Urban Forestry & Urban Greening 96 (2024) 128356

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug

Exploring perceptions, cognitive factors, and motivations: A study on green structures on residential rooftops

Mahsa Tarashkar [a], Salman Qureshi [b,*], Akbar Rahimi [a]

[a] Department of Urban and Regional planning, Faculty of Planning and Environmental Science, University of Tabriz, Tabriz 5166616471, Islamic Republic of Iran
[b] Institute of Geography (Landscape Ecology), Humboldt University of Berlin, Rudower Chaussee 16, Berlin 12489, Germany

ARTICLE INFO

Handling Editor: Dr Cecil Konijnendijk van den Bosch

Keywords:
Rooftop Greenhouses
Social Motivations
Environmental perception
Urban ecology

ABSTRACT

Urban greenhouse and green roof cultivation propose a nature-based solution to current socio-ecological challenges in urban ecosystems, as it offers several socio-ecological solutions and benefits. The interdisciplinary techniques for scientific explorations of cognition and perception towards urban green structures could not get the attention of the researchers across varying scientific disciplines, especially in the developing world. Addressing the personal factors involved in human cognition and its subsequent impact on perceptions will lay the foundation for the studies of the field. The study included questions about socio-demographic characteristics and socio-environmental motivations, as well as a set of images depicting potential future of green structures. The study was accomplished in Tabriz city of Iran with 375 participants. The findings showed that individuals prioritize certain types of rooftop green structures based on their personal characteristics and motivations. Additionally, cognitive differences were observed among individuals based on age, gender, and marital status, leading to perceptual differences towards green structures. Socio-environmental motivations activate perceptual responses within individuals, influencing their preferences for specific types of rooftop greenhouses. Understanding the response of individuals towards green structure types is crucial for effective planning and design. This knowledge can enhance the overall success and satisfaction of rooftop green structures projects, leading to greater wellness and a positive impact on the environment.

1. Introduction

In recent years, there has been an undeniable shift in the global distribution of human populations. More than half of the world's population currently resides in urban areas, which signifies a significant change in human settlement patterns (UN.DESA, 2019). This ongoing trend of urbanization is not expected to slow down any time soon, as projections indicate that urban populations will continue to rise, potentially reaching even higher figures by the year 2050. The process of rapid urbanization brings with it a multitude of advantages for those who choose to embrace urban living. This has led to a growing attraction towards urban areas, as individuals recognize the benefits that come with residing in cities (Qureshi et al., 2014). One of the key advantages lies in the availability of diverse opportunities for employment, education, and cultural experiences. Urban areas typically offer a wider array of job prospects across various industries, making it easier for individuals to find employment and enhance their career prospects (Cattaneo et al., 2022). Moreover, cities are often recognized as hubs of innovation and technological advancement (Concilio et al., 2019). Urban areas tend to have better infrastructure, higher accessibility to resources, and a wider range of amenities. This makes cities more attractive to those who prioritize convenience and a higher quality of life. In addition to economic and technological advantages, urban areas also foster social connections and cultural diversity. The concentration of people from different backgrounds and lifestyles in cities leads to a rich tapestry of cultures, traditions, and perspectives (Keil, 2015). This diversity not only enhances cultural exchange but also stimulates creativity and innovation, as individuals from different backgrounds come together and collaborate on various projects and initiatives. The escalating trends of urbanization are undeniably linked to the detrimental modification of landscapes, resulting in significant implications that adversely affect diverse ecosystems (Global Asthma Network, 2018; Pauleit et al., 2010; Ritchie, 2018; World Health Organization, 2020). In this context, urban green spaces emerge as invaluable assets that not only contribute to urban sustainability but also enhance the overall well-being of urban residents (Chiesura, 2004; Qureshi et al., 2010,

* Corresponding author.
E-mail address: salman.qureshi@geo.hu-berlin.de (S. Qureshi).

https://doi.org/10.1016/j.ufug.2024.128356
Received 2 November 2023; Received in revised form 19 March 2024; Accepted 29 April 2024
Available online 4 May 2024

Qureshi et al., 2013). Urbanization, characterized by the rapid expansion of cities and urban areas, often leads to the fragmentation and loss of natural habitats (Fernández et al., 2019). As concrete jungles replace green landscapes, the biodiversity and ecological balance are disrupted, with consequences for both human and non-human species (Marselle et al., 2021). The conversion of natural ecosystems into built environments results in the loss of vital habitats for numerous plant and animal species, leading to a decline in biodiversity and potential ecological imbalances (Radić & Gavrilovic, 2021). This not only affects the natural world but also disrupts ecosystem services upon which human societies depend, such as pollination, water purification, and climate regulation (Ayompe et al., 2021). Given these challenges, urban green spaces play a critical role in reducing the negative effect of urbanization on ecosystems. They serve as habitats for plant species and wildlife corridors, fostering connectivity and genetic diversity (Vargas-Hernández et al., 2023). Moreover, urban green spaces increase the resilience of ecosystems by counteracting the urban heat island effect, reducing air pollution, and enhancing water management through natural drainage systems (La Rosa & Pappalardo, 2021). Among these green spaces, urban greenhouses emerge as unique sanctuaries, nestled within the bustling urban landscape. By providing havens for biodiversity and contributing to ecological balance, they serve as miniature ecosystems within the urban sprawl, fostering environmental resilience and sustainability (Khan et al., 2020). Urban greenhouses play an important role in contributing to sustainability by providing miniature ecological sanctuaries within urban areas (Tarashkar et al., 2023). Integrating green structures into urban planning, promoting community engagement and participation in the design and maintenance of these green spaces, and implementing sustainable land management practices can ensure the expansion and preservation of urban green spaces (Khan et al., 2020).

1.1. Perceptions towards green structures

There has been a significant increase in interest surrounding the utilization of green structures in recent years. This approach has gained recognition for its potential to enhance the overall well-being and vibrancy of urban areas, particularly through the integration of green roof technology (Kim et al., 2018).

Scientific studies conducted in different parts of the world have provided valuable insights into the perspectives of important stakeholders in the field, including policymakers and practitioners. These studies shed light on their perceptions and attitudes towards the implementation and impact of green structures, and provide valuable insights into the perspectives of different groups involved in the implementation and management of green structures. One such study conducted by Vera Ferreira et al. (2022) delved into the perception of stakeholders regarding the benefits associated with green structures. This study adds to the body of knowledge on how different stakeholders perceive urban green structures as a nature-based solution to various environmental and societal issues faced by urban areas. Triguero-Mas et al. (2020) conducted a study that specifically focused on understanding the motivations, experiences, and challenges faced by gardeners involved in cultivation practices. By delving into the thoughts and opinions of those directly engaged in cultivating urban green spaces, this research sheds light on the practical and personal aspects from the gardener's perspective. The findings of this study contributed to better understanding the factors that influence the success and sustainability of the cultivation projects. Furthermore, the perception of consumers played a significant role in shaping the future fate of the green structures. Ercilla-Montserrat et al. (2019a) explored the attitudes, preferences, and behaviors of consumers towards urban-grown produce. This study aimed to comprehend the perceived benefits and barriers associated with consuming locally grown fruits, vegetables, and herbs. By understanding consumer perspectives, policymakers and practitioners can work towards meeting consumer demands, promoting urban green structures as a sustainable and viable solution for local food production, and enhancing the overall acceptance of urban-grown produce. These scientific studies provide valuable insights into the perceptions and attitudes of various stakeholders, gardeners, and consumers in relation to green structures. Reports from South Asia illustrates that practitioners and non-practitioners value the social, economic, and environmental outcomes of rooftop structures (Safayet et al., 2017). By considering these diverse perspectives, researchers and practitioners can develop more comprehensive strategies and interventions that align with the needs, expectations, and motivations of different groups towards urban green structures. Ultimately, this knowledge can contribute to the successful implementation and widespread adoption of green structures, benefiting both urban dwellers and the environment.

1.2. Visual stimuli to elicit cognitive responses

Urban green spaces play a significant role in enhancing human cognition, as highlighted in the work of Farina (2009). Recent studies have further explored this concept by utilizing landscape images to assess people's perceptual preferences towards different environmental settings (e.g., Hami & Tarashkar, 2018; Tarashkar et al., 2020; Nazemi Rafi et al., 2020). It is worth noting that cognition is closely intertwined with perception, as emphasized by Goldstone and Barsalou (1998). The relationship between these two factors underscores the importance of studying people's cognitive responses to urban green spaces and their impact on overall well-being and cognitive functioning. Perceptual representations and cognitive representations share similar structural properties and content, as discussed by Tacca (2011). Building on this insight, studies have utilized people's preferences as a means to uncover their perceptions, as suggested by Kaplan (1985). These studies have employed visual stimuli, such as images depicting future scenarios or captivating environmental features in the form of photographs (Lafortezza et al., 2008; Qureshi et al., 2022). By utilizing these visual stimuli, researchers have been able to gain valuable insights into how individuals perceive and respond to different environmental settings, providing a deeper understanding of the link between preferences, perceptions, and the design of urban spaces. Studies have also used visual questionnaires to examine people's preferences towards green structures or similar land uses (Choudhry et al., 2015). Lindemann-Matthies et al. (2010) examined people's preferences for alpine landscapes and agricultural land uses with stimulating photographs. They illustrated that cultivation practices positively influence the aesthetic quality of the studied region. Bulut et al. (2010) investigated people's preferences for the fruit trees and urban shrubs by original and manipulated photographs, and manifested their positive impact of visual quality of urban streets. Howley et al. (2012) investigated preferences towards traditional farming landscapes in Ireland using color photographs and proved the aesthetic quality of farming landscapes. A number of studies have focused on people's preferences for green roofs. These studies have assessed perceptions using simulated photos (White & Gatersleben 2011), real photos taken with digital camera (Nagase & Koyama, 2020), and manipulated photos (Lee et al., 2014). Similar studies regarding rooftop greenhouses are indeed extremely rare.

1.3. Effect of personal characteristics and motivations on cognitive responses

Socio-demographic characteristics can significantly influence people's perceptions and decision-makings. Economic status (Hami & Tarashkar, 2018), age and gender (Rahimi et al., 2021), health and well-being (Qureshi et al., 2010a), and marital status (Earnhart, 2002) can influence people's perceptions of urban ecosystems. Studies concerning urban horticulture has found that age, occupation, income (Ma et al., 2020; Qureshi et al., 2010), and gender (Sikorska et al., 2020) might influence people's perceptual preferences. Residential attributes and housing features have a noticeable impact on people's perceptions

(Barrios Garcia and Rodriguez Hernandez, 2008), especially when the study concerns perception of residential environments. People's desire for social, economic and environmental benefits of urban horticulture can motivate them to participate in cultivation activities (Nadal et al., 2018). Economic motivation pertains to individuals' understanding and recognition of potential economic savings and financial gains, which subsequently influences their inclination to engage in rooftop green structures (Nadal et al., 2018). On the other hand, environmental motivation serves as another influential factor that stems from individuals' perception of various environmental benefits, such as improved air quality, temperature regulation, and increased biodiversity (Sanyé-Mengual et al., 2018). Social motivation refers to a driving force that emerges from individuals' perception of an enhancement in the overall quality of their daily lives (Triguero-Mas et al., 2020). Ruggeri et al. (2016) showed that social motivations were deriving forces for horticultural activities in community gardens. Reynolds and Cohen (2016) indicated that urban cultivation is accomplished to advance social goals, and food production is often a secondary motivation. Another study highlighted social and economic motivations of urban farmers (Diehl, 2020). A slight reference to environmental motivation is also evident in the literature (Zhang & Khachatryan, 2021).

