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Agronomic and organizational aspects of Barcelona's community gardens

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As food security becomes a growing concern in urban areas worldwide, municipal authorities are actively seeking ways to enhance and complement the food systems of their respective cities. Integrating a food system's productive components within city limits has emerged as a promising strategy to achieve these goals. However, it is impractical to undertake urban agriculture to the extent of rural agriculture, such as livestock rearing and large-scale field crop production, due to insufficient and inadequate space within cities. Producing high-value crops, however, is feasible and already practiced in many urban areas around the world within community gardens. This study investigates the agronomic practices and organizational aspects of community gardens within Barcelona's municipal boundaries. It does so through surveys of community garden members and visual inspections of the gardens. The results show that 10 of the 22 most consumed vegetables in Barcelona are harvested within the city's community gardens, highlighting their agrobiodiversity. Based on observed crop yields, if monoculture for each crop produced in the community gardens were practiced across all available urban areas in Barcelona, the city could achieve significant self-sufficiency in those crops. However, to realize this potential, urban horticulture would need to be professionalized, and the city's municipal authorities would have to play a coordinating role.

KEYWORDS

agrobiodiversity, city, food system, production, yield

1 Introduction

Interest in integrating the productive elements of food systems into urban environments has grown significantly in recent years (Besthorn, 2013; Godoi et al., 2018; MUFPP, 2015; Opitz et al., 2016). This interest has been fueled by a growing awareness of urban social equity, as well as environmental and food justice concerns, which have prompted deeper discussions about sustainable urban development (Thornton, 2018). Concerns about the long-term sustainability of cities (Deelstra and Girardet, 2000; Specht et al., 2014) and the declining availability of natural public spaces (McDonald et al., 2013) have further increased the urgency of these discussions. Urban planners and policymakers are now placing greater emphasis on urban food security and exploring the benefits of integrating food production within city boundaries (Zeunert and Waterman, 2018). As a result, municipal governments worldwide are actively exploring the potential of producing food within their jurisdictions (MUFPP, 2015).

Urban agriculture (UA) presents a promising approach to produce food within cities. In addition to providing numerous social and environmental benefits (Bell et al., 2016; Camps-Calvet et al., 2016; Maheshwari et al., 2014; Menconi et al., 2020; Zimmerer et al., 2021), UA can enhance a city's food self-sufficiency and bolster the resilience of its food system (Diehl et al., 2020; Fantini, 2023; Grewal and Grewal, 2012; Langemeyer et al., 2021). However, the ability of UA to meet a city's food consumption needs largely depends on the local urban context and the types of food demanded by its residents (Badami and Ramankutty, 2015; Davidson, 2017; Siegner et al., 2018). The extent to which UA contributes to food self-sufficiency depends on the availability of suitable spaces, the practices used, the methods applied, and the people or groups managing its operations. Moreover, the productivity of UA varies widely, often depending on the technology and methods employed. Reported high yields are frequently derived from controlled experiments conducted by researchers, highlighting the potential of advanced systems. High-tech approaches, such as rooftop greenhouses and plant factories, can deliver significantly higher yields compared to the low-tech systems commonly used in community gardens (CGs) (Diekmann et al., 2020; Drottberger et al., 2023; Oh and Lu, 2023; WinklerPrins, 2017). However, the adoption of high-tech UA to undertake urban horticulture (UH), is frequently limited by the substantial financial and energy costs associated with its implementation and operation (Weidner et al., 2021). Consequently, low-tech UH systems in CGs remain the most widespread form of UA globally, owing to their accessibility and lower resource requirements (WinklerPrins, 2017).

