Fronteiras: Journal of Social, Technological, and Environmental Science
http://periodicos.unievangelica.edu.br/fronteiras/
ISSN 2238-8869

Article

Urban Agriculture and the Sustainable Development Goals: A Comparative Study of Curitiba, Paraná, and Belo Horizonte, Minas Gerais

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ABSTRACT
Urban Agriculture (UA) is understood as a cross-cutting strategy for more inclusive, healthy, and resilient cities, integrating local food production, organic waste composting, water management, food education, and the social use of land. The main objective of this study was to analyze how UA, supported by composting initiatives, water management practices, and food governance arrangements, contributes to achieving the targets of Sustainable Development Goals (SDGs) 2, 6, 11, and 12 and to ensuring food and nutritional security in the Brazilian cities of Belo Horizonte (Minas Gerais) and Curitiba (Paraná). This qualitative, descriptive-analytical study compares, using 19 (nineteen) indicators and 5 (five) thematic axes from the Urban Systems platform and official sources (IBGE, SNIS, among others), the results of the AU in Curitiba and Belo Horizonte for the 2023–2024 biennium, combining a literature review and documentary research without the application of inferential statistical tests; it is therefore characterized as a qualitative approach based on secondary indicators. The data collected reveal complementary and asymmetrical trajectories in the two state capitals. Belo Horizonte excels in sanitation, dry waste management, and the regulatory framework for urban agriculture, but lacks direct agri-food indicators. Curitiba has multiscale arrangements and operational strength in composting, with the potential to close organic cycles, but faces challenges in water efficiency, the availability of data by area/ha, and social participation. Limitations include gaps in production and organic indicators. Considering these results, thematic mapping and neighborhood-level monitoring are suggested to prioritize vegetable gardens, cisterns, and compost bins in vulnerable areas. The study's central contribution lies in proposing an integrative SDG–AU–SAN–Circular Economy framework capable of supporting the development of comparable indicators, urban monitoring, and the formulation of public policies.
Keywords: Urban agriculture; Food and Nutritional Security; Composting; SDGs; Urban indicators.

RESUMO
A Agricultura Urbana (AU) é compreendida como estratégia transversal para cidades mais inclusivas, saudáveis e resilientes, integrando produção de proximidade, compostagem de resíduos orgânicos, manejo hídrico, educação alimentar e uso social do solo. O objetivo principal desse estudo foi analisar de que forma a AU, apoiada por iniciativas de compostagem, práticas de manejo hídrico e arranjos de governança alimentar, contribui para o alcance das metas dos Objetivos do Desenvolvimento Sustentável ODS 2, 6, 11 e 12 e para a efetivação da Segurança Alimentar e Nutricional nas cidades brasileiras Belo Horizonte (Minas Gerais) e Curitiba (Paraná). Este estudo é qualitativo, de caráter descritivo-analítico, que compara, por meio de 19 (dezenove) indicadores e 5 (cinco) eixos temáticos da plataforma Urban Systems e de fontes oficiais (IBGE, SNIS, entre outros), os resultados da AU em Curitiba e Belo

Submission: 14/11/2025 Accepted: 19/06/2026 Publication: 14/11/2026

Vol. 15, No. 3, 2026 • pp. 1–13. • DOI http://dx.doi.org/10.21664/2238-8869.2026v15i3.8418

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Horizonte, no biênio 2023–2024, combinando revisão bibliográfica e pesquisa documental, sem aplicação de testes estatísticos inferenciais, caracterizando-se, portanto, como uma abordagem qualitativa baseada em indicadores secundários. Os dados levantados evidenciam trajetórias complementares e assimétricas nas duas capitais. Belo Horizonte sobressai em saneamento, gestão de resíduos secos e marco regulatório de AU, porém necessita de indicadores agroalimentares diretos. Curitiba possui arranjos multiescalares e força operacional em compostagem, com potencial para fechamento de ciclos orgânicos, mas enfrenta desafios na eficiência hídrica e na disponibilização de dados por área/ha e participação social. Limitações incluem lacunas nos indicadores de produção e orgânicos. Considerando esses resultados, sugere-se mapeamento temático e monitoramento por bairro, para priorizar hortas, cisternas e composteiras em áreas vulneráveis. A contribuição central do estudo consiste na proposição de uma moldura integradora ODS–AU–SAN–Economia Circular, capaz de subsidiar a produção de indicadores comparáveis, o monitoramento urbano e a formulação de políticas públicas.
Palavras-chave: Agricultura urbana; Segurança Alimentar e Nutricional; Compostagem, ODS; Indicadores urbanos.

Introduction

Urban agriculture (UA) has been recognized as a cross-cutting strategy to promote more inclusive, healthy, and resilient cities by linking local agri-food production, organic waste composting, food education, public health, and social land use (RUAF Foundation 2019; UN-Habitat 2020; Mougeot 2000; Smit et al. 1996).