Decades of research in cognitive science have illuminated the influence of various factors, such as age, gender, and marital status, on cognition. These factors play a significant role in shaping the way individuals process information, perceive the world around them, and make decisions. Studies have consistently shown that cognition can change over the course of a person's lifespan (Hochberg, & Konner, 2020). Gender also plays a noteworthy role in cognition. Studies have revealed subtle differences between males and females in various cognitive domains (Zaidi, 2010). Additionally, environmental (Tucker-Drob et al., 2013) and economic experiences (Hackman et al., 2010) has been found to influence cognition. It is essential to note that these factors, age, gender, and marital status, do not act in isolation but interact with one another and with a myriad of other variables. Acknowledging the influence of these factors provides valuable insights into the complexity of cognition and offers a foundation for tailoring cognitive interventions that can be utilized in various landscape design strategies to optimize their usability for urban communities. Using cognitive science, this research aims to deepen the understanding of how age, gender, marital status, and other factors can shape cognitive responses for landscape designs. This knowledge will not only inform the understanding of individual differences but also help guide interventions and societal approaches that aim to enhance cognitive abilities and overall well-being for individuals of all backgrounds.

This study aims to assess the citizens' perception of different types of rooftop green structures and answers the following overarching questions.

- How a set of visual stimuli can manifest people's perceptions of rooftop greenhouse?
- How do the people's priorities for different types of rooftop green structures shape?
- How do the personal socio-economic characteristics and motivations influence people's perceptions?

2. Methods

2.1. Study area

The study area in Iran is located in the vibrant city of Tabriz, nestled in the northwest region of the country. The population of the city is approximately 1.5 million people (Rahimi et al., 2020). Cityscape of Tabriz has been transformed during the time. The once vast gardens and agricultural lands have given way to the expanding urban infrastructure (Breuste et al., 2023). This shift reflects the changing economic and demographic dynamics of the city, as urban development and modernization took precedence. Nevertheless, remnants of Tabriz's agricultural past can still be found in the northwest neighborhoods of the city. Hence, Tabriz offers an attraction to evaluate alternatives for the lost traditional urban agriculture. Fig. 1

2.2. Research design

We developed a distinct hybrid questionnaire tailored to address our research inquiries. At the outset of the questionnaire, we included a comprehensive opening paragraph providing study participants with a clear explanation of the study's objectives. The questionnaire itself was structured into three distinct sections. The initial section comprised a series of text-based inquiries regarding the socio-demographic characteristics and health status of the study participants. Each participant's characteristics and physical health status were determined through a direct question. However, the assessment of their mental health was conducted using three indirect questions that aimed to gauge vitality, life spirit, and hope for the future. Simulated photos were included in the second part of the study. These photos showcased a variety of green roof designs, including extensive and intensive green roofs, as well as empty roofs. Additionally, the photos depicted edible rooftop gardens and eight significant greenhouses (e.g., Geodesic Dome, Tripenta, Hexa, Quonset, Tunnel, A-frame, Gable, and Dom), which were selected after consulting ten academic horticultural and landscape experts. In order to assess the relationship between green and empty roofs in relation to rooftop horticulture, the study included a series of photos. These photos were compiled into a booklet and presented to the participants. They were specifically instructed to concentrate on the type of greenhouse depicted in each image. Using a 5-point Likert scale (ranging from 1 for "Extremely low preference" to 5 for "Extremely high preference"), participants were asked to carefully examine each photo and indicate their preference on the main questionnaire paper. The green roofs were engineered to accommodate both ornamental plants and edible crops, offering a sustainable supply of fresh produce. In contrast, the greenhouses were customized for cultivating ornamental plants, enhancing their aesthetic appeal with designs like the geodesic dome or cultivation methods such as the Gable form. Participants were informed about the greenhouse contents through signage or verbal explanations during the study, specifying the types of plants being cultivated inside.

Additionally, another set of textual questions was included in the study to investigate the social, economic, and environmental motivations behind rooftop horticulture. Using a 5-point Likert scale (ranging from 1 for "Extremely low motivation" to 5 for "Extremely high motivation"), participants were asked to rate their level of motivation in each category. The questions pertaining to social motivations aimed to gauge participants' inclination towards engaging in social interactions such as planting crops together with neighbors and socializing with them. The study also explored participants' desire to experience the connection with nature provided by rooftop horticulture, as well as their tendency to spend leisure time in the various types and designs of rooftops presented. The inquiries surrounding economic motivation have shed light on people's aspirations to engage in cost-effective crop harvesting practices and minimize their daily expenses to sustain their families. Furthermore, it has uncovered their eagerness to participate in product trading and generate income, as well as their inclination to accumulate savings for off-season purchases. By addressing these questions, we can gain a clearer understanding of the motivations that drive individuals in their economic endeavors. The questions pertaining to environmental motivation aimed to delve into the impact of crops on air quality, the cooling effect they provide, and the sense of enhanced biodiversity they bring. Participants in the study were requested to answer these questions, taking into account the study's purpose and the visual representations provided to them. By considering these aspects, we can gather valuable insights into the environmental motivations that drive individuals' perceptions of crops.

In this study, we conducted a comprehensive examination of the

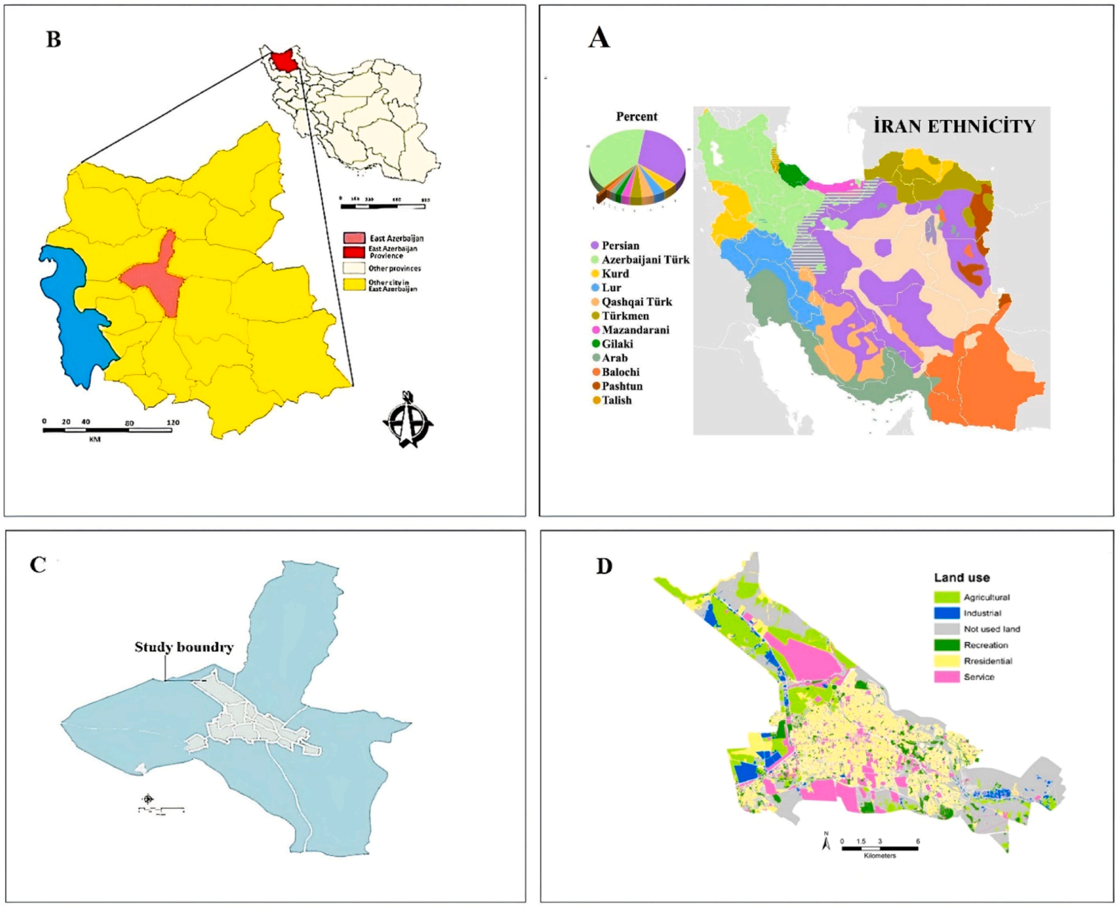


Fig. 1. An overview of the study area. Panel (A) shows the distribution of ethnicities in Iran and the geographic location of East Azerbaijan. Panel (B) illustrates the geographic location of the urban area of Tabriz. Panel (C) presents the geographic situation of Tabriz city. Panel (D) displays the land use map of Tabriz (Breuste & Rahimi, 2015).

cognitive and perception aspects implicated in participants' attitudes and perceptions toward urban greenhouses. This was achieved through a multi-faceted questionnaire that aimed to capture these dimensions in a scientific manner:

- Cognitive Aspect: The initial section of the questionnaire collected socio-demographic data alongside information on participants' mental and physical health status. By incorporating these factors, we sought to account for the cognitive processes that individuals may undergo when assessing urban greenhouses. This approach allowed for an investigation into the potential influence of individual circumstances and cognitive abilities on participants' cognitive assessments and preferences.
- Perception Aspect: The subsequent segment of the questionnaire involved participants ranking landscape images. This methodology was purposefully designed to extract their perceptual preferences and gain insights into their perceptions of urban greenhouses, particularly regarding aesthetics, environmental impact, and functionality. By eliciting ranked responses to landscape images, we aimed to elucidate participants' perceptions and preferences concerning the visual and aesthetic aspects of urban greenhouses in a scientific manner.

By methodically examining these cognitive and perception aspects, our study sought to achieve a comprehensive understanding of how individuals cognitively process and appraise the presence of urban greenhouses in their urban environment. This scientific approach facilitated nuanced insights into the cognitive and perceptual determinants that mold participants' attitudes and perceptions toward urban greenhouses.

2.3. *Image illustrations*

The graphical perspectives illustrating possible future scenarios of rooftop green structures were created using Adobe Photoshop CC. Initially, inspiration was drawn from various online sources to design three-dimensional models of four basic houses. Each of the buildings featured varying architecture, warm color schemes, consistent viewing angles, and identical vantage heights. The utilization of various buildings allowed us to confirm that building architecture has no significant influence on people's preferences. In other words, effectively steering people to overlook building architecture with questions has proven successful. This achievement has been validated through the Cronbach's alpha coefficient. As a result, people could focus on rooftop designs without distraction. Controlling the color and height of the buildings while employing various architectural styles enabled us to isolate the effect of architecture alone and demonstrate that it has no impact on rooftop greenhouse preference. Therefore, we manipulated only one factor (architecture) while keeping others such as color and angle of view constant.