CGs can be described as "safe havens that provide residents with a sense of nature, community, rootedness, and power" (Schmelzkopf, 1995, p. 364). In terms of food, UH in CGs empowers residents to grow their own fruits and vegetables while also delivering intangible benefits that enrich urban living (Barthel et al., 2015; Bassett, 1981; Castañeda-Navarrete, 2021; Furness and Gallaher, 2018). Despite their widespread presence, significant gaps remain in our understanding of key aspects of CGs, including the types of crops cultivated in them, the demographics of participants, and the urban farmer organizational structures that support their operation (Raneng et al., 2023). Barcelona serves as an excellent case study for addressing these knowledge gaps, given its rich tradition of UH within its CGs. While previous research in the city has primarily highlighted the social and environmental benefits of UH in CGs (Camps-Calvet et al., 2016; Domene and Saurí, 2007), little attention has been paid to their agronomic practices, urban farmer organizational structures, or their potential contribution to the city's vegetable supply.

Barcelona, the capital of Catalonia in Northeastern Spain, is home to 1.62 million residents and spans across 101.4 km^2, of which 0.8 km^2 is dedicated to agriculture (idescat, 2025). The city has a long-standing commitment to UA, beginning with the establishment of the Xarxa d'Horts Urbans de Barcelona (Barcelona Network of Urban Gardens, BNUG) in 1997. This initiative encompasses 15 CGs located both within and beyond the city boundaries (Ajuntament de Barcelona, 2024; Morán, 2008). Building on this foundation, Barcelona launched the 2019–2030 Urban Agriculture Strategy as part of the broader "Plan Natura Barcelona 2021–2030." This strategy aims to promote agroecological UH and expand agricultural spaces within the city (Ajuntament de Barcelona, 2019; Gerència d'Àrea d'Ecologia Urbana et al., 2021). Further reflecting its dedication to sustainable urban food systems, Barcelona is a signatory of the Milan Urban Food Policy Pact. Article 20 of this framework, under the section "Recommended actions: food production," explicitly calls for strengthening urban and peri-urban food production (MUFPP, 2015). This strong foundation and commitment to UA underscore the relevance of studying Barcelona's CGs, providing valuable insights into their impact and potential for addressing critical gaps in sustainable food systems.

This study examines the demographics, organizational structures, and agronomic practices of CGs within Barcelona's municipal boundaries. Data were collected through member surveys and on-site visits. Understanding these organizational frameworks is crucial for assessing the scalability of observed agronomic practices to a city-wide level. Furthermore, this research addresses four key empirical gaps identified by Guitart et al. (2012) and reaffirmed by Raneng et al. (2023): the variety of crops grown, UH production modalities, organizational structures within CGs, and their land tenure status. By bridging these gaps, the analysis offers valuable insights into the potential of these practices to contribute to Barcelona's food self-sufficiency and overall urban sustainability goals.

2 Materials and methods

A thirty-question questionnaire, comprising 11 multiple-choice and 19 open-ended questions, was developed based on an extensive review of literature on CGs, UA, horticulture, and agronomy (Annex I). The questionnaire was structured into six sections, each addressing key aspects of the agronomic and organizational characteristics of CGs: (i) the history of the CG, (ii) its physical and social characteristics, (iii) the characteristics of its members, (iv) communication among members, (v) decision-making processes, and (vi) agronomic practices. These sections formed the basis for semi-structured interviews conducted with CG members. Ethics approval for this study was obtained from the Comisión de Ética en la Experimentación Animal y Humana of the Autonomous University of Barcelona on July 15, 2022. Interviews were conducted face-to-face with CG members who provided informed consent. To ensure participant anonymity, no identifiable personal information was collected, and CGs were assigned generic codes rather than being explicitly named in the study. Community gardens included in the analysis were identified and contacted through multiple methods. These included searches on municipal websites for the BNUG and the Empty Urban Spaces with Territorial and Social Involvement (Pla BUITS) program, a component of the Plan Natura Barcelona 2021–2030. Additional CGs were identified through exploratory visits across Barcelona, including the location of informal "squatter" gardens. Snowball sampling was also employed in one instance to recruit participants (Goodman, 1961).