In the context of discussions on urban agriculture and support for the SDGs in Brazilian cities, it is emphasized that "sustainability, historically guided by an anthropocentric bias, has been challenged by approaches that emphasize the ontological interdependence between humans and non-humans" (Putini & Klanovicz 2025), which reinforces the need to understand urban agriculture as a socio-ecological practice and not merely a productive one.

Thus, these initiatives strengthen short food supply chains, expand access to fresh and nutritious food, and enhance urban ecosystem services, establishing themselves as a relevant component of contemporary urban policies.

Within the framework of the 2030 Agenda, urban agriculture establishes a direct link with several Sustainable Development Goals: SDG 2 (Zero Hunger and Sustainable Agriculture), SDG 6 (Water and Sanitation), SDG 11 (Sustainable Cities and Communities), and SDG 12 (Responsible Consumption and Production), requiring integrated policies, comparable indicators, and intersectoral governance for their implementation (IPEA 2024; UN 2015).

In Brazil, this dialogue is linked to Food and Nutritional Security (SAN), understood as a human right and structured by public policies that integrate food supply, assistance, education, and health, in accordance with Law No. 11,346/2006 (Organic Law on Food and Nutritional Security—LOSAN) and the National System for Food and Nutritional Security (SISAN), which consolidate guidelines for cooperation between the State and society (Brazil 2006). The classic definition by *the Food and Agriculture Organization of the United Nations* (FAO, 2009) frames the understanding of food and nutritional security (FNS) as "regular and permanent access to safe, nutritious, and sufficient food for an active and healthy life" (FAO 2023; FAO 2009).

National and international literature associates urban agriculture with social, environmental, and economic co-benefits, especially when combined with ecological infrastructure (community and school gardens, courtyards and compost bins, water harvesting and reuse) and short supply chains, which increase local resilience and food sovereignty (Instituto Escolhas 2024; RUAF Foundation 2019; Orsini et al. 2013).

Among this set of practices, urban composting deserves special mention for closing nutrient cycles, reducing greenhouse gas emissions, and improving soil quality, thereby contributing directly to the goals of SDGs 2, 6, 11, and 12 (IPT 2024; UN-Habitat, 2020).

In light of this, the question guiding this study emerges: How does urban agriculture (UA), supported by initiatives in composting, water management, and food governance, contribute to achieving SDGs 2, 6, 11, and 12 and to ensuring food and nutrition security (FNS) in Brazilian cities? Thus, the main objective is to analyze how Urban Agriculture, supported by such initiatives, contributes to these SDGs and to Food and Nutritional Security by comparing Curitiba, Paraná, and Belo Horizonte, Minas Gerais, during the 2023–2024 biennium, using 19 indicators and 5 thematic areas from the Urban Systems platform and official sources.

The rationale for this study stems from the low comparability of agri-food indicators among Brazilian state capitals, the asymmetry in data on production and organic farming, and the need to consolidate empirical evidence capable of informing public policies and guiding urban planning. Investigating the role of urban agriculture in these contexts helps strengthen intersectoral governance, improve municipal monitoring, and assist in prioritizing initiatives such as community gardens, cisterns, and compost bins in vulnerable urban areas.

This is a comparative study that combines a literature review with documentary research. The literature review updates and underpins the theoretical framework through the analysis of published works (Donthu et

al. 2021; Snyder 2019), while the documentary research allows for the incorporation of a temporal dimension and tracks the maturation and evolution of policies and indicators (Cellard, 2008; Lüdke & André 1986).

The database includes standardized indicators and thematic areas from official sources and urban platforms, such as IBGE, SNIS, Siconfi, Senatran, ANTT, Caged/Rais, DataSUS/CNES, and Urban Systems, as well as documents from the UN/UN-Habitat and ABNT NBR ISO 37120/37122 standards. The information was processed using methodological consistency, a descriptive analysis by thematic areas, and triangulation among indicators, legal frameworks, and the literature (UN-Habitat, 2020).

As a contribution, this study proposes an integrated SDG–AU–SAN–Circular Economy framework capable of informing urban monitoring and public policies, as well as suggesting the development of thematic maps and neighborhood-level monitoring to support the prioritization of community gardens, cisterns, and compost bins in vulnerable areas.

Theoretical Framework

Urban Agriculture (UA)

UA is broadly understood as the "set of activities involving the production, processing, and distribution of food and non-food goods in intra-urban and peri-urban areas, integrating productive uses of land, water, and inputs into the urban fabric" (Mougeot 2000; Smit et al. 1996).

In addition to the classic definition, recent literature emphasizes the multifunctionality of UA—that is, its ability to simultaneously deliver ecological, social, economic, and cultural benefits, ranging from food provision and income generation to ecosystem services, education, and community cohesion (UN-Habitat, 2020; Ruaf Foundation, 2019; Orsini et al., 2013; Lovell, 2010).

In terms of types, urban agriculture ranges from home and community gardens to institutional facilities (schools, health care facilities) and small- and medium-sized commercial enterprises, often guided by agroecological principles and short supply chains (Castro, 2025; UN-Habitat, 2020; Smit et al., 1996).