Additionally, the rooftops were flat and the buildings had semi-square shapes, all set against a white background. To enhance the perception of rooftop accessibility, stairs were digitally added to the buildings. In the next stage, photographs showcasing four distinct greenhouse designs were incorporated onto one of the buildings. Furthermore, images of basil, lettuce, spinach, and tomato fields were placed on another building, allowing viewers to envision the potential varieties of rooftop edible gardens. The rooftops were then adorned with lush green grass installations, effectively showcasing the concept of extensive green roofs. Finally, the rooftops of each house were adjusted to a height of fifty meters, allowing ample space for intensive green roofs with deciduous trees typical of the region. To further enhance the visual impact, three repetitions of each plant type (trees, shrubs, bushes, herbaceous plants, and creepers) were carefully planted on the rooftop of each building. To present the designs to respondents, the prepared images were arranged on A4 paper in the dimensions of 4.5" x 3.5" inches. These images were then compiled into a hardcover booklet, which was distributed to the participants for review and evaluation. Fig. 2

2.4. Participant selection

Participants were individually approached, and the questionnaires were distributed in hard copy format. For the sample to be representative of the city population, it was calculated using Cochran's sample size formula (Cochran, 1977). A 95 % confidence level (α= 95 %, Z=1.96) and 0.05 margin of error (e =0.05) were considered and assigned to the formula.

$$n = \frac{Z^2 \quad p(1-p)}{e^2} = \quad \frac{1.96^2 \quad 0.5(1-0.5)}{0.05^2} = 384$$

According to the output of the formula, 384 residents with an age over 18 were randomly selected to participate in the study. Using ArcGIS, respondents were selected in pairs (two respondents at each point) at 142 random points (see Fig. 3). Questionnaires were distributed on both weekdays and weekends to ensure representation from different

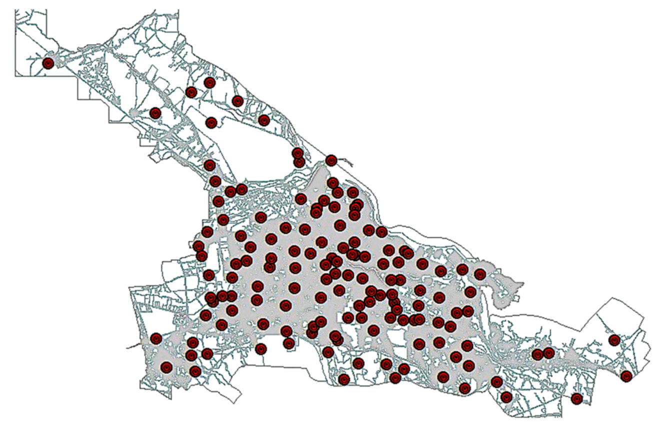


Fig. 3. The distribution of randomly generated points on the map of Tabriz.

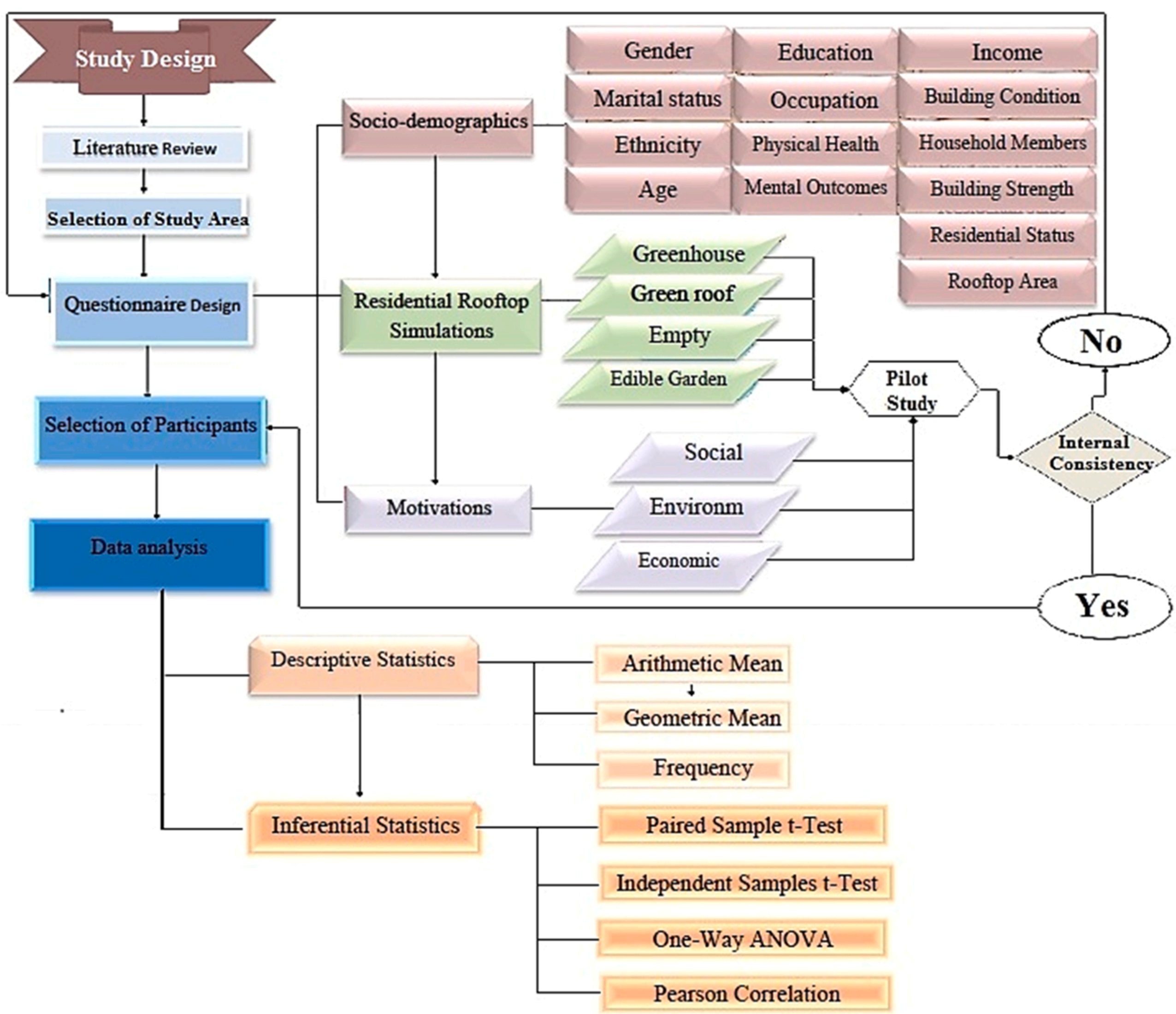


Fig. 2. The flow chart outlining the research methodology.

societal groups.

2.5. Data analysis

The data analysis process was conducted using IBM SPSS V.25. To provide a comprehensive description of the grouped dataset, descriptive statistics and frequency analysis were employed. The means were calculated based on Likert scale ratings provided by the participants. Frequency statistics were utilized to analyze the socio-demographic characteristics of the participants, offering insights into their characteristics. Additionally, arithmetic mean values and standard deviations were calculated to understand the participants' preferences towards rooftop green structures and their underlying motivations. These statistical measures provided a quantitative representation of the participants' preferences and motivations in the study. Arithmetic means were calculated in order to give priority to participants' preferences regarding rooftop green structures and to categorize their personal motivations (Krejčí & Stoklasa, 2018). Inferential statistics were then employed to broaden the understanding of the sample being studied to the entire community. Normality was checked for the data, and the P-value for the test was found to be within an acceptable range, ensuring the validity of the ANOVA results. The Paired Sample t-Test was utilized to identify any significant differences in both perceptional priorities and motivations. The study utilized the Independent Samples t-Test and One-Way ANOVA (analysis of variance) to compare the preferences across different socio-demographic groups. Additionally, the Pearson correlation coefficients were used to assess the relationship between different motivations and various types of green structures, as well as the association between different motivations.

3. Results

3.1. Socio-economic characteristics of study participants

The socio-demographic characteristics of study participants are presented in Table 1. By accurately determining the sampling stations and the number of participants, we were able to achieve a suitable pattern of socio-demographic distribution. The socio-demographic ratios of the study participants properly overlap with the latest census reports, and will properly manifest the whole societies' perception of rooftop horticulture. According to the census report for 2016, the percentage of men living in urban areas of Tabriz is 50.56 %, while the percentage of women living is 49.43 %. This information helped us ensure a balanced representation of both genders in our study. Furthermore, it is worth noting that the majority of the city's population falls into the middle-aged category and hold undergraduate degrees. This suggests that our study sample aligns well with the overall demographic profile of Tabriz, enhancing the generalizability of our findings.

3.2. Preferences for rooftop greenhouses and influence of socio-demographic characteristics

Table 2 provides descriptive statistics and internal consistency measures. It is important to highlight that the groups within our study are completely homogeneous, indicating a strong internal consistency (Bland & Altman, 1997). Interestingly, our findings reveal that people react differently to various types of rooftop horticulture. According to Table 2, the Geodesic Dome Greenhouse emerges as the preferred choice among study participants (Fig. 4). The Geodesic Dome Greenhouse offers a reliable alternative to intensive and extensive green roofs.

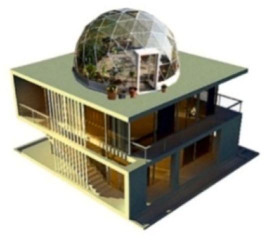
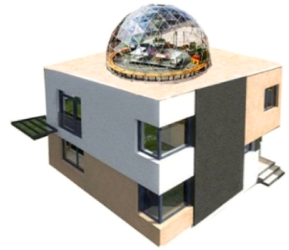
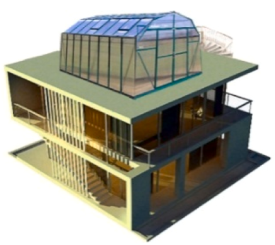
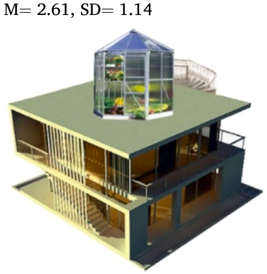
The homogenous group, consisting of the Intensive Green Roof, Tri Penta Greenhouse, and Hexa Greenhouse, is ranked as the second priority among citizens (Table 3). Both the Tri Penta and Hexa greenhouses are perceived to hold equal importance as the Intensive Green Roof. However, the Quonset and Tunnel greenhouses, along with the

Table 1
Frequency analysis for the socio-demographic characteristics of study participants.

Group	Sub-group	Frequency	Percent
Gender	Female	194	50.5
	Male	190	49.5
Marital Status	Single	113	29.4
	Married	271	70.6
Occupation	Having a job	200	52.1
	Jobless	118	30.7
	Student	66	17.2
Age	>35	135	35
	35–54	143	37
	<54	106	27
Economical status	Cluster 1 (Less than 30 Million Rial)	7	1.8
	Cluster 2 (30–60 Million Rial)	42	10.9
	Cluster 3 (60–90 Million Rial)	232	60.4
	Cluster 4 (90–120 Million Rial)	92	24.0
	Cluster 5 (More than 120 Million Rial)	11	2.9
Pysical health	Very Weak	3	.8
	Weak	2	.5
	Moderate	91	23.7
	Good	159	41.4
	Excellent	129	33.6
	Very Weak	7	1.8
Mental health	Weak	40	10.4
	Moderate	132	34.4
	Good	116	30.2
	Excellent	89	23.2
Ethnicity	Turk	361	94.0
	Persian	23	6.0
Household members	1–2	61	15.9
	3–4	293	76.3
	5–6	30	7.8
	≥7	0	0
Residental satus	Rent (tenant)	53	13.8
	Property Owner	331	86.2
Building strength	Enough	236	61.5
	Moderate	141	36.7
	Weak	7	1.8
Building condition	Exclusive house	326	84.9
	Apartment	58	15.1
Rooftop Area	Below 50 m^2	8	2.1
	51–81 m^2	65	16.9
	81–110 m^2	118	30.7
	111–140 m^2	98	25.5
	141–170 m^2	31	8.1
	171–200 m^2	27	7.0
	More than 201 m^2	37	9.6
Total		384	100