In addition to gathering demographics, organizational structures, and agronomic practices data, a specialized assessment tool was developed to visually document five key physical characteristics of the CGs visited during the study (Annex II). This tool facilitated the recording of: (i) the geometric shape of the area over which the garden spans, (ii) the presence and type of barriers surrounding it, (iii) whether these barriers obstruct sunlight, (iv) the slope of the garden relevant to water drainage, and (v) the destination of water runoff, such as infrastructure for water retention or treatment, or direct drainage into the municipal sewer system. While self-reported data from interviews may introduce potential biases, such as recall bias or social desirability bias, which

TABLE 1 Visited community garden typology.

Community garden type and number of complete interviews done	Garden code	Garden's stated purpose	Garden size[a] (m^2)	Garden shape	CG decision-making mechanism
Community (2)	COM1	Nature in urban area	1,088	Rectangular	Neighbor Managed[b]
	COM2	Social cohesion & therapy	422	Square	Administrator takes major decisions
	COM3	Youth centre	456	Irregular	Administrator takes major decisions
Empty urban spaces with territorial and social involvement (0)	EUSTS1	Temporary administration of unused municipal land	101	Triangular	How decisions about the CG are to be made is left up to CG members
	EUSTS2		662	Rectangular	
Civic centre (1)	CIV1	Hobby for its members	355	Rectangular	Administrator makes sure rules are followed
Squatter (1)	S1	Social cohesion	478	Square	Unknown
	S2	Social cohesion	463	Square	Unknown
	S3	Stop real estate development	225	Rectangular	Majority vote
Barcelona network of urban gardens[b] (8)	BNUG1	≥ 65-year-old Barcelona citizen involvement in UA	369	D-Shaped	The municipality has set forth a set of rules members must comply with. The CG administrator enforces the rules.
	BNUG2		5,620	Square + Rectangular (L-Shaped)	
	BNUG3		2,807	Square	
	BNUG4		532	Triangular	
	BNUG5		736	Square	
	BNUG6		667	Rectangular	
	BNUG7		1,462	Rectangular	
	BNUG8		10,115	Rectangular	
	BNUG9		1,111	Triangular	

Only CGs inside of Barcelona's municipal boundaries that are part of this network were visited. Garden sizes are rounded to nearest whole number. Total garden area visited: 27,669 m^2.
[a]Garden sizes were measured using Google Maps' total area estimation tool after a visit.
[b]The amount of influence in the garden's management is a function of garden attendance (how often a volunteer visits the garden).

could influence the findings, the agronomic characteristics of the CGs were documented directly by the researchers to the extent possible. The primary objective of documenting these features was to identify potential constraints affecting the optimal use of CG spaces and to analyze how water runoff is managed. Such insights are vital for agronomists, as they enable the formulation of tailored recommendations for improving horticultural practices in these gardens. Notably, Eriksen-Hamel and Danso (2011) highlight the scarcity of such detailed physical data in existing CG literature, underscoring the importance of this contribution.

3 Results

3.1 Typification of visited CGs

A total of 18 gardens, with varying stated main purposes or objectives were visited between July and November 2022 (Table 1). Though all 18 gardens were community CGs, they could be classified further based on their stated main objective into: Empty Urban Spaces with Territorial and Social Involvement Gardens (Pla BUITS), Civic Center Garden, Squatter Gardens, and the BNUG. Of the 18 CGs visited, full interviews were conducted with members of 12 gardens. The remaining six gardens provided only limited information, as their members did not agree to participate in full interviews. All 18 CGs possessed some form of artificial barrier designed to restrict its access only to members or authorized people. It was explained by most members interviewed that without a barrier, theft of crop production would occur.[1] Interestingly, interviewed CG members seldom knew about the existence of other CGs throughout the city. Therefore, snowball sampling was only possible in one instance (i.e., one CG was visited, and thanks to this visit another CG was visited). Moreover, identifying squatter gardens was simple but interviewing a member of one of these gardens was only possible in one instance. Visited squatter gardens were either some form of protest or project in social cohesion,[2] but their members were very reluctant to discuss any aspect of the CG with the researchers undertaking this study. The reluctance of members to discuss their CG, particularly those product of grassroot efforts, is not unique to Barcelona as Schmelzkopf (1995) previously encountered the same phenomenon in CGs in New York.

