THE POTENTIAL ROLES OF VERTICAL URBAN AGRICULTURE TO PROMOTE THE RIGHT TO FOOD IN BRAZIL

Os potenciais papéis da agricultura urbana vertical na promoção do direito à alimentação no Brasil

Felipe Jardim
State University of Rio de Janeiro (Brazil) and Friedrich-Schiller University Jena (Germany)
ORCID: https://orcid.org/0000-0001-7364-3662
E-mail: felipejardim@outlook.com

Eduardo Alberto Manjarrés Trelles
Universidade Federal do Rio de Janeiro
Lattes: http://lattes.cnpq.br/0507335700759124 ORCID: https://orcid.org/0009-0002-0202-9424
E-mail: ed.urbandesign@gmail.com

Caren Freitas de Lima
Universidade Federal Rural do Rio de Janeiro
Lattes: http://lattes.cnpq.br/5912622040524110 ORCID: https://orcid.org/0000-0002-1168-4183
E-mail: carenfreitas.lima@gmail.com

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ABSTRACT

Considering the food system crisis in Brazil as a problem affecting the right to the city, the study investigated which role vertical urban agriculture could represent to the right to food in Brazil. The analysis was conducted by an inductive method with a qualitative approach for the literature review, documental research, and investigation of samples (Japan, Singapore, Germany, the United States of America, and Brazil). It was possible to find out the vertical urban agriculture acting with cons (when it is appropriated as a profitable system with restricted access products) and pros (occupying vacant urban land, and being produced by/supporting poor families). The results updated the map of urban vertical agriculture (now including Brazil) and the study can encourage urban public policies for the right to food – consequently, promoting the right to the city – using a low-tech and low cost of implementation and maintenance food system.

Keywords: Brazil. Food security. Right to the City. Right to Food. Vertical urban agriculture.

RESUMO

Considerando a crise do sistema alimentar no Brasil como um problema que afeta o direito à cidade, o estudo investigou qual o papel da agricultura urbana vertical poderia representar para o direito à alimentação no Brasil. A análise foi realizada pelo método indutivo com abordagem qualitativa para revisão de literatura, pesquisa documental e observação de amostra de casos (Japão, Cingapura, Alemanha, Estados Unidos da América e Brasil). Foi possível descobrir a agricultura urbana vertical atuando com contras (quando é apropriada como um sistema lucrativo de produtos de acesso restrito) e prós (ocupando imóveis ociosos e ao ser produzida por/apoiando famílias pobres). Os resultados atualizaram o mapa da agricultura urbana vertical (agora incluindo o Brasil) e o estudo pode incentivar políticas públicas urbanas para o direito à alimentação – consequentemente, promovendo o direito à cidade – utilizando um sistema alimentar de baixa tecnologia e baixo custo de implantação e manutenção.

Palavras-chave: Agricultura urbana vertical. Brasil. Direito à alimentação. Direito à cidade. Segurança alimentar.

INTRODUCTION

The **Right to the City** encapsulates the fair utilization of urban spaces guided by principles of sustainability, democracy, equity, and social justice. This collective right is bestowed upon city inhabitants, particularly vulnerable and marginalized groups, empowering them to organize and act based on their cultural practices and needs. Its goal is to enable the realization of the right to free self-determination and a satisfactory standard of living for all urban residents. This includes civil, political, economic, social, cultural, and environmental rights (World Charter for the Right to the City, 2001), such as the **Right to Food.**

However, there is a worldwide crisis regarding the right to food. The problems can be related to food quantity, quality, waste, soil conditions, biodiversity, climate change, urban growth, economy, political decisions, natural disaster, war, etc. The imbalance of these conditions can result in low, moderate, or intense insufficient food consumption. For example, in Brazil 33M people are in an extreme situation of food insecurity (starving) (PENSSAN, 2022).