In the Brazilian context, academic and technical-policy literature simultaneously highlights the breadth of the phenomenon and its regulatory challenges, including access to land and water, sanitary quality, environmental monitoring, and food safety, as well as integration with urban and waste management policies (Castro, 2025; Instituto Escolhas, 2024; ;; Embrapa, 2023; Bizerra, 2016; Machado & Machado, 2002).

These challenges underscore the need for intersectoral governance (health, social assistance, education, environment, economic development) and for tools such as municipal plans, seed banks, biofactories, and composting programs incorporated into urban planning (Castro, 2025; IPT, 2024; Instituto Escolhas, 2022; Rocha & Lessa, 2009).

From a functional perspective, the literature converges on three axes.

a) Ecological axis: Urban Agriculture promotes nutrient cycling (particularly when combined with composting), increased biodiversity, shade, microclimatic regulation, and water infiltration in green-productive infrastructure (IPT 2024; UN-Habitat, 2020; Ruaf Foundation, 2019; Orsini et al., 2013).
b) Social dimension: productive gardens and backyards strengthen food and environmental education, community participation and bonds, and contribute to Food and Nutritional Security (FNS) (Instituto Escolhas, 2024; Instituto de Saúde-SP, 2024; Maluf et al., 1996).
c) Economic dimension: Urban Agriculture (UA) stimulates short supply chains, reduces logistics costs, and can create job and income opportunities at the household, community, and entrepreneurial levels (Castro, 2025; Zezza & Tasciotti, 2010; Smit et al., 1996).

Empirical evidence supports this view. National studies link AU to improvements in public health, the enhancement of public spaces, and social learning, especially when implemented in schools and community centers (Martinello & Benincá 2024; Instituto de Saúde-Sp, 2024; Camelo et al. 2023).

Local research demonstrates the potential for income generation, strengthening social participation, and reducing vulnerabilities in urban areas, with effects on diet and food diversity (Soares et al. 2024; Zezza & Tasciotti 2010).

At the same time, reviews and assessments systematize the state of the art of urban and peri-urban agriculture (AUP) in the country, highlighting advances and gaps, notably in the standardization of indicators,

open data, and integration with land-use, water, and waste management policies (Castro, 2025; IPEA, 2024; IPT, 2024; Bizerra, 2016).

Finally, the literature recommends establishing comparable metrics—such as the number of gardens/production units, area (m^2), production (t/year), beneficiaries, reused water (m^3/year), composted organic matter (t/year), and avoided emissions (tCO_2e/year)— to guide policies and enhance social participation (IPEA, 2024; IPT, 2024; Instituto Escolhas, 2024; UN-Habitat, 2020).

SDGs 2, 6, 11, and 12: Interfaces with UA

Urban agriculture (UA) serves as a convergence point between the social, environmental, and economic agendas of the 2030 Agenda, transforming global principles into concrete territorial arrangements. By bringing production and consumption closer together, repurposing underutilized spaces, and promoting the local circulation of materials and energy, UA makes the goals of SDGs 2, 6, 11, and 12 tangible (IPEA, 2024; UN-Habitat, 2020; UN, 2015).

Under SDG 2 (Zero Hunger and Sustainable Agriculture), the AU can contribute to regular access to safe and nutritious food, as outlined in Target 2.1, and to sustainable and resilient agri-food systems, as outlined in Target 2.4, by strengthening home, community, and school gardens; promoting short supply chains; and directing public procurement toward *fresh* foods. Evidence points to an association between urban agriculture, dietary diversity, and improved diet quality, particularly in contexts of greater vulnerability (Instituto Escolhas, 2024; Camelo et al., 2023; UN-Habitat, 2020; UN, 2015; Zezza & Tasciotti, 2010).

Regarding SDG 6 (Water and Sanitation), Target 6.4 becomes relevant when urban agriculture incorporates rainwater harvesting, reuse, and safe effluent management, including sanitary barriers and monitoring. As part of green infrastructure, the AU also promotes infiltration, retention, and evapotranspiration, contributing to climate resilience and mitigating heat islands (UN-Habitat, 2020; Ruaf Foundation, 2019; UN 2015; Orsini et al., 2013).

Under SDG 11 (Sustainable Cities and Communities), AU expands the reach of participatory planning (Target 11.3), enhances public spaces (Target 11.7), and aligns with metropolitan coordination (Target 11.a) by promoting social land uses in underutilized areas, creating productive landscapes with educational, cultural, and ecological value (Castro, 2025; Instituto Escolhas, 2022; UN-Habitat, 2020). Finally, SDG 12 (Responsible Consumption and Production) links AU to the reduction of losses and waste (Target 12.3) and to recycling/reuse (Target 12.5).

In this context, composting—whether in decentralized (household/community) or centralized (composting yards) systems—constitutes a foundational solution for the recovery of organic matter, nutrient reclamation, and the mitigation of emissions associated with landfills (IPT 2024; UN-HABITAT, 2020).