1 One member expressed that theft of crops and garden tools has occurred in his CG.

2 This was determined because all three visited squatter gardens had signs stating their purpose.

3.2 Community garden history

The first community garden visited was established in 2013, the second in 2019, and the one in the civic center in 2006. As previously mentioned, the BNUG began in 1997 and has grown to include 15 gardens. Community gardens established through the Pla BUITS scheme are a newer and more dynamic phenomenon throughout the city. These gardens are mainly managed by schools, neighborhood associations, and NGOs. Their establishment dates vary since they are created whenever the municipality designates suitable idle land for their establishment. Members of these gardens understand that the municipality can reclaim the land at any time. Furthermore, the establishment dates for two of the visited squatter gardens were unknown, while the third was established in 2019. Due to their physical constraints, being surrounded by residential buildings or roads, it is unlikely these squatter gardens have expanded since their inception. No other visited CG has changed in size since its foundation.

Members of the BNUG and one community garden were the only ones confident that their gardens would still exist five years from now, totaling 10 gardens. In contrast, members of the eight other gardens expressed doubts about their permanence. The BNUG maintains accurate membership records, requiring members to live within the district where the garden is located to be assigned a plot. Plots, varying in size depending on the garden, are assigned for a single five-year period. After this period, plots are reassigned to new incoming members, and those who vacate a plot cannot solicit a new one within the network. In other gardens, determining the number of members was challenging due to a lack of record-keeping. COM3, for example, focuses on serving at-risk youth, resulting in fluctuating membership. COM1 reported having over 500 registered members, but fewer than 20 visit regularly (at least once a week), according to an interviewed member. The member from the S3 garden noted that while new members are regularly added, their activity levels vary. It was impossible to determine the membership numbers of the two squatter gardens. Only COM1, COM2, and COM3 reported having regular volunteers, who are typically retirees, assisting with the gardens' activities.

3.3 Garden decision-making mechanism, member aspects, and communication

All visited CGs were found to have an organizational structure created by or adhered to by their members, directly influencing how decisions are made within these spaces. In the BNUG, garden administrators are appointed to ensure compliance with rules established by Barcelona's municipal authorities. Members of these gardens reported that "minor events" are typically referred to the garden administrator, who is responsible for enforcing the Network's rules or mediating disputes. However, interviewees emphasized that such occurrences are rare. Notably, all BNUG members interviewed were aged 65 or older (Table 1). In contrast, members of self-administered gardens whether community, private, or squatter reported no instances of conflict.

Three distinct decision-making mechanisms were observed across the CGs studied. For CGs administered through the Pla BUITS initiative, entities are free to adopt decision-making processes that best suit their needs. Conversely, BNUG members voluntarily follow a top-down decision-making structure aligned with the Network's regulations. One unique example is the COM2 garden, where three separate entities coexist and manage their allocated spaces within the CG using two distinct decision-making mechanisms: (i) majority voting and (ii) consensus-based decisions. Each of the three entities within COM2 pursues a distinct objective. One entity focuses on scaling up UH innovations and uses a majority-vote mechanism for decision-making. The second entity works with individuals with special needs, employing UH as a form of therapy. The third entity provides UH opportunities for African refugees. Despite their differing goals and decision-making structures, these entities co-inhabit the space harmoniously due to clear delineation of their respective areas. The member interviewed from this CG noted that conflicts have not arisen, largely because two of the three entities prioritize member interaction over food production, resulting in minimal competition for limited gardening space.

Communication among CG members occurs primarily in person, via social messaging apps (including text messages), or a combination of both. Among the 12 members fully interviewed, communication among all garden members was described as rare. This is because activities within these gardens are typically not collective. Instead, members have individual plots or designated areas that they manage independently, reducing the need for interaction or coordination with others.