Given the above, **urban food growing** is one of the possibilities to change this scenario. At the same time, it can promote right to food, food system resilience, and sustainability (FAO, 1996; FAO, 2020; OPITZ et al., 2016; CLINTON et al., 2018; WALSH et al., 2022). From the universe of urban agriculture (community gardens, family agriculture, community supported agriculture etc.), this paper highlights the vertical system of food production because it has the potential to play a critical role in the sustainability (environmental, social, and economic) of food in urban areas (AL-KODMANY, 2018) without demanding much space and occupying vacant land. Then, food is a social function of property and the city.

But **what roles could vertical urban agriculture represent to right to food in Brazil?** Aiming to verify the answer, the study was conducted using an inductive method with a qualitative approach for the literature review, documental research (international conventions, Brazilian legal system), and observation of a samples (Japan, Singapore, Germany, the United States of America, and Brazil) elected because of the mediatic highlights for “vertical urban agriculture” in journals and institutional webpages.

The debate is important not only because of legal responsibilities (food as human right), but also in view that climate change requires mitigation measures, including on the urban food system.

After this introduction, the first section explored the right to food and food security concept followed by a brief data about the global situation of their violation. The second section made an analysis of the current food system crisis in Brazil (including the food insecurity now, and what factors must be considered for the future, like climate change, and urban population growth). The third section presented a bibliographic and documental review to prove the importance of urban agriculture to food security, the concept of urban agriculture, and how is it categorized in Brazil. Since the last decade, the vertical system is a way to produce food in Brazilian cities. Thus, the fourth section investigated the concept of vertical agriculture and motivation for it. To learn about cases already established, the fifth section showcased five international experiences of vertical urban agriculture and three cases in Brazil. From those experiences, the sixth section exposed legal, economic, environmental, and social perspectives of vertical urban agriculture to understand which role vertical urban agriculture has now/could be developed in Brazil.

After that, it was possible to find out vertical urban agriculture acting with cons (when it is appropriated as a fancy and exclusive new food market) and pros (produced by/supporting poor families).

The results update the map of vertical urban agriculture (now including Brazil) and can justify the urgent promotion of urban public policies.

1. FOOD SECURITY CONCEPT AND GLOBAL SITUATION

The **Right to Adequate Food** was first recognized in the United Nations Declaration of Human Rights in 1948: it does not matter who and any kind of condition, everyone has the right to "a standard of living adequate for the health and well-being of himself and of his family" and food is an element to achieve it (Article 25, UN, 1948).

Later, the right to food was outlined by the United Nations in General Comment No. 12/1999. According to it, the right comprises four essential components. Firstly, it stresses the physical availability of food, allowing for choice in production and distribution. Secondly, it emphasizes economic and physical accessibility over time, ensuring access to food without compromising future resources. Thirdly, it highlights the acceptability of food, free from harmful substances and culturally appropriate. Lastly, it underscores the importance of sustainable food production and consumption, promoting resource efficiency, rural livelihoods, and responsible governance. These principles collectively advocate for sustainable agriculture to guarantee food security for present and future generations.

While the right to food is a legal guideline, one of the ways to understand its accomplishment is measuring food security because this right cannot be fulfilled without it. **Food security** means "a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 2022).

The international debate on food security began at the World Food Conference of 1974 (with a concept focused on food availability). In 1983, FAO included the dimension of access, which was complemented by Sen's theory of famine (1981) and the 1986 World Bank Report on Poverty and Hunger (temporal dynamics of food insecurity). The World Food Summit (1996) reinforced the multidimensional ethical and human rights dimension and formally adopted the Right to Adequate Food with an approach based on food security.