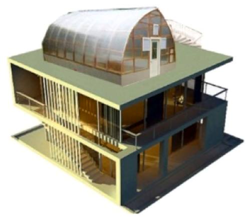
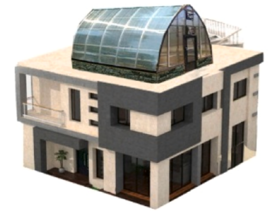
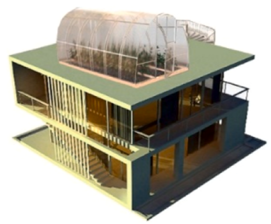
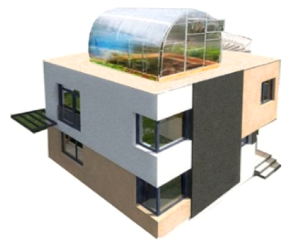
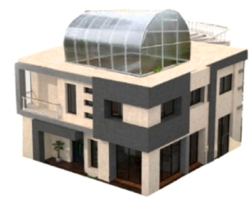
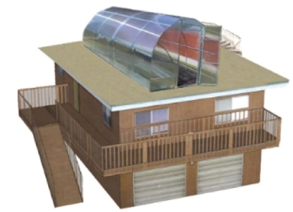
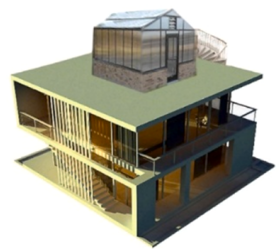
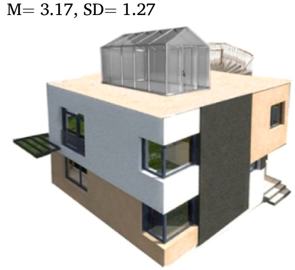
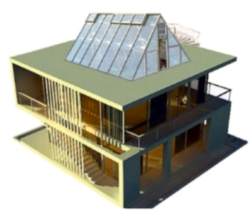
*Note: Due to the fluctuation of the dollar price, the incomes were expressed in official currency of Iran. At the time of data collection, one dollar was about 280,000 Iranian rial (October 12–19, 2021).

Table 2
Arithmetic and geometric mean values for people's preferences across different types of rooftop designs.

	Building1	Building 2	Building 3	Building 4	Geometric means
Geodesic Dome Cronbach's alpha= 0.92 M= 3.59, SD= 1.14					3.35
	M= 3.65, SD= 1.23	M=3.57, SD=1.27	M=3.56, SD= 1.30	M= 3.57, SD= 1.27	
Intensive Green Roof Cronbach's alpha= 0.94 M=3.12, SD=1.27					2.81
Tripenta Cronbach's alpha= 0.88 M=3.02, SD= 1.02					2.82
	M= 2.61, SD= 1.14	M= 3.36, SD= 1.18	M= 2.93, SD= 1.22	M= 3.22, SD= 1.26	
Hexa Cronbach's alpha = 0.87 M=3.03. SD= 1.05					2.80
	M= 3.03, SD= 3.21	M= 3.08, SD= 1.23	M= 3.15, SD= 1.25	M= 2.82, SD= 1.26	

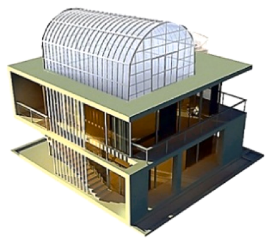
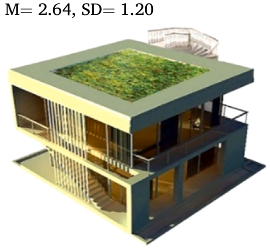
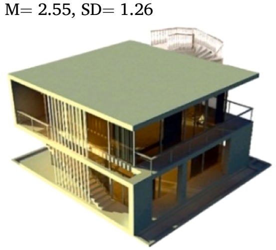
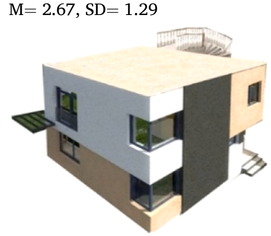
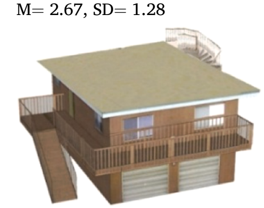
(*continued on next page*)

Table 2 (*continued*)

	Building1	Building 2	Building 3	Building 4	Geometric means
Quanset Cronbach's alpha= 0.87 M= 2.92, SD=1.02					2.71
	M= 2.88, SD= 1.24	M= 2.71, SD= 1.13	M= 2.98, SD= 1.20	M= 3.12, SD= 1.27	
Tunnel Cronbach's alpha= 0.86 M=2.88. SD= 1.00					2.68
	M= 2.88, SD= 1.13	M= 3.17, SD= 1.27	M= 2.76, SD= 1.14	M= 2.72, SD= 1.26	
Gable Cronbach's alpha= 0.84 M= 2.78.SD= 1.13					2.59
	M= 2.75, SD= 1.19	M= 2.55, SD= 1.13	M=3.16, SD= 1.18	M= 2.65, SD=1.16	
A-frame Cronbach's alpha= 0.9 M=2.78, SD= 1.08					2.54
	M= 2.73, SD= 1.25	M= 2.6, SD= 1.18	M= 2.87, SD= 1.26	M= 2.93, SD= 1.26	

(*continued on next page*)

Table 2 (*continued*)

	Building1	Building 2	Building 3	Building 4	Geometric means
Rooftop Edible Garden Cronbach's alpha= 0.92 M=2.72. SD= 1.18	 M= 2.65, SD= 1.32	 M= 2.66, SD= 1.24	 M= 2.93, SD= 1.37	 M= 2.65, SD= 1.30	2.45
Dom Cronbach's alpha= 0.87 M=2.61, SD=0.99	 M= 2.64, SD= 1.20	 M= 2.65, SD= 1.19	 M= 2.5, SD= 1.16	 M= 2.67, SD= 1.16	2.41
Extensive Green Roof Cronbach's alpha= 0.97 M=2.65. SD= 1.12	 M= 2.55, SD= 1.26	 M= 2.67, SD= 1.29	 M= 2.72, SD= 1.24	 M= 2.67, SD= 1.28	2.40
Empty Cronbach's alpha= 0.88 M=2.28. SD= 0.97	 M= 2.34, SD=1.18	 M= 2.16, SD= 1.01	 M=2.33, SD= 1.18	 M= 2.3, SD= 1.16	2.07

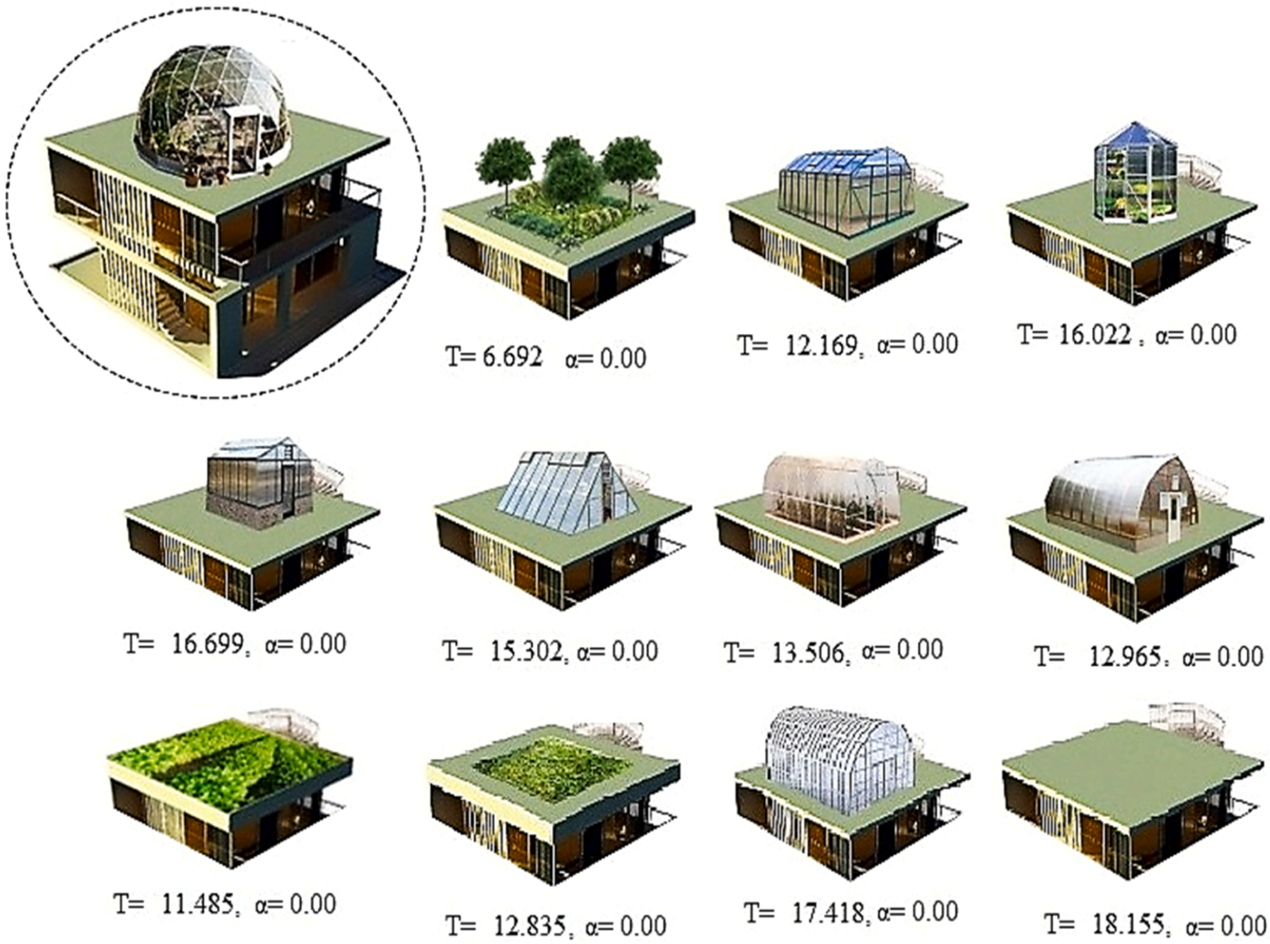


Fig. 4. Graphical presentation illustrating differences between the most preferred greenhouse and other roof types. Note: Each greenhouse in the figure represents the entire group.

subsequent priorities mentioned in Table 3, fall short in comparison to the Intensive Green Roof when it comes to competition.

In any case, citizens express a preference for any design over having empty or vacant rooftops (Fig. 5). This finding indicates that the presence of empty rooftops in the city goes against the criterion of social acceptability.

By exploring the differences between genders and suggesting balanced design approaches, gender equality can be promoted. As depicted in Table 4, all roof types elicit cognitive differences between genders. Women, in particular, demonstrate a greater inclination towards designing greenhouses on their rooftops compared to men. However, it is noteworthy that both gender groups share the same first priority as the overall estimate. This finding showcases how the approach presented here can help authorities evaluate gender equality in urban design.

Single and married individuals have different preferences for rooftop green structures (Table 4). Additionally, ethnicity does appear to play a role in shaping people's preferences. The influence of ethnicity on preferences demonstrates that these preferences are specific to certain regions, and can vary significantly across different regions and countries. Azerbaijani Turks are indigenous to this area, while the minority of Persians included in this study are non-natives who have opted to live and work in this city. It has been observed that Turks tend to express a greater affinity for greenhouse types, as they have a stronger sense of place and belonging in this region (Table 4). People from diverse occupational backgrounds exhibit similar preferences for rooftop greenhouses, suggesting a shared liking for this concept across different professions. Interestingly, the preferences for such green spaces are significantly influenced by the stage of life in which individuals find themselves, as indicated in Table 5. It is worth noting that people's age can impact their cognitive development, thereby leading to varying perspectives on rooftop horticulture. Notably, there is no established template for how perceptions change with age, implying that each rooftop design elicits a distinct perceptual response.