3.4 Crop cultivation practices and sustainability in community gardens

The crops listed in Table 2 were observed to be cultivated in all visited CGs. Artichoke (*Cynara scolymus*) and chayote (*Sechium edule*) were observed in small quantities in only one garden and were therefore excluded from Table 2. Among the crops, tomato was the most extensively cultivated, present in the majority of individual plots across all visited CGs and grown in all observed modalities: directly in the ground, in elevated beds, and on elevated tables. Quantifying the cultivated area for individual crops was not feasible due to the predominant agricultural production system in the visited CGs, namely polyculture (Figure 1). This system is characterized by the cultivation of multiple crop species within a single area and the absence of synthetic inputs for crop management (Adamczewska-Sowińska and Sowiński, 2020). Similarly, it was not possible to quantify crop yield per square meter for the same reason. To address this limitation, average yield data from organic horticultural systems, considered a comparable production model, were used. These organic yields were then contrasted with conventional horticultural yields to provide context.[3] Polyculture, a production modality at the low-tech end of the urban horticulture (UH) spectrum, typically results in lower yields compared to high-tech UH systems. For instance, Edmondson et al. (2020) reported that controlled environment horticulture in the United Kingdom produces tomato yields of 42.9 kg/m^2 per year, significantly higher than the 22.4 kg/m^2 per year achieved in Barcelona.

CG members reported that the crops grown in their respective gardens have remained consistent since they began participating,

3 Conventional agriculture is understood here as agriculture that makes use of synthetic inputs (fertilizers, pesticides, etc.).

TABLE 2 Crops grown in Barcelona's community gardens.

Common name	Latin name	Conventional yield (kg/m^2)	Organic yield[b] (kg/m^2)
Basil[a]	*Ocimum basilicum*	360 leaves per plant	219 leaves per plant
Bell pepper	*Capsicum annuum*	22.5	15.3
Cucumber	*Cucumis sativus*	27.5	18.7
Egg plant	*Solanum melongena*	23.7	16.6
Lettuce	*Lactuca sativa*	22.6	15.4
Onion	*Allium cepa*	31.3	21.3
Pumpkin	*Cucurbita maxima*	35.6	24.2
Squash	*Cucurbita*	29.1	19.8
Tomato	*Solanum lycopersicum*	33	22.4
Zucchini	*Cucurbita pepo*	29.5	20

Conventional yield data based on MAPA (2022). These yields correspond to open field production, i.e., no physical structure protecting against pests.
[a]Based on Sifola and Barbieri (2006). Plants in this experiment were irrigated every three days.
[b]Organic yields were obtained from Lesur-Dumoulin et al. (2017) who found that organic horticulture yields are on average 10 to 32% lower than those of conventional horticulture. The value of −32% yield was taken to compare a 'worst case' scenario for organic yields compared with average conventional yields.

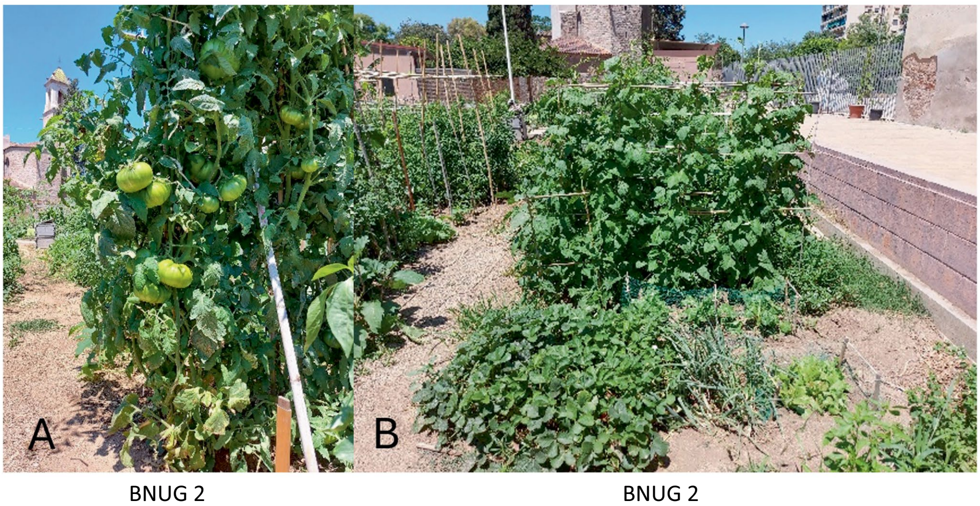

FIGURE 1
Poly culture in Barcelona's community gardens. **(A)** Tomato plant is growing organically. **(B)** The polyculture on the same individual plot is shown.

