq. Leonanrdo Kehdi 1	34.67	1,173	8.92	30,923	8.09
15	Jd. Montreal	36.76	1,294	11.47	42,165	10.00
8	Jd.Wanel Ville V	57.67	2,044	11.59	66,839	10.03
13	Jd. Califórnia	38.05	1,332	19.54	74,344	17.12
32	Jd. Prestes de barros	57.81	1,212	13.73	79,378	20.09
11	Jd. Golden Park Residence*	35.44	635	12.06	42,740	20.65
26	Jd. Sta Esmeralda	58.08	1,570	18.61	108,087	21.12
18	Jd. Piazza Di Roma (2nd phase)	38.28	871	16.13	61,744	21.74
20	Jd. Piazza Di Roma	43.76	970	15.83	69,266	21.90
27	Pq. Res. Horto Florestal*	59.58	1,569	24.93	148,540	29.04
9	Jd.Wanel Ville IV	42.68	1,130	25.08	107,050	29.06
6	Pq. Esmeralda	53.91	1,045	19.33	104,198	30.59
5	Jd. Pagliato	36.44	497	14.12	51,455	31.76
42	Jd. Terras de São Francisco*	36.69	900	28.48	104,505	35.62
12	Jd. Ipanema Ville	48.73	1,291	35.57	173,343	41.19
21, 22, 24	Jd. Nilton Torres	38.51	1,007	37.20	143,252	43.64
43	Pq. Res. Villa dos Ingleses*	64.18	1,070	25.03	160,654	46.06
38, 39, 40	Jd. Res. Mont Blanc*	39.51	560	21.60	85,337	46.74
25	Jd. Paulista	45.48	898	40.44	183,929	62.83
30	Pq. Ibiti Royal Park*	77.26	1,177	32.42	250,477	65.28
16	Jd. Vale do lago*	42.25	205	11.24	47,486	71.06
29	Pq. Ibiti Reserva*	70.44	1,032	38.29	269,730	80.17
46, 47, 48	Pq. Res. Chácara Ondina*	53.54	596	38.26	204,852	105.43
44	Jd. Terras D`Oro*	37.73	191	19.62	74,022	118.88
34	Jd. Res. Campos do Conde II*	53.10	464	45.60	242,152	160.09
33	Jd. Res. Campos do Conde*	33.94	312	48.43	164,384	161.62
45	Jd. Res. Saint Patrick*	55.30	265	27.03	149,468	173.02
2 ,3, 4	Pq. Reserva faz. Imperial*	100.00	359	27.29	272,900	233.18
36, 37	Castello 90*	205.40	698	31.82	653,579	287.23
41	Jd. Solar do Bosque*	35.54	206	16.67	59,241	88.21

*Gated community; TA - Total area of urban neighbourhood; NL - Number of lots; PGA – Percentage of green area; DGA - Dimensions of green area; DEN – green area per inhabitant. Source: developed by the authors. ** Index of the study areas, as numbered in Figure 4.

Data analysis

Firstly, agglomerative hierarchical clustering, based on FSQ, FCQ and DEN variables, using Euclidean distance as the dissimilarity measure, and agglomeration based on Ward's minimum variance method (Ward 1963, Fengler et al. 2017), were applied to split the data into two groups: (Group 1) urban neighborhoods with green area in critical condition; and (Group 2) urban neighborhoods with green area in ideal condition. To achieve this, a cut-off was established by defining the largest width range among these two groups formed in the dendrogram (Figure 5).

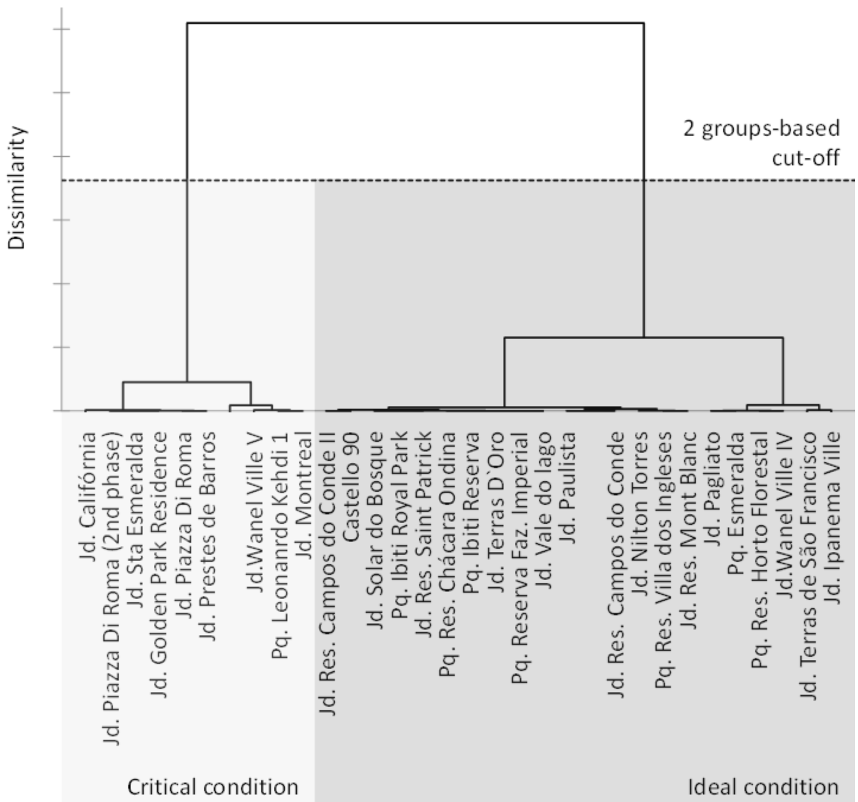

Fig. 5. Urban neighborhoods clustering with regard to condition of green areas.

After verifying by the Shapiro-Wilk test that some model variables does not follow a normal distribution (p-value < 0.05), non-parametric techniques were applied with a significance of 5%. Then the Kruskal-Wallis test and multiple pairwise comparisons using the Conover-Iman procedure were performed to test the following research hypotheses: H_0: the green area condition recommend by FES is not different from one in Group 1 (critical condition) or is not equal to one in Group 2 (ideal condition); H_A: the green area condition recommend by FES is different from one in Group 1 (critical condition) and is equal to one in Group 2 (ideal condition). Thus, if the computed p-value is lower than the significance level (0.05) the null hypothesis H_0 should be rejected, and the alternative hypothesis H_A should be accepted. IF the H_A is accepted, then the FES should be considered a promising alternative to deal with uncertainties in the analysis of green areas in urban neighborhoods.