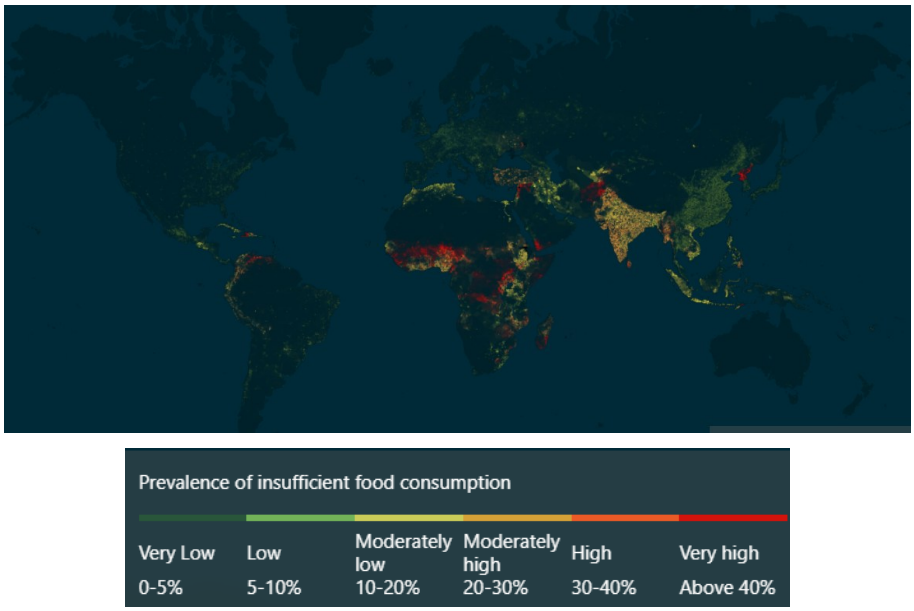
Nowadays the concept has four recognized dimensions: food availability, economic and physical access to food, food utilization, and stability over time, but the concept of food security is evolving to recognize the centrality of agency and sustainability[1] (FAO, 2022):

a. **Availability** – This dimension addresses whether or not food is actually or potentially physically present, including aspects of production, food reserves, markets and transportation, and wild foods.
b. **Access** – If food is actually or potentially physically present, the next question is whether or not households and individuals have sufficient physical and economic access to that food**.**
c. **Utilization** – If food is available and households have adequate access to it, the next question is whether or not households are maximizing the consumption of adequate nutrition and energy. Sufficient energy and nutrient intake by individuals is the result of good care and feeding practices, food preparation, dietary diversity and intra-household distribution of food, and access to clean water, sanitation, and healthcare. Combined with good biological utilization of food consumed, this determines the nutritional status of individuals.
d. **Stability** – If the dimensions of availability, access, and utilization are sufficiently met, stability is the condition in which the whole system is stable, thus ensuring that households are food secure at all times. Stability issues can refer to short-term instability (which can lead to acute food insecurity) or medium to long-term instability (which can lead to chronic food insecurity). Climatic, economic, social, and political factors can all be a source of instability.

[1] "The State of Food Security and Nutrition in the World 2022 also refers to two additional dimensions of food security that are proposed by the High Level Panel of Experts (HLPE) of the Committee on World Food Security (CFS); however, they are not formally agreed upon by FAO or others, and there is not a negotiated agreed upon language. However, due to their relevance in the context of this report, they are included here. These two additional dimensions of food security are reinforced in conceptual and legal understandings of the right to food and are currently referred to and defined as follows: e. Agency refers to the capacity of individuals or groups to make their own decisions about what foods they eat; what foods they produce; how that food is produced, processed and distributed within food systems; and their ability to engage in processes that shape food system policies and governance. f. Sustainability refers to the long-term ability of food systems to provide food security and nutrition in a way that does not compromise the economic, social and environmental bases that generate food security and nutrition for future generations" (FAO, 2022).

Food security is one of the data[2] provided by the Hunger Map from the World Food Programme (WFP), a global hunger monitoring system of 94 countries (Map 01) (WFP, 2022).

Map 01 - Prevalence of insufficient food consumption (2022)



Source: UN, 2022. [3]

The projection from June to September 2022 is 20 countries or situations (including two regional clusters) with acute food insecurity (called hunger hotspots) related to one or more key problems: **a) Organized violence and conflict risks:** Democratic Republic of the Congo, Ethiopia, Nigeria, Mozambique, Sahel, Somalia, South Sudan, Syrian Arab Republic, Ukraine, and Yemen; **b) Natural hazard risks:**

[2] "It combines key metrics from various data sources – such as food security information, weather, population size, conflict, hazards, nutrition information and macro-economic data – to help assess, monitor and predict the magnitude and severity of hunger in near real-time. The resulting analysis is displayed on an interactive map that helps WFP staff, key decision makers and the broader humanitarian community to make more informed and timely decisions relating to food security" (WFP, 2022).