with no novel crops introduced. The primary reasons cited for selecting specific crops included: (i) ease of cultivation, (ii) alignment with crops grown by other CG members, and (iii) personal preference for consuming those crops. Members sourced seeds from a variety of sources, including rural farmers, purchased seeds, and seeds salvaged from vegetables purchased at local supermarkets.

In the BNUG gardens, the use of synthetic inputs is prohibited. Similarly, members of all other visited CGs voluntarily reported practicing UH without synthetic inputs. Among the three visited squatter gardens, members from one garden (S3 in Table 1) explicitly stated that synthetic inputs were not used, while information on fertilizer use in the other two squatter gardens remains unknown. All CGs reported the use of compost as fertilizer. In most BNUG gardens (7 of 9), horse manure was also applied as a natural fertilizer. However, exact quantities and application frequencies could not be determined due to a lack of record-keeping by garden members. The manure was either purchased or obtained as a donation.

Members across all CGs expressed a belief that their gardens were managed sustainably. Interestingly, the majority (10 out of 12 respondents) reported growing the same crops in their plots without practicing crop rotation. Visual inspections of the crops revealed no significant signs of disease or major insect damage in any of the visited CGs, including the squatter gardens. However, members reported mice, rats, and the common city pigeon (*Columba livia domestica*) as the primary pests affecting their crops. Efforts to mitigate pest damage, particularly from pigeons, through methods such as protective nets or scarecrows were deemed largely ineffective (Figure 2).

3.5 Water management in Barcelona's community gardens

In all the CGs visited, irrigation water is sourced from the municipal water supply. CG members are not charged for their water usage and have unrestricted access to this resource, using it as needed

FIGURE 2
Nets are utilized to protect crops from potential damage caused by pigeons and rats. In the image on the left (CIV1), nets are installed on tables to protect crops from pigeons. The central image (BNUG 8) shows nets placed on the ground, providing protection against both mice and pigeons. In contrast, the image on the right (BNUG 4) features a scarecrow used as a deterrent to prevent pigeons from disturbing recently planted crops.

without any monitoring or awareness of the quantities consumed. Manual irrigation using hoses is the standard practice across all observed gardens. Notably, all the CGs rely on potable water for irrigation, with the exception of BNUG3, which utilizes water from its own well for gardening activities. This unregulated water use is particularly significant given Barcelona's increasing vulnerability to droughts, a challenge that is intensifying in both frequency and severity due to climate change (Wilson, 2023). Despite these conditions, none of the visited CGs monitor their water consumption. Furthermore, all water used in these gardens ultimately drains untreated into the municipal sewer system, highlighting a potential area for improving water management practices in UA.

3.6 Physical characteristics of Barcelona's CGs

All of the CGs visited during the study are located on sites that previously housed buildings. In the BNUG network, all gardens except BNUG3[4] have undergone topsoil replacement to eliminate the risk of soil contaminants being translocated into vegetables and fruits consumed by garden members. Notably, a significant portion of the surface area in each CG was covered by cement or structural remnants, which restricted the feasibility of on-ground UH. In an extreme example, the CIV1 garden was entirely situated on a cement floor, as it was located on the roof of a community center. In cases where on-ground UH is physically unviable, members have adapted by cultivating crops in elevated beds or on raised tables (Figure 3).