Results

From the case studies, Table 2 presents the condition of green area (CGA) recommended as adequate by the fuzzy expert system (FES) for the urban neighborhoods and the current CGA, that exist in each neighbourhood. As a result from the agglomerative hierarchical clustering, the Figure 5 presents a classification of the neighborhoods according to the condition of the green areas, in which it can be seen that the most of the gated communities had similar condition. Figure 6 show the findings from the multiple pairwise comparisons with regard to condition of green areas in the urban neighborhoods, pointing out that the green area condition recommend by FES is different from one in Group 1 (critical condition) and is equal to one in Group 2 (ideal condition). Therefore, one should reject the null hypothesis H_0, and accept the alternative hypothesis H_A.

Discussion

The findings indicate the FES produced outputs consistent with the expected, as discussed below. The case studies included 16 gated communities and 14 open neighborhoods. Gated communities comprised 1000 ha, of which an average of 28.04% was allocated to green areas, equivalent to 107.6 m^2/inhab. Conversely, open neighborhoods comprised 630.8 ha, with a natural site coverage of 20.54%, corresponding to 26.37 m²/inhab. Analysing Table 2, findings showed that in 17 of the 30 analysed neighborhoods the current CGA were worse (in terms of density, quantity and quality) than FES recommendation, pointing out that there is a need to restore 56.7% of forest cover in these 17 neighborhoods.

Tab. 2. Green areas recommended as adequate by the fuzzy expert system (FES).

Urban neighborhoods	Input Variables			FES Output	Current
	FCQ	FSQ	DEN	CGA (%)	CGA (%)
Ideal scenario	1.00	10.00	50.0	20.00	20.00
Jd. Paulista	0.66	9.99	50.0	20.06	40.44
Jd. Res. Campos do Conde	0.96	9.99	50.0	20.06	48.43
Pq. Res. Horto Florestal	0.60	10.00	29.0	20.93	24.93
Jd. Terras de São Francisco	0.46	8.78	36.0	22.78	28.48
Jd. Nilton Torres	0.48	8.45	44.0	23.13	37.20
Jd. Pagliato	0.73	8.05	32.0	23.45	14.12
Jd. Piazza Di Roma	0.94	9.99	22.0	23.52	15.83
Pq. Res. Villa dos Ingleses	0.35	8.72	46.0	23.60	25.03
Jd. Solar do Bosque	0.84	7.66	50.0	23.66	16.67
Jd. Ipanema Ville	0.35	7.41	41.0	23.75	35.57
Pq. Ibiti Royal Park	0.52	7.41	50.0	23.76	32.42
Jd. Res. Mont Blanc	0.80	7.41	47.0	23.76	21.60
Jd. Res. Saint Patrick	0.59	7.41	50.0	23.76	27.03
Jd. Prestes de Barros	0.82	9.96	20.0	23.85	13.73
Jd.Wanel Ville IV	0.62	8.05	29.0	24.13	25.08
Pq. Esmeralda	0.28	8.45	31.0	24.76	19.33
Pq. Res. Chácara Ondina	0.56	6.62	50.0	26.00	38.26
Jd. Piazza Di Roma (2nd phase)	0.81	7.41	22.0	27.29	16.13
Pq. Ibiti Reserva	0.89	6.21	50.0	27.52	38.29
Jd. Terras D`Oro	0.28	5.84	50.0	28.56	19.62
Jd. Sta Esmeralda	0.44	8.05	21.0	28.94	18.61
Jd. Califórnia	0.77	7.41	17.0	29.03	19.54
Pq. Reserva Faz. Imperial	0.62	5.50	50.0	29.42	27.29
Jd. Vale do lago	0.76	5.33	50.0	29.84	11.24
Pq. Leonanrdo Kehdi 1	0.52	8.45	08.0	30.63	8.92
Jd. Golden Park Residence	0.38	7.41	20.0	31.21	12.06
Jd. Montreal	0.80	7.41	10.0	31.60	11.47
Jd. Res. Campos do Conde II	0.12	3.10	50.0	36.86	45.60
Castello 90	0.08	3.59	50.0	37.64	31.82
Jd.Wanel Ville V	0.52	3.59	10.00	43.90	11.59
Critical scenario	0.00	1.00	0.00	50.00	0.00

FCQ - Forest cover-based quantity; FSQ - Forest stage-based quality; DEN - Density; CGA – Condition of Green Area. Source: developed by the authors.