Income plays a significant role in shaping individuals' preferences for various rooftop designs, as illustrated in Table 5. Interestingly, lower-income groups exhibit the highest preference for different roof types and designs. It appears that individuals belonging to the low-income category perceive green structures as an opportunity to enhance their household's economic well-being. In other words, the desire for improved nutritional quality serves as a cognitive motivator, compelling people to embrace a wide range of rooftop greenhouses. It seems that the physically poor people prefer rooftop green structures in the hope of improving their health (Table 5). Generally, green structures offer opportunities for individuals to participate in physical activities and improve their physical health, as supported by Thompson's (2018) findings. Interestingly, individuals with poorer mental health display a preference for rooftop edible gardens, hoping to enhance their mental well-being, as indicated in Table 5. Therefore, rooftop edible gardens can serve as therapeutic spaces, providing potential benefits for individuals seeking mental health improvements. Home ownership is an important factor influencing perceptions (Table 6). Homeowners have a greater degree of freedom when it comes to transforming their roofs into various types of gardens, including green roofs. In contrast, tenants often face cognitive limitations that hinder their ability to fully appreciate the advantages of rooftop green spaces (Table 6).

Table 3
The results of the paired sample T-test for various rooftop designs.

		T	Df	Sig. (2-tailed)
Tri-penta	Intensive Green Roof	-1.295	383	.196
	Hexa	.259	383	.796
	Quonset	3.514	383	.000
	Tunnel	5.157	383	.000
	Gable	7.487	383	.000
	A-frame	6.035	383	.000
	Rooftop Edible Garden	4.483	383	.000
	Dom	12.339	383	.000
	Extensive Green Roof	5.649	383	.000
	Empty	11.383	383	.000
Intensive Green Roof	Hexa	1.440	383	.151
	Quonset	2.892	383	.004
	Tunnel	3.618	383	.000
	Gable	5.110	383	.000
	A-frame	4.843	383	.000
	Rooftop Edible Garden	7.115	383	.000
	Dom	7.114	383	.000
	Extensive Green Roof	8.223	383	.000
	Empty	11.090	383	.000
Hexa	Quonset	2.405	383	.017
	Tunnel	3.746	383	.000
	Gable	6.786	383	.000
	A-frame	5.319	383	.000
	Rooftop Edible Garden	4.265	383	.000
	Dom	9.559	383	.000
	Extensive Green Roof	5.499	383	.000
	Empty	11.571	383	.000
Quonset	Tunnel	1.475	383	.141
	Gable	4.320	383	.000
	A-frame	3.191	383	.002
	Rooftop Edible Garden	2.876	383	.004
	Dom	9.904	383	.000
	Extensive Green Roof	4.188	383	.000
	Empty	10.086	383	.000
Tunnel	Gable	3.267	383	.001
	A-frame	2.503	383	.013
	Rooftop Edible Garden	2.535	383	.012
	Dom	8.670	383	.000
	Extensive Green Roof	3.817	383	.000
	Empty	9.834	383	.000
Gable	A-frame	-.068	383	.946
	Rooftop Edible Garden	.825	383	.410
	Dom	5.096	383	.000
	Extensive Green Roof	2.021	383	.044
	Empty	8.996	383	.000
A-frame	Rooftop Edible Garden	.836	383	.403
	Dom	4.355	383	.000
	Extensive Green Roof	2.003	383	.046
	Empty	7.776	383	.000
Rooftop Edible Garden	Dom	1.600	383	.110
	Extensive Green Roof	2.698	383	.007
	Empty	7.076	383	.000
Dom	Extensive Green Roof	-.545	383	.586
	Empty	5.774	383	.000
Extensive Green Roof	Empty	6.198	383	.000

People living in exclusive houses have more tendency to have Geodesic Dome and Tunnel greenhouses and Extensive Green Roofs on their rooftops (Table 6). Living in an apartment and the need for collective decision-making pose specific limitations and reduce people's preferences. People living in small houses have higher preferences for rooftop green structures (Table 7). There is a general pattern of decline in people's preferences with increasing area. This pattern of preferences is similar to the preferences of income clusters. Therefore, even though the roofs of these households are small, they feel more in need of rooftop cultivation due to their poor economy and low welfare. The findings reveal that individuals residing in households consisting of five or six people display the strongest inclinations towards productive greenhouses, as illustrated in Table 7. In simpler terms, those living in larger families perceive specialized greenhouses as an effective means of fulfilling their household requirements.

3.3. Preference for rooftop greenhouses and influence of motivations

The social, economic, and environmental incentives present favorable prospects for encouraging green structures on residential rooftops. Interestingly, citizens' motivation in terms of environmental and social factors surpasses their economic motivations, as demonstrated in Table 8. Consequently, these motivations hold the potential to elevate people's inclination towards rooftop greenhouses while ensuring socio-environmental sustainability, as indicated in Table 8. There are strong overlaps between social, environmental, and economic motivations in the context of rooftop greenhouses (Table 9). These interconnected factors work together to increase and encourage individuals to engage in this practice. Special greenhouses play a vital role in evoking both social and environmental motivations. For instance, the Geodesic Dome Greenhouse specifically taps into environmental motivations by offering sustainable and eco-friendly solutions. On the other hand, the Tri-penta and Hexa greenhouses primarily appeal to social motivations, fostering a sense of community and social interaction (Table 9). Therefore, it can be observed that these different types of greenhouses tap into specific aspects of social and environmental motivations, complementing and reinforcing each other in the promotion and adoption of rooftop horticulture.

4. Discussion

4.1. Socio-demographic characteristics and cognitional correlates

The green structures and cultivation practices on residential rooftops can shed light on the cognitive disparities between genders. It is widely recognized that men and women have different cognitive attributes due to anatomical, functional, and biochemical dissimilarities in their brains (Kheloui et al., 2023; Subramaniapillaiet al., 2021; Zaidi, 2010). As a result, these cognitive variations lead to divergent preferences in how genders perceive and engage with rooftop greenhouses. Women, in particular, tend to demonstrate a higher level of interest in the idea of incorporating greenhouses on rooftops, as compared to men. The varying cognitive development between genders results in women deriving greater benefits from urban horticulture and green structures (Ambrose et al., 2020; Sillman et al., 2022) and displaying a stronger inclination towards rooftop greenhouses. Furthermore, differences can also be observed between married and single individuals. Single individuals often prioritize recreational and aesthetic needs, while married individuals may feel a responsibility to provide household food (Ngome & Foeken, 2012). These differences in priorities contribute to distinct preferences for different types of rooftop greenhouses.

Age can significantly influence individuals' preferences, as noted by Sikorska et al. (2020). The cognitive development that occurs throughout a person's lifespan plays a crucial role in shaping their perceptions and inclinations towards various forms of rooftop horticulture. This notion is supported by existing research establishing that the brain continues to develop even in adulthood (Hochberg & Konner, 2020; Mehta et al., 2023). Considering the impact of cognitive development, individuals at different stages of life are likely to exhibit distinct interests in specific types of green structures. Exploring this relationship further could enhance our understanding of the underlying cognitive processes and their effects on preferences for horticultural activities in urban environments. The preferences for various types of rooftop greenhouses are significantly influenced by the needs imposed by

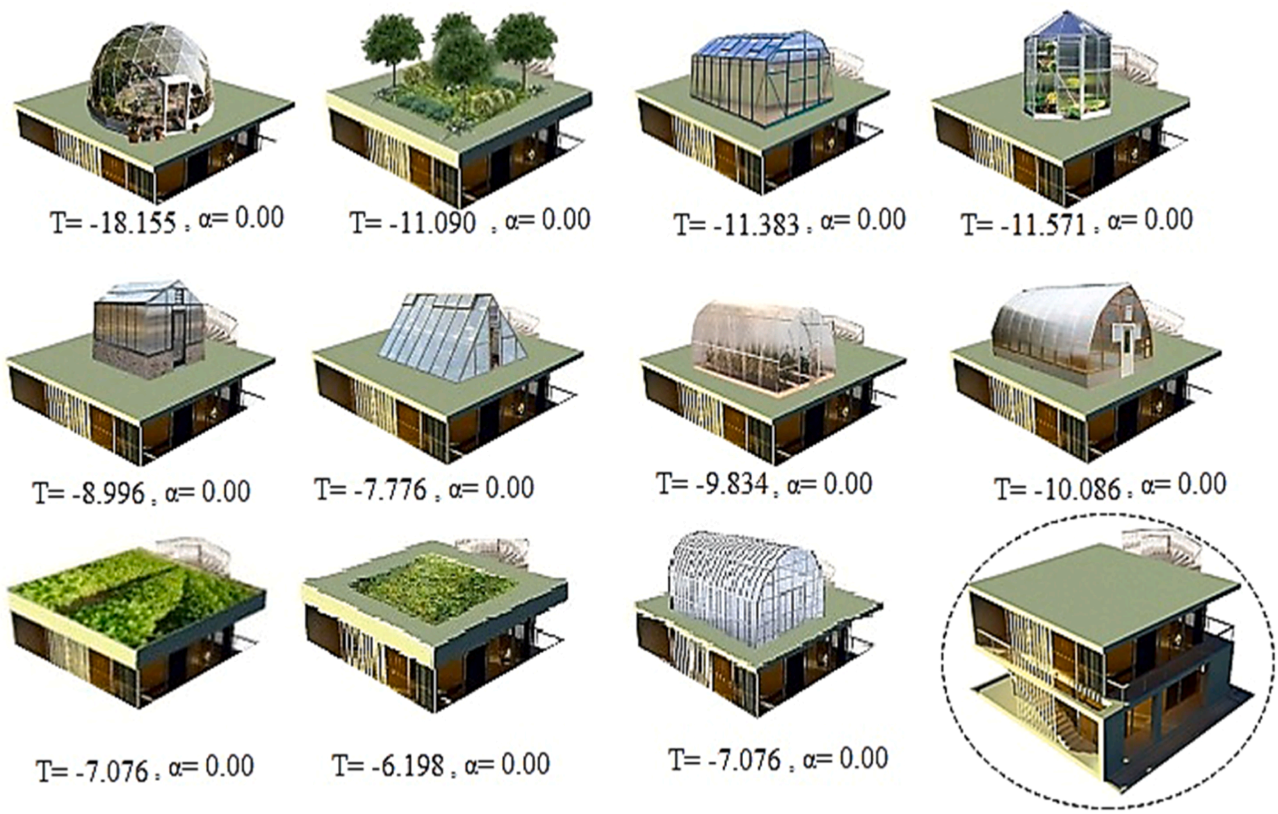


Fig. 5. The graphical representation of differences between the least preferred greenhouse and other roof types. Note: Each greenhouse in the figure represents the entire group.

Table 4
Paired-sample T-test for preferences among different gender groups, marital statuses, and ethnicities for rooftop designs.