4 Discussion

An agronomic and organizational assessment of 18 CGs across Barcelona reveals that 10 of the 22 most consumed vegetables in Catalonia are cultivated within these spaces (MAPA, 2024). This indicates a notable level of agrobiodiversity in the city's CGs. If the yields achieved in these gardens were scaled up to a city-wide level, they could contribute partially to meeting Barcelona's overall vegetable consumption needs. Garden members have demonstrated adaptability by tailoring their production techniques to the unique conditions of their respective spaces. Crops are cultivated directly in the ground where feasible, while raised tables are utilized in areas where on-ground horticulture is not possible. Despite these innovations, it is important to recognize that all CG activities are carried out on a voluntary basis. Consequently, relying solely on volunteer efforts to achieve Barcelona's food self-sufficiency goals is not a sustainable long-term strategy for enhancing the resilience of the city's food system.

In terms of infrastructure, the BNUG community gardens are particularly well-suited to contribute to the productive component of Barcelona's urban food system, especially for vegetable cultivation. Several factors support this assessment. While UH in Barcelona's CGs is primarily practiced as a hobby, a therapeutic activity, or a means of social interaction, and the BNUG gardens are no exception, these gardens stand out for their superior management. Moreover, the BNUG gardens possess key infrastructure features that could be repurposed for urban vegetable production, including reliable water access and adequate space. Another significant advantage of the BNUG is its sustained municipal support, which ensures its continued operation. In contrast, the future of CGs outside this network, with the exception of COM1, remains uncertain. This is particularly true for squatter gardens and those established under the Pla BUITS scheme, where long-term viability is not guaranteed. Consequently, it is impractical to base a new urban food system on CGs with an uncertain future.

A notable challenge facing CGs in Barcelona, particularly the COM1–3 gardens, is the lack of sustained member participation. This phenomenon is not unique to Barcelona and has been documented in CGs globally (Feinberg et al., 2021a; Feinberg et al., 2021b; Feinberg et al., 2021c). Broadstone and Brannstrom (2017) similarly identify the difficulty of securing committed participants as the primary, and often sole, challenge for CGs in Houston, USA. In the case of Barcelona, the limited engagement of members is understandable, as these gardens are predominantly used as recreational spaces by retirees or as therapeutic environments for individuals with special needs.

4 This garden is located near the Collserola mountain range and retains its original soil.

FIGURE 3
In the left panel **(A)**, African refugees cultivate their crops in ground-level wooden beds. In contrast, the right panel **(B)** depicts individuals engaging in UH as a form of therapy, utilizing elevated tables designed for accessibility, particularly for individuals who use wheelchairs and for whom ground-level beds are unsuitable. Notably, some of these elevated tables are constructed from metal, which, due to their intense red coloration and exposure to direct sunlight, retain high temperatures throughout much of the day. This sustained heat could have significant implications for crop irrigation, potentially increasing water requirements to offset heightened evaporation and water loss caused by the elevated temperatures.

4.1 Urban horticulture productivity and food self-sufficiency potential in Barcelona's community gardens

UH practices in Barcelona's CGs reflect a partial adaptation of rural agricultural systems to the urban context. This is evident in the focus on field crop cultivation. However, unlike the monoculture commonly practiced in rural agricultural systems, CG members in Barcelona universally employ polyculture. As shown in Table 2, the productivity of UH in Barcelona is 10 to 32% lower than conventional agriculture under optimal conditions, such as direct ground cultivation, absence of pests or diseases, and intensive use of agricultural inputs.

Given the maximum of 0.8 km^2 (80 hectares) of land available for UA in the city, scaling up the current UH practices could only meet a significant proportion of Barcelona's vegetable demand if monoculture under ideal conditions were adopted. For instance, in 2022, Barcelona's citizens consumed 28,416 tons of tomatoes (MAPA, 2024).[5] Using the organic tomato yield projections from Table 2 and assuming full utilization of the available area for tomato cultivation over a single growing cycle (~7 months), a theoretical production of 17,920 tons could be achieved, equating to 63% of the city's annual tomato consumption. However, this projection is based on several improbable assumptions: that all available UA land is used exclusively for tomatoes, CG members universally agree to cultivate a single crop (contrary to the prevailing polyculture practices), no pests or diseases affect yields, and the municipal authorities ensure a sufficient water supply for cultivation. Given these constraints, this scenario remains a theoretical exercise. Nevertheless, it underscores the potential production capacity of UH in CGs. If systematically and strategically implemented, UH could make meaningful contributions to Barcelona's food self-sufficiency, albeit primarily for specific crops consumed fresh, such as tomatoes.