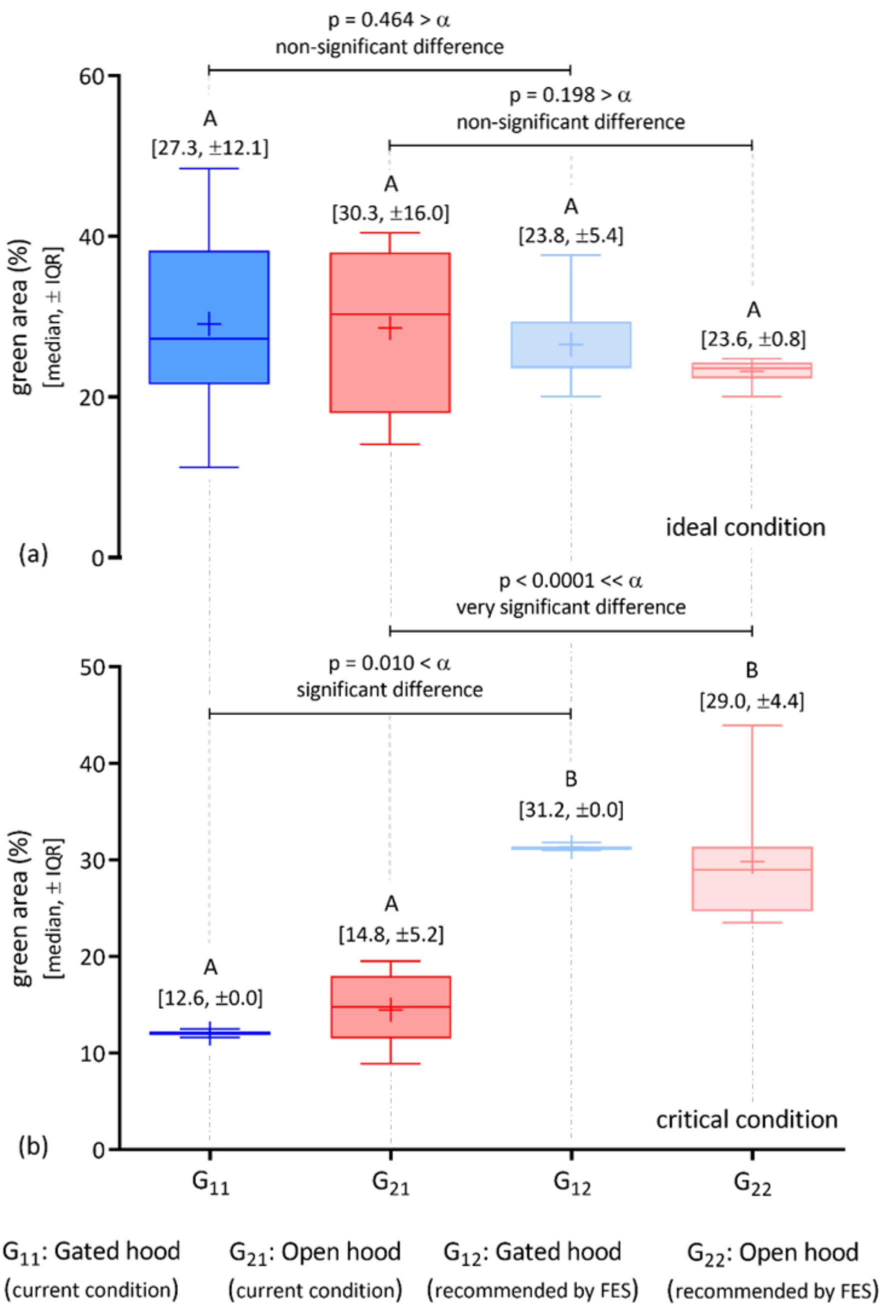

Fig. 6. Comparative analysis between condition of green areas, (a) ideal and (b) critical, and Fuzzy Expert System (FES) recommendation. Groups (G_{ij}) with same letter do not differ at 5% probability.

Most of these neighborhoods with green areas of lower quality than the FES recommendation (Jd. Sta Esmeralda, Jd. Califórnia, Pq. Leonanrdo Kehdi 1, Jd. Montreal, and Jd.Wanel Ville V) are urban open neighborhoods, which correspond to low income neighborhoods. On the other hand, gated communities accounted for 70% of neighborhoods where the percentage of green areas was better than the one recommended by the FES.

Thus, gated communities present green areas with better conservation condition than open neighborhoods, as observed by Byrne and Wolch (2009) in Europe. According to these authors, well conserved green areas are more frequent in wealthy regions. There are inequalities in the distribution of green areas and recreational spaces in the urban environment (Anguelovski 2015) and marginalized regions, especially poor neighborhoods, have less access to leisure spaces, recreation, and parks (Rupprecht and Byrne 2014).

From the outcomes in Figure 6, as the alternative hypothesis H_A was accepted, the FES should be considered a promising alternative to deal with uncertainties in the analysis of green areas in urban neighborhoods. The fuzzy system was consistent in recommending higher percentages of green areas to neighborhoods with lower forest cover (FCQ). For example, Jd. Paulista, with high quantity, quality and density of green areas, had a FES-based green area recommendation that was lower (20.06%) than its current condition (40.44%). This additional area is explained by a Brazilian legal requirement for permanent preservation areas to be associated with water bodies (Forest Code, Law 12651: Brasil 2012). On the other hand, Jd. Wanel Ville V neighbourhood had green area of low quality and density, which explained its 11.59% current condition and the recommendation to increase tree cover to 43.9%. Current condition of green areas in both gated communities and open neighborhoods were significantly lower than fuzzy-based recommendation in the cases in critical condition (p-value = 0.358; Figure 6); moreover, for the cases in ideal condition, the current green areas and the on recommended by FES did not differ (p-value < 0.05).

From the integrated analysis of parameters of quantity, quality and density of the existing vegetation, the proposed model allows classifying the condition of an urban green area at different levels of suitability for local characteristics. Based on this classification, the model can support public and private managers in proposing and analysing the feasibility of projects that impact urban green areas. For example, based on a case-by-case assessment using the proposed model, the authorization for new constructions can be conditioned to measures of adequacy of the green area at the project site.

Take measures to guarantee adequate treatment of green areas is a fundamental issue in planning healthy cities. As a management tool, the proposed model can support decision-making in the urban planning process. The municipal public administration can use the results from the model to justify the adoption of local quantitative and qualitative parameters in determining urban guidelines related to the minimum percentage of green areas destined to leisure, recreation and preservation of natural attributes. Thereby, we believe that the proposed methodology can contribute as an applied management tool for assessing and improving environmental quality in urban neighborhoods.

According to the obtained results, it is worth highlighting some novelty and usefulness of the present study. Firstly, the current decisions about the percentage of green area in urban settlements do not consider indicators like the succession stage, the forest cover, and the human population size in the urban neighbourhood. In this context, the introduced model, assessed and discussed in the light of presented study cases, comprises an alternative approach that yields systematic decision-making based on a multi-criteria analysis over the indicators mentioned above. The second novelty lies in the fuzzy artificial intelligence concepts employed to model the decision-making system applicable to green areas management, capable of case-by-case analysis rather than standardized and/or arbitrary decisions.

The proposed fuzzy artificial intelligence-based system offers a convenient mathematical treatment concerning the information/indexes that embraces the discussed decision-making process. Since such indicators comprise continuous variables, it naturally imposes difficulties on the choice of hard thresholds towards the transitions of classes (i.e., bad, regular, good, and very good, for instance).

Consequently, using an Artificial Intelligence approach based on soft transitions rises as a prominent approach, as verified in the presented study cases. For further advances in future studies, the proposed model can be compared with other soft computing approaches, aiming its continuous improvement as a tool for managing urban green areas.

Conclusions

Disorderly urban expansion has impacted the environmental quality of cities, requiring tools capable of supporting managers in the correct conservation of green areas. On the other hand, the uncertainties involved in the case-by-case analysis of green areas make it difficult to define the ideal conditions for proper conservation. There is a trend in the real estate market to expand urban occupations by maximizing the percentages of commercial areas, associated with entrepreneurs' desire to decrease the percentages of green areas under the allegation of reducing real estate costs. However, the indiscriminate reduction of green areas can compromise the quality of life of its future residents. They will not have the option of practicing leisure, recreation and offering environmental services provided by such areas. This study introduced a fuzzy expert system (FES) as tool for analysing the condition of green areas in urban neighborhoods. The findings indicate the FES produced outputs consistent with the expected. Thereby, as the main contributions of this study, they can be highlighted: (i) fuzzy modelling of indicator variables of green area condition based on expert knowledge; (ii) a novel fuzzy-based tool capable of dealing with uncertainties; and (iii) a promising approach for a case-by-case analysis applied to green area management in urban neighborhoods.