In summary, the implementation of the SDG-AU interfaces depends on sets of comparable indicators, such as the number of gardens/units, area (m^2), production (t/year), beneficiaries, reused water (m^3/year), composted organic waste (t/year), avoided emissions (tCO_2e/year) and volumes in short supply chains, combined with annual targets and data transparency. This arrangement strengthens governance and aligns the AU, SAN, and the climate, waste, and land-use agendas within a single strategic framework (Castro, 2025; IPEA, 2024; IPT, 2024; Instituto Escolhas, 2024; UN-HABITAT, 2020; Rocha & Lessa, 2009).

Urban Composting and the Circular Economy

Urban composting plays a central role in circular economy strategies by reconnecting organic matter flows to the soil and reducing dependence on external inputs. Operationally, it can be implemented through decentralized (household and community-based) and centralized (municipal composting yards or facilities) arrangements, which complement one another depending on urban density, logistics, and waste diversion targets (IPT 2024; IPEA, 2024; UN-Habitat, 2020).

From an urban management perspective, household and neighborhood composting facilities tend to foster environmental education and community engagement, in addition to avoiding collection and transportation costs; municipal composting facilities, on the other hand, allow for scale, standardized process control, and traceability (IPT 2024; Embrapa, 2023).

Integration with urban agriculture (UA) closes nutrient cycles within the territory, improves the structure and fertility of garden beds, and enhances the resilience of local food systems (Embrapa, 2023; UN-Habitat, 2020; Orsini et al., 2013).

Within the public policy framework, recent plans and guidelines reinforce the need to reduce the disposal of organic waste in landfills and expand its local recovery, integrating composting, environmental education,

selective collection of organic waste, and urban agriculture as complementary strategies for urban sustainability and food security (Besen et al. 2026; IPT 2024; Siqueira & Abreu 2016; Mougeot 2000).

This movement is aligned with the goals of SDG 12, particularly the reduction of food loss and waste (target 12.3) and the increase in recycling and reuse of materials (target 12.5). Furthermore, the recovery of organic waste through composting and circular strategies generates climate co-benefits by reducing greenhouse gas emissions associated with the disposal of this waste in landfills (Zorpas 2020; UN-Habitat 2020; Siqueira & Abreu 2016; Orsini et al. 2013).

In summary, when integrated with urban agriculture, composting contributes to closing nutrient cycles, improves the physical and biological properties of the soil, and fosters community mobilization— — transforming organic waste into strategic inputs and embodying, at the local level, the principles of the circular economy and objectives associated with SDGs 12 and 11.

Furthermore, this integration has indirect effects on SDG 2 by promoting the production of and access to fresh food, and on SDG 6 by improving water retention and soil quality, thereby contributing to a more efficient use of water resources (Zorpas 2020; UN-Habitat 2020; Siqueira & Abreu 2016; Orsini et al. 2013; Mougeot 2000).

Food and Nutritional Security (FNS)

Food and Nutritional Security (FNS) is a multidimensional construct that encompasses food availability, access, bioavailability (or use), and stability, and now incorporates dietary quality and the food environments that shape daily choices (FAO 2023; HLPE 2017; FAO 2009). In short, it is not enough for food to be produced: there must be an effective capacity to access safe, nutritious, and culturally appropriate food on a regular basis over time (HLPE, 2017; FAO, 2009).

In Brazil, the National Food and Nutrition Strategy (SAN) is grounded in the Human Right to Adequate Food (DHAA) and institutionalized by the National Food and Nutrition Law (LOSAN), which established the National Food and Nutrition System (SISAN) and enshrined intersectorality and social control as its guiding principles (Brazil 2006).

Key works establish food and nutritional security (SAN) as an enforceable human right, dependent on integrated policies and social participation to ensure its legitimacy and effectiveness (Maluf et al. 1996). In practice, initiatives such as PLANSAN (National Plan for Food and Nutritional Security), PNAE (National School Feeding Program), and PAA (Food Procurement Program) link locally-based production to regular access to fresh and minimally processed foods, with positive effects on equity and health (IPEA 2024; BRAZIL 2006).

Urban food governance has placed cities at the center of responses to food insecurity. Councils, networks, and forums bridge public administration and civil society, enabling coordination among health, social assistance, education, agriculture, and the environment, and promoting the scale, sustainability, and territorial focus of these actions (UN-Habitat, 2020; Brandão 2016; Rocha & Lessa 2009).

Urban food policy initiatives and food policy councils have contributed to the organization of local food systems, to the improvement of food environments through farmers' markets, markets, and public facilities, as well as to the integration of food security, land use, and urban planning, thereby strengthening the resilience and sustainability of urban food systems (Castro 2025; UN-Habitat 2020; IPES-Food 2017; Rocha & Lessa 2009).