5 The Ministry of Agriculture of Spain (MAPA) reports per capita data for Catalonia consumption. This data for 2022 was aggregated and assumed to be representative of the citizens of Barcelona. According to idescat (2024), in 2024 Barcelona had a total population of 1,686,208 residents.

4.2 Potential contamination of UH products in Barcelona

Crops produced within Barcelona's urban environment may not be entirely free of contamination. Rodríguez-Bocanegra et al. (2018) highlight the growing interest in locally and sustainably produced food, emphasizing the importance of monitoring potentially toxic element concentrations in urban soils. Their study focused on soil in an empty urban space in the Sants district, located in southeastern Barcelona, a former industrial area previously occupied by a metal smelting industry. The results revealed that tomato plants cultivated in this neighborhood contained elevated levels of copper (Cu), lead (Pb), and zinc (Zn) in their shoots. Additionally, drainage water from the CG where these crops were grown showed high concentrations of Pb, exceeding 10 μg L − 1. Lead, in particular, is of significant concern for UA due to its extreme toxicity and prevalence in urban soils (Finster et al., 2004).

Even efforts to remediate soil contamination in urban gardens often yield mixed results, with no guarantee of effectively neutralizing heavy metal pollutants (Paltseva et al., 2020; Una et al., 2022). Beyond soil contamination, urban crops are also vulnerable to airborne pollution. For instance, Antisari et al. (2015) note that heavy metals can be deposited on crop surfaces through air pollution. Ercilla-Montserrat et al. (2018) found that lettuce grown in urban settings accumulated heavy metals from the air, although at concentrations well below the European Union's maximum allowable levels.

Given that most of Barcelona's CGs are situated at ground level, further research is necessary to assess whether crops grown in these spaces are similarly affected by airborne heavy metal contamination. Such studies are essential for understanding the full scope of potential risks associated with UH in CGs in Barcelona.

4.3 Enhancing UH in Barcelona: the need for municipal coordination and professionalization

Barcelona's CGs hold potential to contribute meaningfully to the city's vegetable supply through UH. However, achieving significant production levels would require the adoption of monoculture practices for specific crops currently cultivated in these gardens. Realizing this goal necessitates greater involvement and coordination by municipal authorities to streamline production efforts. Such an approach would enhance the efficiency and impact of UH in meeting Barcelona's vegetable demand, contrasting with rural food production systems, where farmers base their decisions on factors such as expertise and market prices. Given the fundamental differences between urban and rural agricultural contexts, and considering Barcelona's longstanding commitment to expanding UA through various agreements and legal instruments, the economic motivations for UH expansion could be redefined. For example, the municipality could provide urban farmers with access to garden areas under its administration without charging fees for vegetable production. Additionally, ensuring a free water supply for CGs could further incentivize UH and remove barriers to its expansion. These policy adjustments would encourage a more productive integration of UH within the city's CGs. Such a shift, however, would also require a transformation in the profile of the urban farmer. If UH is to significantly contribute to Barcelona's food supply, it cannot continue to rely solely on volunteer efforts. Instead, it must evolve into a professionalized activity. Mcdougall et al. (2020) underscore this point, noting that "amateur" labor, as observed in their study of urban agriculture in Sydney, is insufficient to sustain a productive urban food system. Further research is needed to explore the extent to which Barcelona's municipal authorities are willing and able to coordinate the productive capacities of this emerging urban food system. Additionally, understanding the ideal profile of an urban farmer in Barcelona's CGs is crucial for designing policies that can support the transition to a more professionalized and impactful urban agriculture model.

Data availability statement

Requests to access the datasets should be directed to the corresponding author.

Author contributions

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2025.1459265/full#supplementary-material

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