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5 MINUTA DE ARTIGO

Public Willingness-to-Pay for Urban Green Spaces: Prospects Towards Healthier Cities

Abstract

Statement of problem. Urbanization poses a global challenge as cities expand, leading to the potential degradation of urban green spaces (UGS). Research gap. Although various studies emphasize the importance of UGS, there is a gap in comprehending how public percep-tion, specifically regarding health benefits, influences WTP for UGS, particularly in de-veloping nations like Brazil. Purpose. This gap hinders effective urban planning and policy formulation. The study aims to investigate this potential association between WTP and perceived benefits. Method. The research employed an online survey with 2597 respond-ents in Brazilian metropolitan areas. The perceived benefits were measured using a Likert scale and employing the contingent valuation method to determine WTP. Welch's ANOVA, Games-Howell post-hoc, Cohens' d, and Pearson's χ^2 tests were applied to analyze the data. Results and conclusions. Respondents demonstrated overall awareness of UGS health benefits, with mental and respiratory health garnering strong agreement. The WTP for UGS maintenance, reflected in an 8.7% increase in annual property taxes, un-derscores the substantial valuation of UGS. Income emerged as a notable factor influ-encing WTP, with landscaping having the most significant impact. Practical implications. The study advocates for an integrated and strategic approach to UGS planning, empha-sizing safety, mental and respiratory health benefits, and equitable access. Policymakers are urged to allocate resources for UGS development, considering the economic and social value highlighted by significant WTP. Future directions. Further research could delve into the relationship between income and WTP, exploring strategies for inclusivity and ac-cessibility of UGS. Additionally, studies could assess the effectiveness of awareness programs to enhance public support for UGS.

Keywords. Urban green spaces, willingness-to-pay, health benefits, urban planning.

Introduction

Urbanization indeed emerges as a global challenge. As cities expand, urban populations are surpassing their rural counterparts in numerous regions worldwide. Projections of United Nations (2018) indicate that around 68% of the world's population will reside in urban areas by 2050. As a potential adverse effect, the growth of built-up areas can threaten the preservation of urban green spaces (UGS), causing both the degradation of natural ecosystems and the deterioration of the quality of life (Rameli et al., 2019).

UGS encompass areas with vegetation, free from structural development, yet may include infrastructure and facilities for leisure and recreation (Nieuwenhuijsen et al., 2021). Due to their multifunctional capacity, encompassing ecological functions and a significant social role, UGS serves as a strategic alternative for urban land management (Rigolon et al., 2018; Klompmaker et al., 2018; Kroll et al., 2019; Enssle and Kabisch, 2020). Gómez-Baggethun et al. (2018) emphasize that ecosystem services offered by UGS play a crucial role in social cohesion, integral to modern urban planning. In turn, the positive impact of UGS on public health is corroborate by an extensive body of literature, demonstrating benefits to blood pressure (Yang et al., 2019), sleep quality (Xie et al., 2020), respiratory health (Wu et al., 2020), cardiovascular diseases (Liu et al., 2021), as well as alleviating stress, depression, and anxiety (Shan et al., 2020; Liao et al., 2020; Bressane et al., 2022).

Tian et al. (2020) point out the growing focus of urban planners and policymakers on the society's willingness-to-pay (WTP) for UGS conservation. Delving into this issue, Chen et al. (2020) focus on the lack of public awareness of UGS benefits in developing countries, and emphasize the need to explore its relationship with WTP. In this context, Zhang et al. (2020) also highlight the significance of public perception in the decision-making process. The authors found that perceived benefits, such as improved air quality, have an impact on WTP. On the other hand, Sabyrbekov et al. (2020) found that heightened nature awareness does not invariably translate to increased WTP. The study discusses that factors such as income and education constrain WTP for UGS provision.

Dinda and Ghosh (2021) assessed WTP across diverse sociodemographic profiles in India, revealing that gender, age, education, and economic status impact preferences and WTP for UGS. In Juliaca, Peru, Mamani et al. (2021) identified family income, education, proximity, and visit frequency as influential factors in WTP for UGS recovery and conservation. Idris et al. (2022) highlighted public perception, knowledge of UGS functions, and marital status in Padang, Indonesia, affecting WTP. Luo et al. (2022) observed over half of surveyed participants in China expressing WTP for UGS, emphasizing perceived health benefits, particularly mental health. Cheung et al. (2022) explored WTP among Hong Kong residents, revealing the impact of positive and negative perceptions correlated with education levels and age groups, emphasizing the importance of understanding WTP for effective urban management aligned with citizens' expectations.

In light of these studies, the evidence supporting the importance of UGS in cities is undeniable. However, a deeper understanding on how the public perception regarding the health benefits affect the WTP by UGS remains underexplored, especially in developing countries like Brazil (Zhang et al., 2019;

Lynch, 2021; Bressane et al., 2022). To bridge this gap, the present study in Brazil aims to verify the research hypothesis that there is a significant association between WTP for UGS and the perceived public health benefits. Thus, this research sought to expand the evidence from earlier studies, providing the following contributions to the field:

(*i*) addressing a critical knowledge gap - the research fills a gap by investigating public awareness and WTP for UGS, particularly in non-developed countries like Brazil;

(*ii*) international relevance - the findings are not limited to Brazil and have broader relevance for urban areas in non-developed countries facing similar challenges;

(*iii*) strong awareness of UGS health benefits - the study underscores that a majority of respondents are well aware of the benefits, with a specific emphasis on mental health;

(*iv*) key influence of income - income is identified as a crucial factor significantly affecting WTP for UGS, a significant implication for urban planners and policymakers;

(*v*) public support for UGS investment - despite concerns about high taxes, respondents expressed a notable WTP, reinforcing the strong perception on their importance;

(*vi*) importance of safety concerns: the study verified the need to address safety concerns associated with UGS to fully realize their health and wellbeing potential.

Material and method

Following the procedure that complies with ethical requirements, approved under Process #57365022.2.0000.0077, data were collected through an online public survey with residents in metropolitan urban regions in Brazil, totaling a sample size of 2597 respondents (Table 1).