Type	Gender		T	Df	Sig.
	Women	Men			
Geodesic Dome	3.79	3.38	3.536	382	.000
A-frame	2.90	2.66	2.225	382	.027
Rooftop Edible Garden	3.13	2.31	7.278	382	.000
Dom	2.76	2.47	2.862	382	.004
Quonset	3.07	2.77	2.840	382	.005
Extensive Green Roof	2.98	2.31	6.056	382	.000
Intensive Green Roof	3.42	2.81	4.785	382	.000
Tri-penta	3.18	2.87	2.959	382	.003
Tunnel	3.03	2.72	3.061	382	.002
Gable	2.89	2.66	2.387	382	.017
Hexa	3.18	2.85	3.184	382	.002
Type	Marital status		T	Df	Sig.
	Single	Married			
Geodesic Dome	3.76	3.52	1.961	382	.050
A-frame	2.56	2.87	-2.561	382	.011
Dom	2.33	2.73	-3.615	382	.000
Quonset	2.62	3.05	-3.792	382	.000
Hexa	3.22	2.94	2.413	382	.016
Type	Ethnicity		T	Df	Sig.
	Turk	Persian			
Geodesic Dome	3.64	2.78	3.564	382	.000
Rooftop Edible Garden	2.76	2.09	2.680	382	.008
Dom	2.66	1.96	3.310	382	.001
Quonset	2.97	2.17	3.675	382	.000
Tri-penta	3.08	2.16	4.266	382	.000
Tunnel	2.91	2.31	2.805	382	.005
Gable	2.82	2.06	3.759	382	.000
Hexa	3.08	2.12	4.379	382	.000

Note: The table includes statistically significant results only.

income level and economic status, as identified by Poulsen et al. (2015). Particularly, individuals belonging to the lowest income group or the deprived strata of society exhibit a strong inclination towards rooftop greenhouses that can fulfill the food demands of their household. Green structures like urban greenhouses prove to be a vital tool in addressing the food security concerns of poor urban households (Poulsen et al., 2015; Dagar et al., 2023). By engaging in rooftop horticultural activities, these households can cultivate their own fresh fruits and vegetables, reducing their reliance on external food sources. This self-sufficiency contributes to an increased sense of food security and ultimately enhances the overall well-being of the individuals and their families. Ambrose et al. (2020) further support the notion that cultivation activities positively influences the well-being of impoverished urban communities. Cultivating plants and greenery in urban spaces not only provides access to nutritious food but also creates a therapeutic and aesthetically pleasing environment, helping alleviate stress and promoting a sense of well-being.

The environmental factors, as demonstrated by Tucker-Drob et al. (2013), and economic experiences, as shown in the study by Hackman et al. (2010), have been found to have a significant impact on the development of people's cognition. This study indicates that individuals from lower socioeconomic backgrounds tend to display a higher preference towards rooftop horticulture. This finding adds scientific validity to the idea that environmental and economic factors play a crucial role in shaping cognitive processes and influencing preferences for certain activities, such as rooftop gardening. Moreover, it is worth considering socio-economic features that can arise from house ownership, building status (exclusive house or apartment), house size, and the number of household members. These features impose cognitive needs (Hackman et al., 2010) and contribute to the emergence of specific types of rooftop horticulture. Identifying and understanding these factors is essential for future research and interventions in order to cater to the needs and

Table 5
Mean comparison (ANOVA) for the preferences of different age groups, income brackets, and individuals with varying health statuses for distinct rooftop designs.

	Age					Df	F	Sig.
Type	35 & less		36–54	55 & above				
Geodesic Dome	3.78^{a}		3.50^{ab}	3.04^{b}		2381	6.324	.002
Quonset	2.88^{ab}		3.03^{a}	2.47^{b}		2381	3.930	.020
Extensive Green Roof	2.48^{a}		2.80^{b}	2.61^{ab}		2381	3.671	.026
Tri-penta	3.10^{a}		3.04^{a}	2.53^{b}		2381	3.789	.023
Hexa	3.15^{a}		2.97^{ab}	2.54^{b}		2381	4.619	.010
	Income					Df	F	Sig.
Type	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5			
Geodesic Dome	4.46^{ab}	3.90^{ab}	3.40^{a}	3.90^{b}	3.60^{ab}	4379	5.566	.000
A-frame	4.43^{a}	2.63^{bc}	2.67^{cd}	3.06^{b}	2.43^{bd}	4379	7.149	.000
Rooftop Edible Garden	4.36^{a}	2.62^{b}	2.77^{b}	2.47^{b}	3.18^{ab}	4379	5.216	.000
Dom	4.14^{a}	2.64^{b}	2.5^{b}	2.70^{b}	2.43^{b}	4379	4.964	.001
Quonset	4.36^{a}	3.05^{b}	2.82^{b}	3.08^{b}	2.36^{b}	4379	5.740	.000
Tri-penta	4.39^{a}	3.14^{b}	2.88^{b}	3.28^{c}	2.83^{bc}	4379	6.264	.000
Tunnel	4.46^{a}	2.79^{b}	2.82^{b}	2.94^{b}	3.07^{b}	4379	5.044	.001
Gable	4.36^{a}	2.64^{bc}	2.68^{b}	3.00^{c}	2.50^{bc}	4379	7.536	.000
Hexa	4.43^{a}	3.20^{bc}	2.86^{b}	3.28^{c}	2.64^{bc}	4379	6.885	.000
	Physical health status							
Type	Very Weak	Weak	Moderate	Good	Very good	Df	F	Sig.
A-frame	5.00^{a}	3.00^{b}	2.68^{b}	2.74^{b}	2.84^{b}	4379	3.640	.006
Gable	5.00^{a}	2.50^{b}	2.57^{b}	2.88^{b}	2.76^{b}	4379	5.915	.000
	Mental health status							
Type	Very Weak	Weak	Moderate	Good	Very good	Df	F	Sig.
Rooftop Edible Garden	3.00^{a}	2.21^{ab}	2.82^{ab}	2.63^{ab}	2.53^{b}	4379	3.056	.017

Note: 1Cell entries are mean values based on 5 point Likert scale (1=least preferred, 2=somewhat preferred, 3=neither preferred nor preferred, 4=preferred, 5=most preferred). 2The raw mean with different superscript differ significantly at $p < 0.05$. 3Tukey was used for Post Hoc test.
Note: The table includes statistically significant results only.

Table 6
Paired-sample t-test for evaluating the impact of residential and building status on preferences for rooftop designs.

Type	Residential status		T	Df	Sig.
	Rent (Tenant)	Property Owner			
Empty	2.66	2.22	3.080	382	.002
	Building status				
Type	Exclusive house	Apartment	T	Df	Sig.
Geodesic Dome	3.65	3.28	2.29	382	.022
Extensive Green Roof	2.70	2.35	2.22	382	.027
Tunnel	2.94	2.56	2.76	382	.006

Note: The table includes statistically significant results only.

preferences of different groups within society. In addition to socio-economic factors, various studies, such as those conducted by Cadzow & Binns (2016) and Simiyu & Foeken (2014), indicate that urban gardening practices, including rooftop horticulture, can be influenced by multiple factors. These could include social, cultural, and personal aspects, further highlighting the diverse ways in which different individuals engage in urban gardening practices. Understanding these factors can provide valuable insights for designing effective strategies and interventions that are tailored to specific contexts and demographics.

4.2. Perceptual preferences and motivations towards rooftop horticulture

In recent years, there has been a growing recognition of the significance of public perceptions as a crucial first step in the implementation of rooftop horticulture. Sanyé-Mengual et al. (2015) emphasized the importance of considering public perceptions as the initial step in executive efforts to establish rooftop horticulture. Several studies have supported this argument and have examined people's preferences for rooftop green structures (Cristiano et al., 2023; Ercilla-Montserrat et al., 2019b; Meyer & Trandafir, 2023). Most of these studies have utilized traditional textual questionnaires and interviews (Sun & Shao, 2020).

Table 7
Mean comparison (ANOVA) for preferences of individuals residing in residences of varying sizes and occupancy toward rooftop green structures.

	House Area							Df	F	Sig.
Type	<50	51–80	81–110	111–140	141–170	171–200	>201			
Geodesic Dome	4.62^{a}	3.88^{a}	3.75^{a}	3.50^{a}	3.37^{ab}	3.52^{ab}	2.82^{b}	6377	5.669	.000
A-frame	3.87^{a}	3.08^{ac}	2.96^{ad}	2.58^{bd}	2.54^{bc}	2.77^{abc}	2.18^{b}	6377	5.900	.000
Rooftop Edible Garden	3.69^{a}	2.80^{ab}	2.64^{ab}	2.96^{ab}	2.64^{ab}	2.44^{ab}	2.28^{b}	6377	2.765	.012
Dom	3.50^{a}	2.79^{a}	2.78^{a}	2.56^{a}	2.90^{b}	2.00^{b}	1.93^{b}	6377	7.728	.000
Quonset	4.50^{a}	3.20^{b}	3.04^{b}	2.83^{bc}	3.11^{b}	2.31^{c}	2.28^{c}	6377	9.687	.000
Tri-penta	4.37^{a}	3.31^{ab}	3.06^{bd}	3.07^{b}	3.14^{be}	2.53^{cde}	2.28^{c}	6377	8.445	.000
Tunnel	4.00^{a}	3.22^{ab}	2.84^{bc}	2.94^{bd}	2.81^{bc}	2.47^{cd}	2.38^{c}	6377	5.655	.000
Hexa	4.31^{ac}	3.29^{cd}	3.04^{bd}	3.14^{bd}	2.84^{bd}	2.83^{bd}	2.15^{b}	6377	8.259	.000
	Household members							Df	F	Sig.
Type	1–2		3–4		5–6					
A-frame	2.95^{ab}		2.70^{a}		3.22^{b}			2, 381	4.052	.018

Note: 1Cell entries are mean values based on 5 point Likert scale (1=least preferred, 2=somewhat preferred, 3=neither preferred nor preferred, 4=preferred, 5=most preferred). 2The raw mean with different superscript differ significantly at $p < 0.05$. 3Tukey was used for Post Hoc test.4 Note: The table includes statistically significant results only.

Table 8
Arithmetic means, geometric means, and Paired Samples t-Test results examining environmental, social, and economic motivations.

Type	Mean	Geometric mean	Std. Deviation	Type	Paired Samples t –Test		
					T	Df	Sig.
Environmental Motivations	3.46	3.29	.95	Environmental motivations – Economic motivations	-9.201	383	.000
Social Motivations	3.45	3.28	.97	Social motivations – Economic motivations	-8.511	383	.000
Economical Motivations	3.11	2.67	1.04	Environmental motivations- Social motivations	-0.429	383	.660

Table 9
The relationship between environmental, social, and economic motivations and their impact on rooftop green structure adoption.

Type		Economical motivations	Environmental motivations	Geodesic Dome	Tri-penta	Hexa
Environmental motivations	Pearson Correlation	.72**	1	.51**	-	-
	Sig. (2-tailed)	.00		.00	-	-
Social motivations	Pearson Correlation	.70**	.78**	.50**	.5**	.5**
	Sig. (2-tailed)	.00	.00	.00	.00	.00

Pearson correlation coefficient: <0.3 negligible correlation, 0.3 0.5 weak correlation, 0.5–0.7 moderately strong correlation, 0.7–0.9 strong correlation, 0.9<very strong correlation (Hinkle et al., 2003). ** Correlation is significant at the 0.01 level (2-tailed). Note: The table includes statistically significant results only.

This particular study adopted a more innovative approach by combining textual questions and simulated images, thereby offering a more comprehensive understanding of individuals' cognitive responses, perceptions, preferences, and various factors that may influence these aspects. Several studies have examined the different types of rooftop cultivation and their influence on people's perceptual responses (Fernandez-Cañero et al., 2013; Lee et al., 2014; Meyer & Trandafir, 2023; Nagase & Koyama, 2020). With the aim of establishing a robust order of preference, meticulous analysis was carried out, allowing for the acquisition of valuable insights into the most and least favored rooftop horticulture types and designs. Furthermore, the study delved into the motivations that inspire individuals to undertake rooftop gardening on their own. Drawing upon the research conducted by Diehl (2020), McClintock & Simpson (2018), and Zoll et al. (2018), it became evident that a multitude of factors drive and fuel the desire to engage in rooftop gardening. Social and environmental motivations mostly encourage people to grow on their rooftops. The motivations are controlled through the human cognition, and the certain types of rooftop greenhouses evoke the responses. We have obtained noteworthy findings that demonstrate a significant connection between various motivations. Supporting this, a study by Di Fiore et al. (2021) has confirmed our results, revealing that motivations occasionally intersect. These findings offer a valuable reference point for upcoming research and initiatives in urban executive work (Allahyar & Kazemi, 2021).