National and international empirical evidence shows that territorial strategies—such as school and community gardens, short-circuit farmers' markets, affordable restaurants, and food education programs—increase dietary diversity, enhance public spaces, and strengthen social capital that supports healthier habits (Soares et al., 2024; Instituto de Saúde - SP, 2024; Camelo et al., 2023; Zezza & Tasciotti, 2010).

In this sense, urban agriculture and waste management policies—especially those focused on composting—serve as operational drivers of Food and Nutritional Security (FNS) by bringing production and consumption closer together, reducing losses and waste, and increasing the availability of fresh food in local communities, thereby strengthening more resilient and sustainable local food systems (UN-Habitat 2020; Siqueira & Abreu 2016; Orsini et al. 2013; Rocha & Lessa 2009; Mougeot 2000).

Methodological Procedures

This study is qualitative in nature, with a descriptive-analytical focus in the form of a multiple-case study, using as units of observation the state capitals of Curitiba, Paraná (estimated population 1,773,733) and Belo

Horizonte, Minas Gerais (estimated population 2,315,560), with a time frame covering the 2023–2024 biennium (Census, 2022/IBGE). This is a qualitative approach based on secondary data, without the application of inferential statistical tests, aimed at comparing results based on indicators.

The selection of Curitiba, Paraná, and Belo Horizonte, Minas Gerais, stems from the recognition of these cities as significant examples within the Brazilian context in terms of urban sustainability policies, food security, and urban agriculture.

Both cities have well-established initiatives related to composting, waste management, and local food systems, although they have different demographic and regional characteristics. This heterogeneity allows for the analysis of distinct territorial and operational arrangements, identifying convergences, potentials, and limitations in the implementation of strategies associated with SDGs 2, 6, 11, and 12 (Besen et al. 2026; Castro 2025; UN-Habitat 2020; IPES-Food 2017).

The research combines a literature review and documentary research to analyze the contribution of urban agriculture to SDGs 2, 6, 11, and 12, based on 19 (nineteen) indicators and 5 (five) thematic areas divided into Environment (MAM) with 8 (eight) indicators, Urban Planning (URB) with 5 (five) indicators, Health (SAU) with 3 (three) indicators, Mobility (MOB) with 2 (two) indicators, and Governance (GOV) with 1 (one) indicator, totaling 19 (nineteen) indicators from the *Urban Systems* platform.

The literature review contributed to updating and substantiating the theoretical framework through the analysis of specialized literature (Donthu et al. 2021; Snyder 2019), while the documentary research added a temporal dimension to the study, allowing for the tracking of the evolution of policies, programs, and indicators over the analyzed period (Cellard 2008).

Official secondary data with standardized definitions and units were consulted: IBGE (Municipal Profiles and Population Estimates), SNIS (water, sewage, waste), Siconfi (finance), SENATRAN (vehicle fleet), ANTT (road connectivity), CAGED/RAIS (employment/businesses), DATASUS/CNES (health), and *Urban Systems – Connected Smart Cities* (urban indicators), as well as documents from the UN/UN-Habitat.

Data processing included harmonization of denominators (IBGE population) and units, verification of consistency and duplicates, and descriptive analysis by thematic areas. The analysis triangulated quantitative indicators, legal frameworks, and specialized literature to strengthen the validity and reliability of the findings (UN-Habitat, 2020), which will be presented below.

Results and Discussion

Table 1 provides a comparative summary of the 19 (nineteen) indicators divided into 5 (five) thematic areas: (Environment (MAM), Urban Planning (URB), Health (SAU), Mobility (MOB), and Governance (GOV)), aligned with SDGs 2, 6, 11, and 12 for the state capitals of Curitiba, Paraná, and Belo Horizonte, Minas Gerais. The purpose is to provide an integrated view of the essential dimensions related to urban agriculture, sanitation, waste management, and land use, enabling the identification of commonalities, information gaps, and priorities for intervention.

Table 1 - Comparative summary of SDG 2, 6, 11, and 12 indicators: Curitiba and Belo Horizonte

SDG	THEMATIC AREA	INDICATOR	CURITIBA	BELO HORIZONTE	UNIT	SOURCE
SDG 2	N/A	Direct indicators of AU/SAN (vegetable gardens, cultivated area, production, beneficiaries)	—	—	n/a	—
SDG 6	MAM URB	Urban Water Service Coverage Index – IN023_AE	95%	100%	%	SNIS
SDG 6	MAM URB SAU	Urban Sewage Service Coverage Index – IN024_AE	94%	100%	%	SNIS
SDG 6	MAM	Sewage Treatment Index – IN046_AE	71%	97%	%	SNIS
SDG 6	MAM	Water Distribution Loss Index – IN049_AE	42%	28%	%	SNIS

SDG 11	MOB SAU	Bike Lanes	5.10	15.79	km / 100,000 inhabitants	Urban Systems Survey
SDG 11	MOB MAN URB	Other modes of public transportation (km per 100,000 inhabitants)	1.21	0.01	km per 100,000 inhabitants	Urban Systems Survey
SDG 11	URB	Municipal Strategic Master Plan (note)	**10**	**9**	note	IBGE – Municipal Profiles
SDG 11	URB GOV	Zoning/Land Use and Occupancy (note)	**5**	**10**	note	IBGE – Municipal Profiles
SDG 12	MAM SAU	Waste collection service coverage – IN015_RS	79%	97%	%	SNIS
SDG 12	MAM	Recyclable Materials Recovery Rate – IN031RS	0.8%	2.7%	%	SNIS
SDG 12	MAM	% of plastic waste recovered in the city	0.43%	3.08%	%	SNIS / Urban Systems / ABRELPE

Source: Urban System Platform, (2023–2024 biennium).