Table 1. Sociodemographic profile of respondents (n = 2.597).

gender [identity]	age group [years old]	income [min. wage]	education [level]	home [type]	UGS [proximity]
male 43.8%	young [18, 25[48.7%	lower) [0, 2[28.0%	elementary 1.0%	apartment 39.9%	nearby 79.2%
female 55.3%	adult [25, 45[34.6%	lower-middle [2, 4] 22.5%	high-school 45.2%	house 60.1%	far away 20.8%
non-binary 0.9%	middle-age [45, 60[12.3%	middle]4, 10] 33.0%	university 53.8%		
	elderly [60, +∞[4.5%	higher-middle]10, 20] 12.0%			
		higher [20, +∞) 4.4%			

The survey form was organized into two main sections: (*i*) perceived benefits provided by UGS; and (*ii*) contingent valuation, regarding the WTP for an annual amount to support UGS maintenance. In the first section, respondents were asked to rate their agreement with the capability of UGS in promoting physical health (sleep quality, breathing, cardiovascular problems, blood pressure), mental health (stress, anxiety, depression), and social health (feeling of security, social interaction, communication between neighbors). For this, a five-point Likert scale was used, considering: 1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, and 5 = strongly agree. In the final section, questions were formulated according to the contingent valuation method (CVM), one of the most commonly used methods to estimate the value of environmental services, based on data collected through surveys (Guo et al., 2020).

Following standard guidelines to ensure validity and reliability of the results (Johnston et al., 2017), the CVM was based on the payment card approach.

This approach is widely used to determine monetary values in a simple, efficient, and conservative manner with sequential bidding, thereby avoiding starting point bias that can sometimes result from bidding games and dichotomous decisions (Withey et al., 2019). When asked about their WTP for specific annual costs to support the maintenance of the UGS, the amount was framed as an increase in property taxes. Respondents were then prompted to choose the highest amount of property tax increase they would be willing to report annually as their WTP, taking into account the inclusion of infrastructure items in the UGS: afforestation with walking path, landscaping, water mirror (as a small lake), playground, gym equipment, sports courts, skating rink, and amphitheater (Figure 3). For the contingent valuation, all amounts were measured in Brazilian real currency (R$). A payment card consisted of 8 levels of WTP based on tax increase (none, R$1.00, R$3.00, R$5.00, R$10.00, R$30.00, R$50.00 and R$100.00).

Assuming a sample size (n = 2597) sufficiently large to meet sample means approximately normally distributed, as stated by Central Limit Theorem (Mwiti et al., 2019), parametric tests were applied for numerical dependent variables using Welch's ANOVA with Games-Howell post-hoc test. The effect size (d_{Cohen}) was measured considering the greatest difference between means based on Cohen's d formula, given by:

$$d_{Cohen} = \frac{\mu_{i+1} - \mu_i}{\sqrt{\frac{(n_{i+1} - 1)\sigma^2{}_{i+1} + (n_i - 1)\sigma^2{}_i}{n_{i+1} + n_i - 2}}}$$

where, n, μ, and σ are the sample size, mean and standard deviation of the i^{th} group, respectively. As per Funder and Ozer (2019), an effect size of around 5% (rho ≤ d < 7.5%) indicates a very small effect, approximately 10% represents a small effect (7.5 ≤ d < 15%), 20% signifies a medium effect (15 ≤ d < 25%), around 30% reflects a large effect (25 ≤ d < 35%), and approximately 40% or greater (d ≥ 35%) indicates a very large effect size. All analyzes considered a test power (1 − β) of 0.8 for a significance level (α) of 0.05, and a minimum detectable effect size (rho) of 7%, determined by G*Power software (Faul et al., 2013).

Results

Overall, the majority of respondents demonstrated awareness of the health benefits provided by UGS (Figure 1). Social health had the largest proportion of respondents who disagreed (or strongly disagreed) with the perceived benefits. In particular, the perception that green spaces are places where acts of violence or crimes can occur if not properly supervised by authorities impacted the perception of security benefits, which obtained the highest rate of disagreement (15.6%).

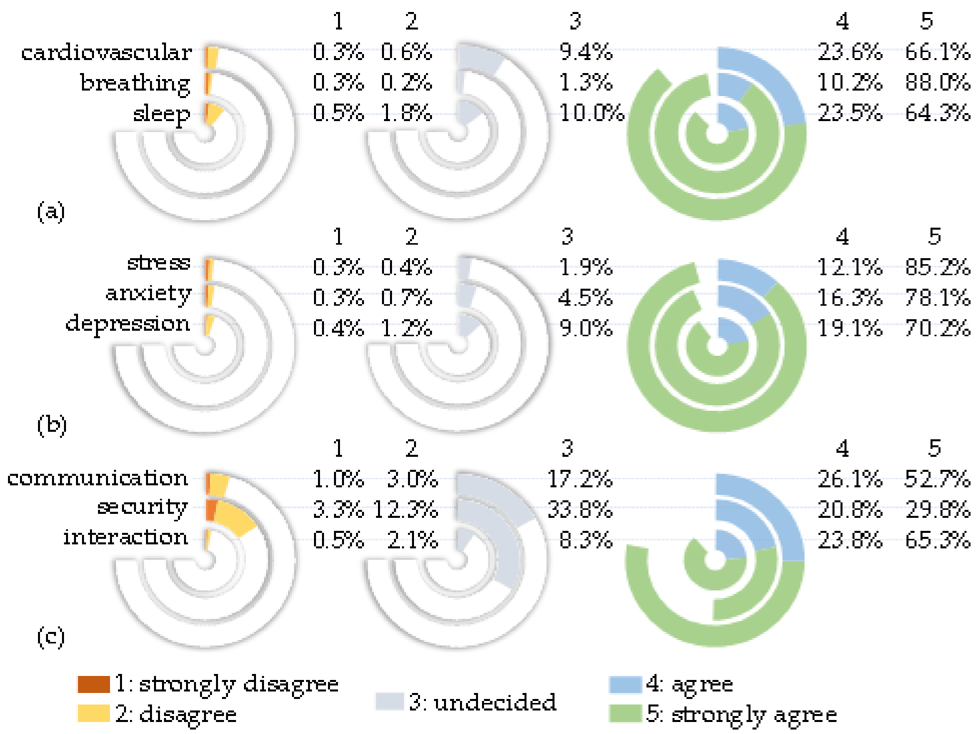

Figure 1. Perceived benefits provided by UGS: (a) physical, (b) mental, and (c) social health.

In contrast, mental health had the highest proportion of respondents who strongly agreed with the perceived benefits, particularly in relation to stress (85.2%) and anxiety (78.1%). The benefit for breathing also stood out (88.0%), a perception possibly associated with the prospect of improving air quality linked to the presence of green spaces.

The WTP for each infrastructure item in UGS ranged from R$11.20 (skating rink) to R$15.90 (landscaping), with the accumulated value for all items totaling R$107.80, reflecting an increase in annual property taxes (Figure 2).