4.3. Sense of place, mental wellbeing, and physical health consequences of rooftop horticulture

Individuals who are native residents of the city exhibit the most pronounced perceptual inclinations towards rooftop horticulture. Previous research by Marsh et al. (2017) has already established that a strong sense of belonging to a particular location influences preferences for green structures like community garden. Moreover, documented evidence suggests that individuals involved in experience an enhanced sense of belonging to their respective places (Dunlap et al., 2013; Nicholas et al., 2023). The findings from our study indicate that a stronger sense of belonging plays a crucial role as a cognitive factor, motivating urban dwellers to engage in horticultural practices on their rooftops. Additionally, previous research has demonstrated that horticultural practices can greatly contribute to creating a sense of place among immigrant populations (Charles-Rodriguez et al., 2023; Saldivar-Tanaka and Krasny, 2004). Consequently, ethnic minorities residing in the city are likely to experience an enhancement in their overall quality of life. Urban green structures are an important element of urban public health (Sędzicki et al., 2023; Brown & Jameton, 2000), since provides mental and physical health outcomes for people who actively engage in cultivation operations (Audate et al., 2019). Interestingly, people are cognitively aware of the benefits before participating in such activities, and they turn to rooftop greenhouses and green roofs to improve their mental and physical health. The lower the mental health of the people, the more inclined they are to roof gardening.

5. Conclusion

The study successfully identified homogeneous and inhomogeneous groups within the realm of rooftop horticulture, highlighting the varied perceptions associated with different horticultural practices. Furthermore, it offered valuable insights into how personal acquired and intrinsic factors influence individual-based cognitive behavior, ultimately shaping perceptual preferences for rooftop horticulture.

Our findings underscore a clear preference among participants for geodesic dome greenhouses, particularly when compared to green roofs. Moreover, our results reveal a general preference for any rooftop green structure over empty rooftops, indicating a widespread acknowledgment of the value of urban green spaces. Interestingly, our data suggest that women exhibit a stronger inclination towards green structures, while marital status appears to influence preferences, with single individuals favoring ornamental designs and married individuals prioritizing more productive options. In the same vein, individuals native to regions exhibit a greater affinity for green structures, likely due to their stronger sense of place and connection to the local environment. Conversely, higher age groups demonstrate lower preferences for green structures, suggesting potential generational differences in environmental preferences. Interestingly, lower income groups express the highest preferences for green structures, possibly reflecting a desire for accessible and affordable green spaces. Additionally, individuals with lower mental health exhibit the highest preferences for rooftop edible garden, underscoring the potential therapeutic benefits of urban greenery for overall well-being. House features play a significant role in shaping preferences for green structures, indicating the influence of architectural design on individuals' choices. Moreover, environmental motivations emerge as the most influential factor driving people towards green structures, underscoring the importance of environmental considerations in urban planning and design. Social and economic motivations follow closely behind, suggesting the interplay of social dynamics and economic factors in shaping attitudes towards green spaces. These insights shed light on the nuanced factors influencing preferences for rooftop green structures, providing valuable guidance for urban planning and design initiatives aimed at enhancing urban greenery and sustainability.

Access to comprehensive societal perceptions opens up opportunities for macro planning at the city level, enabling policymakers and urban planners to make informed decisions regarding rooftop horticulture. Understanding the factors that shape cognition and subsequent perception is crucial for effective planning and design. By considering individual-based cognitive behavior, influenced by personal acquired and intrinsic factors, planners can create rooftop design initiatives that align with the preferences and needs of the community. This personalized approach fosters a stronger sense of ownership and engagement, leading to the long-term success and sustainability of rooftop gardens. Furthermore, while this study focused on a specific region and type of, examining studies from other countries and different types of green structures can yield valuable insights. By comparing and contrasting approaches across different contexts, we can gain a broader understanding of the underlying factors shaping perception and preferences. Additionally, studying public motivations in detail can provide valuable insights for policymakers. By understanding what drives individuals to engage in rooftop horticulture, such as environmental concerns, social interactions, or personal well-being, planners can tailor initiatives to effectively meet these motivations. This not only increases the likelihood of community participation but also enhances the overall impact of rooftop horticultural projects in cities. The results obtained can be utilized to design green structures on rooftops, tailored to meet the specific needs of households.

CRediT authorship contribution statement

Salman Qureshi: Conceptualization, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. **Mahsa Tarashkar:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing. **Akbar Rahimi:** Project administration, 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.

References

Allahyar, M., Kazemi, F., 2021. Landscape preferences of a children's hospital by children and therapists. Urban For. Urban Green. 58, 126984.
Ambrose, G., Das, K., Fan, Y., Ramaswami, A., 2020. Is gardening associated with greater happiness of urban residents? A multi-activity, dynamic assessment in the Twin-Cities region. Usa. *Landsc. Urban Plan.* 198, 103776.
Audate, P.P., Fernandez, M.A., Cloutier, G., Lebel, A., 2019. Scoping review of the impacts of urban agriculture on the determinants of health. BMC Public Health 19, 672.
Ayompe, L.M., Schaafsma, M., Egoh, B.N., 2021. Towards sustainable palm oil production: The positive and negative impacts on ecosystem services and human wellbeing. J. Clean. Prod. 278, 123914.
Barrios Garcia, J.A., Rodriguez Hernandez, J.E., 2008. Housing demand in Spain according to dwelling type: Microeconometric evidence. Reg. Sci. Urban Econ. 38 (4), 363–377.
Bland, J.M., Altman, D.G., 1997. Cronbach's alpha. Br. Med. J. 314, 572.
Brown, K.H., Jameton, A.L., 2000. Public Health Implications of Urban Agriculture. J. Public Health Policy 21 (1), 20.
Breuste, J., Rahimi, A., 2015. Many public urban parks, but who profits from them? The example of Tabriz. Iran. *Ecol. Process.* 4 (1), 1–15.
Bulut, Z., Sezen, I., Karahan, F., 2010. Determination of spring visual ceremonies of urban fruit trees and shrubs: A case study from Erzurum, Turkey. *J. Food,* Agric. Environ. 8.
Cadzow, H., Binns, T., 2016. Empowering Freetown's women farmers. Appl. Geogr. 74, 1–11.
Cattaneo, A., Adukia, A., Brown, D.L., Christiaensen, L., Evans, D.K., Haakenstad, A., Weiss, D.J., 2022. Economic and social development along the urban–rural continuum: New opportunities to inform policy. World Dev. 157, 105941.
Concilio, G., Li, C., Rausell, P., Tosoni, I., 2019. Cities as enablers of innovation. Innov. Capacit. City.: Enabling Role Des. 43–60.
Chiesura, A., 2004. The role of urban parks for the sustainable city. Landsc. Urban Plan. 68 (1), 129–138.
Cochran, W.G., 1977. *Sampling techniques* (3rd ed.). John Wiley & Sons, New York.
Choudhry, K.Z., Coles, R., Qureshi, S., Ashford, R., Khan, S., Mir, R.R., 2015. A review of methodologies used in studies investigating human behaviour as determinant of outcome for exposure to "naturalistic and urban environments. Urban For. Urban Green. 14 (3), 527–537.
Charles-Rodriguez, U., Venegas de la Torre, M.D., Hecker, V., Laing, R.A., Larouche, R., 2023. The relationship between nature and immigrants' integration, wellbeing and physical activity: a scoping review. J. Immigr. Minor. Health 25 (1), 190–218.
Cristiano, E., Deidda, R., Viola, F., 2023. Awareness and willingness to pay for green roofs in Mediterranean areas. J. Environ. Manag. 344, 118419.
Dagar, J.C., Gupta, S.R., Sileshi, G.W., 2023. Urban and peri-urban agroforestry to sustain livelihood and food security in the face of global environmental change and epidemic threats. In *Agroforestry for Sustainable Intensification of Agriculture in Asia and Africa*. Springer Nature Singapore, Singapore, pp. 89–118.
Diehl, J.A., 2020. Growing for Sydney: Exploring the urban food system through farmers' social networks. Sustainability 12 (8), 3346.
Di Fiore, G., Specht, K., Zanasi, C., 2021. Assessing motivations and perceptions of stakeholders in urban agriculture: a review and analytical framework. Int. J. Urban Sustain. Dev. 1–17.
Dunlap, R., Harmon, J., Kyle, G.T., 2013. Growing in place: The interplay of urban agriculture and place sentiment. Leis. /Loisir *37* (4), 397–414.
Earnhart, D., 2002. Combining revealed and stated data to examine housing decisions using discrete choice analysis. J. Urban Econ. 51 (1), 143–169.
Ercilla-Montserrat, M., Sanjuan-Delmás, D., m Sanyé-Mengual, E., Calvet-Mir, L., Banderas, K., Rieradevall, J., Gabarrell Durany, X., 2019. Analysis of the consumer's perception of urban food products from a soilless system in rooftop greenhouses: a case study from the Mediterranean area of Barcelona (Spain). Agric. Hum. Values 36 (4).
Ercilla-Montserrat, M., Sanjuan-Delmás, D., Sanyé-Mengual, E., Calvet-Mir, L., Banderas, K., Rieradevall, J., Gabarrell, X., 2019. Analysis of the consumer's perception of urban food products from a soilless system in rooftop greenhouses: a case study from the Mediterranean area of Barcelona (Spain). Agriculture and human values 36, 375–393.Chicago.
Farina, A. (2009). The Cognitive Landscape. Ecology, Cognition and Landscape. Landscape series, vol 11. Springer Sceince & Businuss Media, 161pp.
Ferreira, V., Barreira, A.P., Pinto, P., Panagopoulos, T., 2022. Understanding attitudes towards the adoption of nature-based solutions and policy priorities shaped by stakeholders' awareness of climate change. Environ. Sci. Policy 131, 149–159.
Fernandez-Cañero, R., Emilsson, T., Fernandez-Barba, C., Machuca, M., 2013. Green roof systems: a study of public attitudes and preferences in southern Spain. J. Environ. Manag. 128, 106–115.
Fernández, I.C., Wu, J., Simonetti, J.A., 2019. The urban matrix matters: Quantifying the effects of surrounding urban vegetation on natural habitat remnants in Santiago de Chile. Landsc. Urban Plan. 187, 181–190.
Global Asthma Network (2018). The Global Asthma Report 2018. Auckland, New Zealand. 〈http://www.globalasthmareport.org/resources/global_asthma_report_2018.pdf〉.
Goldstone, R., Barsalou, L.W., 1998. Reuniting perception and conception. Cognition 65, 231–262.
Hami, A., Tarashkar, M., 2018. Assessment of women's familiarity perceptions and preferences in terms of plants origins in the urban parks of Tabriz, Iran. Urban For. Urban Green. 32, 168–176.
Hackman, D., Farah, M., Meaney, M., 2010. Socioeconomic status and the brain: mechanistic insights from human and animal research. Nat. Rev. Neurosci. 11, 651–659.
Hochberg, Z.E., Konner, M., 2020. Emerging Adulthood, a Pre-adult Life-History Stage. Front. Endocrinol. 10, 918.
Hinkle, D.E., Wiersma, W., Jurs, S.G., 2003. Applied Statistics for the Behavioral Sciences. Houghton Mifflin, Boston.
Howley, P., Donoghue, C.O., Hynes, S., 2012. Exploring public preferences for traditional farming landscapes. Landsc. Urban Plan. 104 (1), 66–74.
Kaplan, R., 1985. The analysis of perception via preference: A strategy for studying how the environment is experienced. Landsc. Plan. 12 (2), 161–176. https://doi.org/10.1016/0304-3924(85)90058-9.
Keil, R., 2015. Towers in the park, bungalows in the garden: Peripheral densities, metropolitan scales and the political cultures of post-suburbia. Built Environ. 41 (4), 579–596.
Kheloui, S., Jacmin-Park, S., Larocque, O., Kerr, P., Rossi, M., Cartier, L., Juster, R.P., 2023. Sex/gender differences in cognitive abilities. Neurosci. Biobehav. Rev., 105333
Kim, E., Jung, J., Hapsari, G., Kang, S., Kim, K., Yoon, S., Choe, J.K., 2018. Economic and environmental sustainability and public perceptions of rooftop farm versus extensive garden. Build. Environ. 146, 206–215.
Khan, M.M., Akram, M.T., Janke, R., Qadri, R.W.K., Al-Sadi, A.M., Farooque, A.A., 2020. Urban horticulture for food secure cities through and beyond COVID-19. Sustainability 12 (22), 9592.
Krejčí, J., Stoklasa, J., 2018. Aggregation in the analytic hierarchy process: Why weighted geometric mean should be used instead of weighted arithmetic mean. Expert Syst. Appl. 114, 97–106.
Lafortezza, R., Corry, R.C., Sanesi, G., Brown, R.D., 2008. Visual preference and ecological assessments for designed alternative brownfield rehabilitations. J. Environ. Manag. 89 (3), 257–269.
La Rosa, D., Pappalardo, V., 2021. Policies and planning of urban green infrastructure and sustainable urban drainage systems. Urban Serv. Ecosyst.: *Green. Infrastruct. Benefits Landsc. Urban Scale* 297–316.
Lee, K.E., Williams, K.J.H., Sargent, L.D., Farrell, C., Williams, N.S., 2014. Living roof preference is influenced by plant characteristics and diversity. Landsc. Urban Plan. 122, 152–159.