Integrated Analysis of SDGs 2, 6, 11, and 12 in the Cities of Curitiba and Belo Horizonte (2023–2024)

SDG 2 - Zero Hunger , and Sustainable Agriculture

The literature consistently identifies urban agriculture as a key driver of Food and Nutritional Security (FNS), as it brings production and consumption closer together, diversifies diets, fosters short supply chains, and strengthens community capacities (UN-Habitat 2020; Orsini et al. 2013; Mougeot 2000; Smit et al. 1996). International evidence links household and community-based agricultural practices to greater dietary diversity (Zezza & Tasciotti 2010), while the Brazilian tradition establishes FNS as a human right whose realization depends on intersectoral policies and social participation (Maluf et al. 1996)

However, the platform lacks indicators and does not include direct agri-food variables, such as the number of gardens/production units, cultivated area (m²/ha), production (t/year), beneficiaries, schools with gardens, and public procurement of fresh food. Without these metrics, the contribution of Curitiba, Paraná, and Belo Horizonte, Minas Gerais, to targets 2.1 (regular access to safe and nutritious food) and 2.4 (sustainable and resilient agri-food systems) is underestimated (UN 2015; IPEA 2024).

Although the *Urban Systems* platform does not provide specific indicators for urban agriculture, information obtained from institutional sources allows for the identification of progress in both capitals. In Curitiba, notable initiatives include the Urban Farm, community and school garden programs, and household composting initiatives, which promote food education and strengthen short production chains (Curitiba, 2024).

In Belo Horizonte, Decree No. 18,385/2023 and the actions carried out by the Subsecretariat for Food and Nutritional Security (SUSAN) demonstrate the existence of well-established urban agriculture policies specifically aimed at socially vulnerable populations (GEFAU/SUSAN, 2025; Belo Horizonte, 2023).

These initiatives demonstrate that both cities have institutional structures capable of supporting urban agriculture and contributing to SDG targets 2.1 and 2.4, even though such results are not captured by the indicators used in this study.

SDG 6 – Water and Sanitation

Analysis of the indicators reveals three complementary layers. In the Environment category, it is observed that Belo Horizonte operates with greater ecological efficiency in the urban water cycle, as evidenced by the treatment of 97% of sewage and lower distribution losses (28%). This situation reduces the degradation of water bodies and increases nutrient circularity (UN-Habitat, 2020; IPT 2024). Curitiba, on the other hand, has a lower treatment rate (71%) and higher distribution losses (42%), indicating fragility in the environmental water cycle and greater pressure on water resources.

These results corroborate the findings presented by FAO (2023) and UN-Habitat (2020), according to which water efficiency and universal access to sanitation are fundamental elements for urban resilience and food security.

In the medium and long term, high water losses and lower treatment rates can increase operational costs, put greater pressure on natural resources, and compromise the sustainability of urban food systems. (UNESCO 2024; FAO 2023; UN-Habitat 2020;)

In this context, policies aimed at reducing distribution losses, expanding wastewater treatment, and encouraging water reuse can help strengthen urban agriculture and increase the resilience of cities.

In the area of urban planning, the figures for Belo Horizonte (universal access to water and sewage services) demonstrate a well-established urban infrastructure, with essential services virtually universal, which reinforces territorial resilience and the stability of the water supply (IPEA, 2024). In Curitiba, despite high coverage rates, there is still a gap in universal access, which can lead to intra-urban disparities, especially in outlying areas, where urban planning tends to be weaker (Rolnik, 2021; Santos, 2020).

In the area of health, sanitation is critical for food safety and for safe urban agriculture. The FAO (2023) and the HLPE (2017) emphasize that universal access to sewage systems reduces the risk of fecal-oral contamination, making it a central component of food and nutritional security. Thus, the efficiency of the urban water cycle is not merely an environmental metric: it is also a direct measure of public health protection.

Connection to Urban Agriculture and Food and Nutrition Security

When linking SDG 6 to urban agriculture, it is necessary to go beyond traditional network infrastructure by incorporating area-specific indicators, such as:

- volume of reused/collected water (m^3/year);
- number of cisterns in community and school gardens;
- safe irrigation techniques adopted in the area.