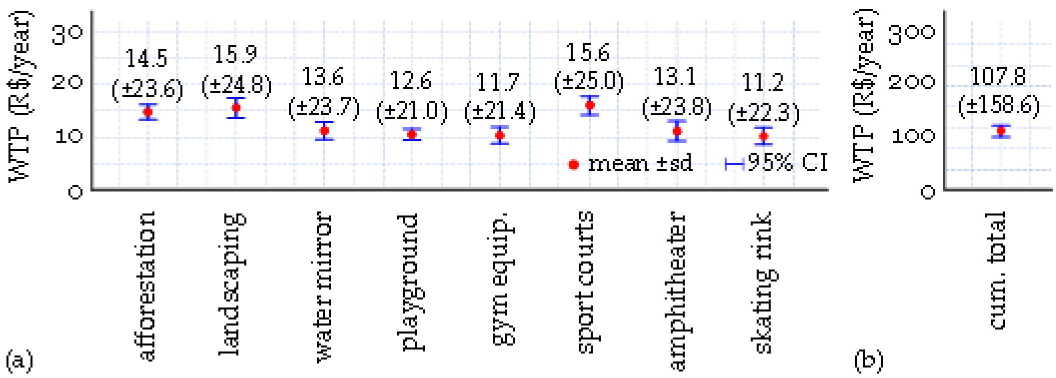

Figure 2. Willingness-to-pay for UGS: (a) by infrastructure item, (b) total accumulated.

With the average annual property tax declared by respondents being R$1,237.50, the total accumulated value of the WTP for UGS represents an 8.7% increase in this annual tax. Given the respondents' concerns about the already high tax burden in Brazil, this WTP reflects a significant valuation of UGS. While most factors associated with the socio-demographic profile showed no significant effect on WTP for UGS, income ($p < 0.01$) had an almost 25% effect, with landscaping (27.0%) emerging as the infrastructure item with the largest impact (Table 2 and Figures 3 e 4).

Table 2. Effect of sociodemographic profile on WTP for UGS.

	gender (identity)	age (group)	income (family)	education (level)	home (type)	UGS (closeness)
afforestation	4.23%*	11.7%*	24.8%*			
landscaping	7.42%*	14.8%*	27.0%*	6.37 %*		
water mirror	7.92%*		21.4%*			
playground	5.02%*	12.8%*	21.3%*			
gym equipment	2.00%*	11.7%*	18.9%*			
multisport courts	6.71%*		20.0%*			
amphitheater						
skating rink	4.98%*		8.17 %*			
cumulative total	6.11%*		24.6 %*			

* $p < 0.05$; gray cell = non-significant effect; red = potential effect less than the minimum detectable; orange = very small effect; yellow = small; green = medium; light blue = large effect; and dark blue: very large effect size.

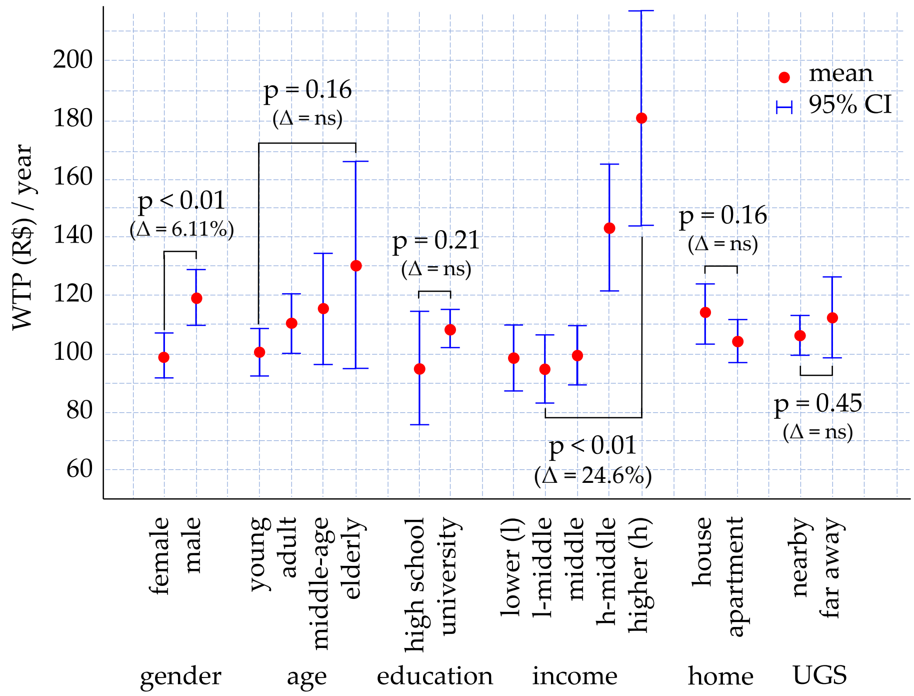

Figure 3. Sociodemographic profile factors and total WTP for UGS.

Table 3. Effect size of perceived public health benefits on WTP for UGS.

	sleep	breathing	cardiovascular	stress	anxiety	depression	security	interaction	communication
afforestation	22.1%*		34.4%*	20.8%*	19.6%*	11.8%*	16.6%*		24.2%*
landscaping	25.1%*		22.7%*	24.0%*	20.4%*	12.0%*	15.6%*	18.6%*	15.6%*
water mirror	26.9%*	28.2%*	13.5%*	19.2%*	15.9%*	8.87%*	16.0%*	16.2%*	16.1%*
playground	17.9%*	29.4%*	5.76%*	15.6%*	14.1%*	24.3%*	16.3%*	18.2%*	28.6%*
gym equipment	48.2%*	34.5%*	20.4%*	28.6%*	24.6%*	11.8%*	20.2%*	16.7%*	20.4%*
multisport courts	26.6%*	34.7%*	32.4%*	30.6%*	30.9%*	10.0%*	12.2%*	16.2%*	19.8%*
amphitheater	28.9%*	30.7%*	31.7%*	29.9%*	23.7%*	27.2%*	21.4%*	18.8%*	24.5%*
skating rink	26.6%*	29.8%*	6.53%*	21.7%*	20.3%*	11.6%*	19.1%*	16.3%*	27.4%*
cumulative total	28.7%*	29.0%*	21.8%*	25.7%*	23.1%*	14.2%*	20.7%*	18.9%*	24.5%*

* significant effect at $p < 0.05$; gray cell = non-significant effect; red = potential effect less than the minimum detectable; orange = very small effect; yellow = small; green = medium; light blue = large effect; and dark blue: very large effect size.