Lindemann-Matthies, P., Briegel, R., Schüpbach, B., Junge, X., 2010. Aesthetic preference for a Swiss alpine landscape: The impact of different agricultural land-use with different biodiversity. Landsc. Urban Plan. 98 (2), 99–109.
Ma, Y., Liang, H., Li, H., Liao, Y., 2020. Towards the Healthy Community: Residents' Perceptions of Integrating Urban Agriculture into the Old Community Micro-Transformation in Guangzhou. China *Sustain.* 12 (20), 8324.
Marselle, M.R., Lindley, S.J., Cook, P.A., Bonn, A., 2021. Biodiversity and health in the urban environment. Curr. Environ. Health Rep. 8 (2), 146–156.
Marsh, P., Gartell, G., Egg, G., Nolan, A., Cross, M., 2017. End-of-Life care in a community garden: findings from a participatory action research project in regional Australia. Health Place 45, 110–116.
Meyer, N., Trandafir, S., 2023. Public attitudes and preferences for green rooftop technologies in the US: a choice experiment. Agric. Resour. Econ. Rev. 1–27.
McClintock, N., Simpson, M., 2018. Stacking functions: Identifying motivational frames guiding urban agriculture organizations and businesses in the United States and Canada. Agric. Hum. Values 35 (1), 19–39.
Nadal, A., Cerón-Palma, I., García-Gómez, C., Pérez-Sánchez, M., Rodríguez-Labajos, B., Cuerva, E., Josa, A., Rieradevall, J., 2018. Social perception of urban agriculture in Latin-America. A case study in Mexican social housing. Land Use Policy 76, 719–734.
Nagase, A., Koyama, S., 2020. Attractiveness and preference of extensive green roofs depend on vegetation types and past experience with plants in Japan. Urban forestry & urban greening 51, 126658. Chicago.
Nazemi Rafi, Z., Kazemi, F., Tehranifar, A., 2020. Public preferences toward water-wise landscape design in a summer season. Urban For. Urban Green. 48.
Nicholas, S.O., Groot, S., Harré, N., 2023. Understanding urban agriculture in context: Environmental, social, and psychological benefits of agriculture in Singapore. Local Environ. 28 (11), 1446–1462.
Ngome, I., Foeken, D., 2012. My garden is a great help": gender and urban gardening in Buea, Cameroon. GeoJournal 77, 103–118.
Pauleit, S., Breuste, J., Qureshi, S., Sauerwein, M., 2010. Transformation of Rural-Urban Cultural Landscapes in Europe: Integrating Approaches from Ecological, Socio-Economic and Planning Perspectives. Landsc. Online 20, 1–10.
Poulsen, M.N., McNab, P.R., Clayton, M.L., Neff, R.A., 2015. A systematic review of urban agriculture and food security impacts in low-income countries. Food Policy 55, 131–146.
Qureshi, S., Haase, D., Coles, R., 2014. The Theorized Urban Gradient (TUG) method—A conceptual framework for socio-ecological sampling in complex urban agglomerations. Ecol. Indic. 36, 100–110.
Qureshi, S., Breuste, J.H., Jim, C.Y., 2013. Differential community and the perception of urban green spaces and their contents in the megacity of Karachi, Pakistan. Urban Ecosyst. 16 (4), 853–870.
Qureshi, S., Hasan Kazmi, S.J., Breuste, J.H., 2010. Ecological disturbances due to high cutback in the green infrastructure of Karachi: Analyses of public perception about associated health problems. Urban For. Urban Green. 9 (3), 187–198.
Qureshi, S., Tarashkar, M., Matloobi, M., Wang, Z., Rahimi, A., 2022. Understanding the dynamics of urban horticulture by socially-oriented practices and populace perception: Seeking future outlook through a comprehensive review. Land Use Policy 122, 106398.
Radić, B., Gavrilovic, S., 2021. Natural habitat loss: Causes and implications of structural and functional changes. Life on Land 699–712.
Rahimi, A., Tarashkar, M., Jahantab, B., 2021. Contribution of Design Indicators in Perception of Social Capital, and Interference of Socio-Demographic Information in the Process. Sustainability 13, 3589.
Reynolds, K., & Cohen, N. (2016). Beyond the Kale: Urban Agriculture and Social Justice Activism in New York City on JSTOR (Vol. 28). University of Georgia Press. https://www.jstor.org/stable/j.ctt189tsck.
Ritchie, H. (2018). Global mental health: Five key insights which emerge from the data. Our World in Data. https://ourworldindata.org/global-mental-health.
Ruggeri, G., Mazzocchi, C., Corsi, S., 2016. Urban Gardeners' Motivations in a Metropolitan City: The Case of Milan. Sustainability 8 (11), 1099.
Safayet, M., Arefin, M.F., Hasan, M.M.U., 2017. Present practice and future prospect of rooftop farming in Dhaka city: A step towards urban sustainability. J. Urban Manag. 6 (2), 56–65.
Saldivar-Tanaka, L., Krasny, M.E., 2004. Cultivating community development, neighbourhood open space and civic agriculture: the case of Latino community gardens in New York City. Agric. Hum. Values 21, 399–413.
Sanyé-Mengual, E., Anguelovski, I., Oliver-Solà, J., Montero, J.I., Rieradevall, J., 2015. Resolving differing stakeholder perceptions of urban rooftop farming in Mediterranean cities: promoting food production as a driver for innovative forms of urban agriculture. Agric. Hum. Values 33 (1), 101–120.
Sanyé-Mengual, E., Specht, K., Krikser, T., Vanni, C., Pennisi, G., Orsini, F., Gianquinto, G.P., 2018. Social acceptance and perceived ecosystem services of urban agriculture in Southern Europe: The case of Bologna, Italy. PLOS ONE 13 (9), e0200993.
Sikorska, D., Macegoniuk, S., Łaszkiewicz, E., Sikorski, P., 2020. Energy crops in urban parks as a promising alternative to traditional lawns – Perceptions and a cost-benefit analysis. Urban For. Urban Green. 49, 126579.
Sillman, D., Rigolon, A., Browning, M.H., McAnirlin, O., 2022. Do sex and gender modify the association between green space and physical health? A systematic review. Environ. Res. 209, 112869.
Subramaniapillai, S., Almey, A., Rajah, M.N., Einstein, G., 2021. Sex and gender differences in cognitive and brain reserve: Implications for Alzheimer's disease in women. Front. Neuroendocrinol. 60, 100879.
Sun, Y., & Shao, Y. (2020). Measuring Visitor Satisfaction toward Peri-urban Green and Open Spaces Based on Social Media Data. Urban Forestry & Urban Greening, 126709.
Simiyu, R.R., Foeken, D.W.J., 2014. Urban crop production and poverty alleviation in Eldoret, Kenya: Implications for policy and gender planning. Urban Stud. 51 (12), 2613–2628.
Sędzicki, D., Cudzik, J., Nyka, L., 2023. Computer-Aided Greenery Design—Prototype Green Structure Improving Human Health in Urban Ecosystem. Int. J. Environ. Res. Public Health 20 (2), 1198.
Thompson, R., 2018. Gardening for health: a regular dose of gardening. Clin. Med. (Lond., Engl.) *18* (3), 201–205. https://doi.org/10.7861/clinmedicine.18-3-201.
Tacca, M.C., 2011. Commonalities between perception and cognition. Frontiers in psychology 2, 358.
Tarashkar, M., Hami, A., Namin, F.E., 2020. The Effects of Parks' Landscape Characteristics on Women's Perceptual Preferences in Semi-arid environments. J. Arid Environ. 174, 104080.
Triguero-Mas, M., Anguelovski, I., Cirac-Claveras, J., Connolly, J., Vazquez, A., Urgell-Plaza, F., Cardona-Giralt, N., Sanyé-Mengual, E., Alonso, J., Cole, H., 2020. Quality of Life Benefits of Urban Rooftop Gardening for People With Intellectual Disabilities or Mental Health Disorders. Prev. Chronic Dis. 17, E126.
Tarashkar, M., Matloobi, M., Qureshi, S., Rahimi, A., 2023. Assessing the growth-stimulating effect of tea waste compost in urban agriculture while identifying the benefits of household waste carbon dioxide. Ecological Indicators 151, 110292.
Tucker-Drob, E.M., Briley, D.A., Harden, K.P., 2013. Genetic and Environmental Influences on Cognition Across Development and Context. Curr. Dir. Psychol. Sci. 22 (5), 349–355.
Vargas-Hernández, J.G., Pallagst, K., Zdunek-Wielgołaska, J., 2023. Urban green spaces as a component of an ecosystem. In *Sustainable Development and Environmental Stewardship: Global Initiatives towards Engaged Sustainability*. Springer International Publishing, Cham, pp. 165–198.
White, E.V., Gatersleben, B., 2011. Greenery on residential buildings: Does it affect preferences and perceptions of beauty? Journal of environmental psychology 31 (1), 89–98.
World Health Organization. (2020). Obesity and overweight. ⟨https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight⟩.
Zhang, X., Khachatryan, H., 2021. Effects of perceived economic contributions on individual preferences for environmentally friendly residential landscapes. Land Use Policy 101, 105125.
Zaidi, Z.F., 2010. Gender Differences in Human Brain: A Review. Open Anat. J. 2, 37–55.
Zoll, F., Specht, K., Opitz, I., Siebert, R., Piorr, A., Zasada, I., 2018. Individual choice or collective action? Exploring consumer motives for participating in alternative food networks. Int. J. Consum. Stud. 42 (1), 101–110.