These variables bring Target 6.4 (efficient use) closer to the concrete practice of urban agriculture in the territory and reinforce the water-food nexus advocated by international organizations (IPT 2024; FAO 2023; UN-Habitat, 2020).

Thus, SDG 6 must be understood as systemic infrastructure for the Environment, Urban Planning, and Health—essential for improving urban agriculture, reducing health vulnerabilities, and strengthening Food and Nutritional Security in Brazilian urban areas.

SDG 11 - Sustainable Cities and Communities

Social land use, mobility, and participation

SDG 11 highlights the direct link between social land use, sustainable mobility, and urban quality of life (UN-Habitat, 2020). Belo Horizonte has the longest network of bike lanes per capita, which promotes active travel and reduces GHG emissions, in addition to improving urban accessibility—a factor that also impacts the city-food relationship (HLPE, 2017).

Curitiba, on the other hand, stands out for its alternative modes of public transportation, demonstrating greater operational diversity in its mobility matrix, which aligns with its tradition of urban innovation (Rolnik, 2021; Gehl, 2013).

In the field of urban planning, Curitiba scores higher on the Strategic Master Plan, reflecting more robust macro-planning processes. However, Belo Horizonte scores higher in zoning/land use, suggesting more precise regulation of land use, which may favor more specific policies for designating areas for vegetable gardens, parks, productive plazas, and community facilities (Santos, 2020).

Interface with urban agriculture

The literature is clear: cities with well-defined zoning, localized community participation, and active mobility networks are better positioned to implement urban agriculture integrated into the urban fabric (RUAF

Foundation, 2019; Mougeot, 2000). This means that both land use and logistical accessibility (bike paths, neighborhood connections, local transit options) directly influence the establishment, management, and distribution of agri-food production on a local scale, especially when considering short-distance marketing.

The findings of this study align with the arguments put forth by Castro (2025), the RUAF Foundation (2019), and Mougeot (2000), who contend that land-use planning and the availability of suitable urban spaces are determining factors for the development of urban agriculture. In the long term, urban planning tools capable of setting aside areas for community gardens, productive parks, and food education facilities tend to strengthen local food systems and enhance the socio-environmental resilience of cities.

Therefore, SDG 11 is not merely abstract urban planning: it is the territorial and political foundation for urban agriculture to gain scale, legitimacy, and sustained operation within Brazilian urban areas. Cities that effectively regulate land use and promote active mobility create more concrete conditions for transforming urban agriculture into an urban policy for food security and territorial justice (FAO 2023; HLPE, 2017).

SDG 12 - Responsible Consumption and Production: Completing the Organic Cycle

Circularity, Waste, and Urban Environmental Quality

Under SDG 12, Belo Horizonte demonstrates a comparative advantage across all analyzed indicators: higher collection coverage (97%), higher recovery of recyclables (2.7%), and higher specific recovery of plastics (3.08%). This scenario points to a waste management system closer to the circular model, with a greater capacity to reintroduce materials into the economy and a consequent reduction in pressure on landfills (ABRELPE, 2023; UN-Habitat, 2020).

Curitiba, although historically recognized for environmental innovation, still has low recycling rates for recyclables and plastics (0.8% and 0.43%), indicating that a portion of potentially reusable waste continues to be disposed of through conventional waste streams, with less return to the production cycle.

This difference between the two state capitals has significant environmental and economic implications. The higher rate of material recovery observed in Belo Horizonte helps reduce the volume of waste sent to landfills, extending their useful life and lowering the costs associated with final waste disposal. Furthermore, higher recycling rates enable the recovery of secondary raw materials, reduce the extraction of natural resources, and lower greenhouse gas emissions resulting from the production of virgin materials.

From an economic perspective, waste recovery contributes to the generation of income and employment within recycling chains, reinforcing the principles of the circular economy. Conversely, the lower rates observed in Curitiba indicate a loss of economic and environmental potential, as well as increased pressure on landfills and urban collection systems (IPT 2024, ABREMA, 2023; UN-Habitat, 2020).

Direct Links to Urban Agriculture

International and national literature demonstrates that urban agriculture plays a strategic role in decentralized waste management, especially when linked to community-based composting of organic waste (RUAF, 2019; Orsini et al., 2013).

Composting reduces municipal costs, strengthens the circular economy, decreases GHG emissions, and improves urban soil fertility (IPT 2024; HLPE, 2017). Thus, when analyzing SDG 12 from a territorial perspective, it becomes evident that urban systems with greater capacity for material recovery create more favorable conditions for integrating urban agriculture into waste cycles, especially those involving organic waste.

These results are consistent with IPT (2024), UN-Habitat (2020), and Orsini et al. (2013), who highlight composting and waste recovery as mechanisms capable of promoting the circular economy, reducing greenhouse gas emissions, and decreasing reliance on landfills. Among the measures that municipal governments can adopt are the expansion of source-separated collection, the establishment of municipal composting facilities, incentives for community composting, and the integration of urban agriculture into municipal solid waste and food security policies.