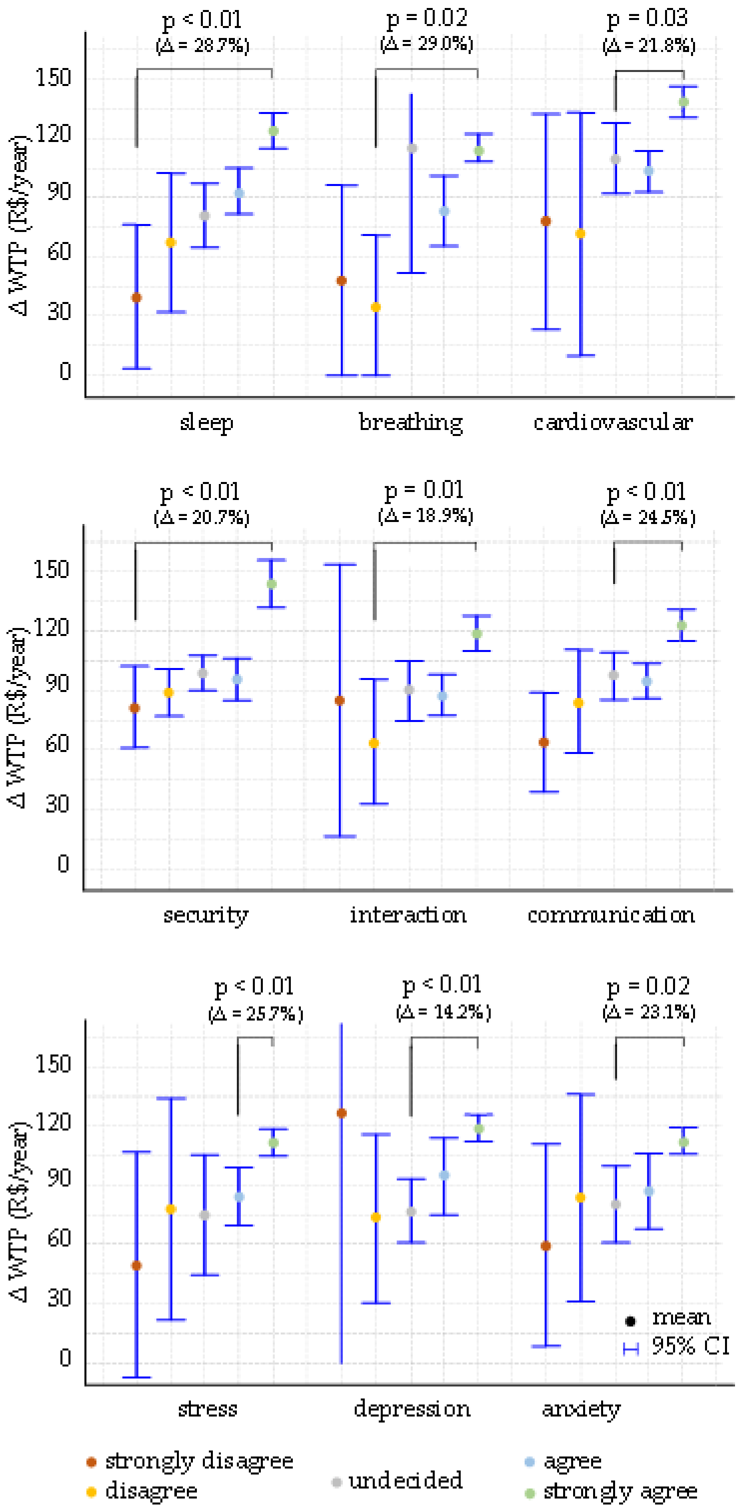

Figure 4. Perceived public health benefits and variation (Δ) in WTP for UGS (cumulative total).

Considering the total accumulated value of property tax increase, all health benefits had a significant effect on WTP, ranging from 14.2% (depression improvement) to 29.0% (breathing). The most substantial effect was observed for sleep improvement, contributing to a 48.2% increase in WTP for gym equipment. Improved sleep and stress also had a large effect on the accumulated total, while other perceived public health benefits demonstrated a medium effect ($15 \leq d_{Cohen} <$ 25%).

Discussion

Despite the overall awareness of health benefits associated with UGS, the study reveals varying perceptions across different health aspects. Social health stands out with a substantial number of respondents expressing disagreement, particularly regarding security concerns. In consonance, Branas et al. (2011) delve into the intricate relationship between green spaces, crime reduction, and public health, emphasizing the need to address safety concerns to fully harness the health and well-being potential of UGS.

Conversely, respiratory and mental health, respectively, focusing on improved breathing, stress and anxiety reduction, garnered strong agreement from respondents regarding the perceived benefits. This underscores the recognized positive impact of UGS on mental wellbeing and air quality enhancement. Aligned with our results, Dzhambov et al. (2018) established a correlation between green space exposure and reduced perceived stress, while Markevych et al. (2017) highlighted UGS's role in reducing air pollution.

Turning to WTP for UGS maintenance, respondents expressed varying levels of willingness for different infrastructure items. The total accumulated value for all items, totaling R$107.80, equivalent to a significant increase in annual property taxes, reflects a substantial valuation of these spaces. This aligns with Lategan et al. (2022), emphasizing the economic and social value of green spaces and reinforcing their significance to urban residents.

Analyzing sociodemographic factors, income emerged as a notable influence on WTP, impacting it by almost 25%. Notably, landscaping emerged as the infrastructure item with the most substantial effect among respondents. While the association between income and proximity to UGS was not statistically significant, a higher proportion of higher-income respondents tended to live closer to green spaces, echoing findings by Wolch et al. (2014) on income disparities in access to urban green spaces. These findings underscore the importance of addressing equity in UGS planning and development to ensure widespread access and benefits.

The present study confirms the research hypothesis that the WTP for UGS is significantly associated with perceived public health benefits. The findings revealed a public awareness of the health benefits associated with UGS, emphasizing the need to address safety concerns, the substantial valuation of UGS, and the influence of income on WTP. These insights have direct implications for shaping strategies to enhance the role of UGS in city planning and health policies.

Prospects Towards Healthier and Sustainable Cities

As a practical implication, the study underscores the need for an integrated and strategic approach to UGS planning and management. It suggests that initiatives aimed at improving safety, enhancing mental and respiratory health benefits, and addressing equity concerns are crucial. The design of UGS should consider not only aesthetic and recreational aspects but also incorporate features that mitigate safety concerns and maximize health benefits. Furthermore, urban planners should advocate for policies that allocate sufficient resources for the maintenance and development of UGS, given their significant economic and social value. Some more specific recommendations are presented below.

Initiatives to enhance safety should implement targeted programs within UGS to address the perceived security concerns highlighted by respondents. This may include increased surveillance, improved lighting, and community engagement initiatives to create a safer environment. Collaboration with law enforcement and community organizations is crucial to ensure comprehensive safety measures

Design and programming with a health focus should consider the strong agreement among respondents regarding mental and respiratory health benefits. Developing programs and spaces that promote stress reduction, anxiety alleviation, and improved air quality is recommended. Incorporating features such as meditation areas, exercise stations, and adequate greenery can enhance the health and well-being aspects of UGS

Strategies for equitable access should address income-related disparities in both WTP and proximity to UGS. Focus on creating fair access to UGS across various income groups by strategically locating new green spaces in areas with lower-income populations. Consider implementing income-sensitive pricing models or community engagement initiatives to ensure that UGS benefits are accessible to all community members.

Economic valuation advocacy, considering the substantial WTP revealed by the study, to argue for increased financial investment in UGS maintenance. Engage with policymakers to emphasize the economic and social value of green spaces, highlighting their role in enhancing property values and contributing to the overall well-being of urban residents. Allocate sufficient resources to support the conservation and development of UGS.

Public awareness and education programs should be implemented to inform residents about the multifaceted benefits of UGS. Emphasize the positive impact on mental and respiratory health, economic value, and overall well-being. This can enhance public perception, potentially addressing safety concerns and increasing willingness-to-pay. Collaborate with local educational institutions, community organizations, and media outlets to disseminate information effectively.

These recommendations drawn from the present study have far-reaching consequences for the planning and management of UGS. Thus, our findings provide actionable insights that, when implemented, can contribute to the creation of healthier and more sustainable cities, where UGS play a central role in enhancing public health and well-being.

Conclusion

The research hypothesis, positing an association between perceived health benefits and WTP for UGS, finds strong confirmation. This study corroborates the key role of UGS in enhancing public health and the considerable willingness of individuals to invest in their creation and maintenance, even within a context of perceived high tax burdens.

From a practical standpoint, this research provides insights for urban planners and policymakers, emphasizing the importance of prioritizing the conservation and development of UGS. Policymakers can use this information to craft strategies that leverage the multifaceted benefits of UGS while addressing safety concerns. Moreover, the findings suggest that income-related strategies should be considered to ensure UGS remain accessible to individuals across different income groups.

Looking ahead, future research in this area could delve deeper into the relationship between income and WTP for UGS, exploring innovative strategies to enhance inclusivity and accessibility of green spaces for all community members. Additionally, studies could investigate the effectiveness of awareness programs aimed at enhancing public perception and support for urban green spaces. In conclusion, this study contributes to a growing body of knowledge on the pivotal role of UGS in urban planning and the well-being of urban populations.

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6 CONCLUSÕES E RECOMENDAÇÕES

6.1 Principal

A hipótese de pesquisa foi confirmada, pois os benefícios percebidos para a saúde pública tiveram uma influência significativa na disposição a pagar. A maioria dos entrevistados está ciente dos benefícios para a saúde pública proporcionados pelos espaços verdes urbanos, sendo a saúde mental (melhoria na ansiedade e estresse) e a saúde física (respiração) os benefícios mais percebidos. No geral, essas descobertas enfatizam a importância dos espaços verdes urbanos e seu impacto positivo na saúde pública, bem como a disposição das pessoas em investir em sua manutenção e conservação.

6.2 Específicas

Há uma disposição entre os entrevistados para pagar pela manutenção desses espaços verdes urbanos. A associação entre renda e proximidade de espaços verdes urbanos não foi significativa, mas uma proporção maior de entrevistados com renda mais alta mora perto de espaços verdes.

Houve algumas variações na percepção em relação a diferentes aspectos da saúde. A saúde social teve uma proporção maior de entrevistados discordando dos benefícios percebidos, especialmente em relação a preocupações com segurança. Isso sugere que os espaços verdes são associados a possíveis atos de violência ou crimes se não forem devidamente supervisionados. Por outro lado, a saúde física e mental, especificamente em termos de estresse, ansiedade e melhora na respiração, teve uma proporção maior de entrevistados concordando com os benefícios percebidos. Isso indica que há um reconhecimento do impacto positivo dos espaços verdes no bem-estar, qualidade de vida e na melhoria da qualidade do ar.

Em relação à disposição a pagar pela manutenção de espaços verdes urbanos, o valor acumulado para todos os itens listados no formulário totalizou R$107,80, o que equivale a um aumento anual de 8,7% no imposto predial territorial urbano. Ponderando que os entrevistados já consideram que a carga tributária no Brasil é alta, essa disposição a pagar um adicional pode ser vista como uma valoração significativa dos espaços verdes urbanos, apesar do valor parecer ser baixo.

Entre os fatores sociodemográficos analisados, a renda teve um efeito significativo na disposição a pagar. Especificamente, o paisagismo teve o maior efeito entre os itens de infraestrutura. No entanto, a associação entre renda e proximidade de espaços verdes urbanos não foi estatisticamente significativa para uma análise aprofundada, embora uma proporção maior de entrevistados com renda mais alta tendesse a morar mais perto de espaços verdes em comparação com aqueles com renda mais baixa.

Todos os benefícios para a saúde examinados tiveram um efeito significativo na disposição a pagar, com diferentes graus de influência. A melhoria do sono teve o maior efeito na disposição a pagar para equipamentos de academia, enquanto a respiração teve o efeito mais alto no total acumulado. Outros benefícios, como a redução do estresse e a melhoria da depressão, também tiveram um impacto considerável no valor total acumulado da disposição a pagar.

6.3 Recomendações

Com base nas conclusões, sugere-se para pesquisas futuras: (i) analisar a percepção dos espaços verdes urbanos em relação à saúde social, explorando associações com preocupações de segurança e considerando o impacto das medidas de segurança na aceitação e uso desses espaços; (ii) investigar a relação entre renda e proximidade de espaços verdes para compreender disparidades socioeconômicas na acessibilidade, orientando políticas para garantir igual acesso a todos; (iii) analisar a disposição a pagar em diferentes contextos geográficos, proporcionando uma compreensão abrangente das preferências relacionadas a espaços verdes urbanos em diversas cidades ou regiões; (iv) avaliar a relação entre benefícios percebidos e impacto real na saúde, incorporando dados objetivos, como medições de qualidade do ar e indicadores de saúde física e mental, para complementar percepções subjetivas; (v) conduzir estudos longitudinais para uma análise mais precisa das mudanças na percepção e disposição para pagar ao longo do tempo, permitindo uma compreensão aprofundada das tendências e efeitos de intervenções específicas nos espaços verdes urbanos. Essas recomendações visam a ampliar o conhecimento sobre a relação entre espaços verdes urbanos, percepção pública e disposição a pagar, proporcionando insights cruciais para o planejamento urbano e a promoção de ambientes saudáveis e sustentáveis.

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