In summary, SDG 12 is not limited to waste: it serves as a structural pillar linking urban waste, environmental quality, urban agriculture, and public health, thereby consolidating the circular economy as infrastructure for water and sanitation (WASH).

Implications for Public Policy

The results show that Urban Agriculture (UA) can play a strategic role in integrating food security, waste management, sanitation, and land-use planning. However, the lack of specific indicators limits the ability to monitor and evaluate public policies targeting this sector.

In this regard, it is necessary to incorporate metrics related to the number of community and school gardens, cultivated area, production volume, number of beneficiaries, amount of composted organic waste, and emissions avoided, thereby enabling greater alignment between local information systems and the targets of SDGs 2, 6, 11, and 12 (IPEA, 2024; IPT 2024; UN-Habitat, 2020).

The results also indicate the need to strengthen the integration between sanitation and urban agriculture policies. Measures aimed at reducing water losses, expanding sewage treatment, utilizing stormwater, and implementing water reuse systems can increase water resilience and promote food production in urban environments, especially in areas of greater socio-environmental vulnerability (FAO 2023; UN-Habitat, 2020).

In the context of waste management, the results underscore the importance of expanding composting and the selective collection of organic waste. The establishment of municipal composting facilities and the promotion of community- and household-based systems can reduce the amount of waste sent to landfills, increase nutrient recovery, and strengthen circular economy strategies associated with urban agriculture (IPT 2024; ABREMA, 2023).

Another important implication concerns the need to tailor public policies to specific local contexts. The development of thematic maps by neighborhood, identifying areas with greater social vulnerability and less access to healthy foods, can support the prioritization of urban gardens, cisterns, compost bins, and public facilities focused on food education, thereby enhancing the effectiveness of municipal actions (Instituto Escolhas, 2024; IPEA, 2024).

Finally, the results suggest that urban planning instruments—especially master plans and land-use and land-occupation legislation—should more explicitly incorporate food security and urban agriculture. The allocation of areas for community gardens, productive parks, and food supply infrastructure can contribute to the consolidation of more resilient food systems, promoting greater integration between urban sustainability, the circular economy, and the human right to adequate food (Castro, 2025; RUAF Foundation, 2019; Mougeot, 2000).

Thus, the effectiveness of urban agriculture's contributions to the SDGs depends not only on the existence of isolated initiatives, but also on the coordination between land-use planning, environmental management, food security, and monitoring systems capable of guiding evidence-based public policies.

Final Considerations

The results obtained allow us to conclude that urban agriculture constitutes a cross-cutting strategy capable of integrating food security, waste management, sanitation, and territorial planning, thereby contributing to SDGs 2, 6, 11, and 12. The comparative analysis between Curitiba, Paraná, and Belo Horizonte, Minas Gerais, revealed complementary yet asymmetrical trajectories, highlighting distinct potentials and challenges in the two state capitals.

It is understood, however, that the main limitation of this study is the absence, in the set of indicators used, of direct agri-food metrics and organic waste flow data (for example: number of vegetable gardens, cultivated area, annual production, metric tons of composted waste, and tCO_2e avoided). This gap reduces the visibility of concrete achievements in the AU and may underestimate the cities' actual contributions to the SDGs; therefore, we emphasize the importance of developing mechanisms and strategies that can present the corresponding data and information.

Future studies should incorporate production metrics and territorialized organic indicators, as well as explore qualitative approaches to delve deeper into dimensions of social participation, governance, and community perception, thereby expanding the explanatory power regarding the effects of the AU on reducing socio-environmental vulnerabilities.

It is understood that one of the study's contributions is that it organizes, within a single analytical framework, the SDGs–AU–SAN–Circular Economy, highlighting how water, waste, and land use interact to shape the human right to food.

In light of this, we reiterate the importance of public policies prioritizing the inclusion of agri-food and organic indicators in official databases and urban platforms for the effective monitoring of the AU, such as: (i) promoting frameworks and programs that integrate composting, water management, and food security,

bringing together departments and intersectoral councils; and (ii) implementing thematic mapping by neighborhood to prioritize vegetable gardens, cisterns, and compost bins in the most vulnerable areas.

In terms of scientific advancement, it is recommended to develop standardized indicators by production unit (number of gardens/units, area/ha, annual production, beneficiaries) and by organic waste stream (tons composted; emissions avoided), and to conduct neighborhood-level monitoring combined with qualitative case studies, thereby allowing statistical data to be cross-referenced with actual on-the-ground practices.

In summary, the results demonstrate that urban agriculture constitutes a strategy capable of integrating food security, sanitation, waste management, and territorial planning, highlighting that the effectiveness of SDGs 2, 6, 11, and 12 depends on the capacity of municipalities to transform scattered initiatives into public policies monitored by territorialized indicators.

In this regard, expanding the availability and standardization of information is a necessary condition for urban agriculture to move beyond being an underprioritized practice and assume a strategic position on municipal agendas for sustainable development and food and nutritional security.

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