[3] "**People with insufficient food consumption** refers to those with poor or borderline food consumption, according to the Food Consumption Score (FCS). The **Food Consumption Score (FCS)** is a proxy indicator for food security that measures the diversity of household diets, and how frequently food is consumed. The FCS is calculated using the frequency of consumption of eight food groups by a household during the 7 days before the survey using standardized weights for each of the food groups reflecting its respective nutrient density, and then classifies households as having 'poor', 'borderline' or 'acceptable' food consumption. **Poor food consumption:** Typically refers to households that are not consuming staples and vegetables every day and never or very seldom consume protein-rich food such as meat and dairy (FCS of less than 28). **Borderline food consumption:** Typically refers to households that are consuming staples and vegetables every day, accompanied by oil and pulses a few times a week (FCS of less than 42). **Acceptable food consumption:** Typically refers to households that are consuming staples and vegetables every day, frequently accompanied by oil and pulses, and occasionally meat, fish and dairy (FCS greater than 42)" (WFP, 2022).

Afghanistan, Somalia, Ethiopia, Kenya, South Sudan, Benin, and Guinea, Nigeria, Cabo Verde, Angola, Madagascar, Mozambique, Zimbabwe, and Haiti; **c) Economic risks:** Yemen, Syrian Arab Republic, Lebanon, Haiti, Sri Lanka, Afghanistan, Ethiopia, Kenya, and Ukraine; **d) Animal and plant pests and diseases:** Ethiopia, Yemen, and Kenya; **e) Aggravating factor (humanitarian access constraints):** Afghanistan, Ethiopia, Mali, Nigeria, Syrian Arab Republic, Democratic Republic of the Congo, Niger, Somalia, and South Sudan (FAO, 2022a).

2. THE CURRENT FOOD SYSTEM CRISES IN BRAZIL

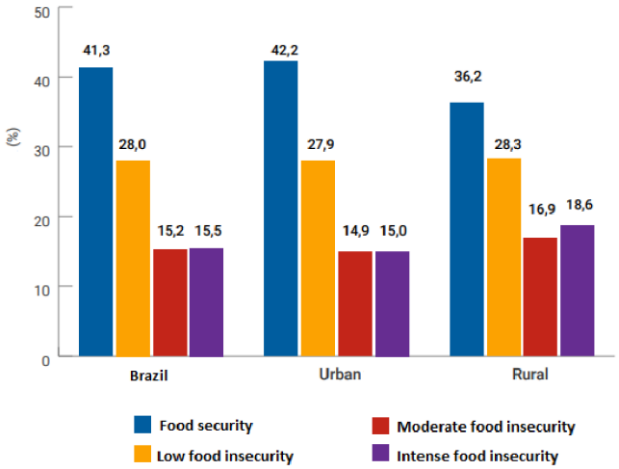
In 2010, the right to food became a social right protected by the Federal Constitution of Brazil (1988). This was a result of the work of civil society, social organizations and movements, public and private bodies, artists, and citizens from all over the country who mobilized for the "Food – Right for All" Campaign (BRAZIL, 2011). Only in 2014 Brazil left the Hunger Map[4] (the level of Prevalence of insufficient food consumption was lower than 5% of the population – total population around 203M in 2014).

After a short time of success, the tables turned after 2016 given the political and economic crisis, and the pandemic of Covid-19: in 2018 were 10.3M people in intense food insecurity situation (starving), 19.1M in 2020, and **33.1M in 2022** (PENSSAN, 2022). The data included residents from **urban houses**. Between late 2021 and early 2022, 42,2% of them had full access to food (they were living in a food security situation). In 27,9% of the houses, there was a reference to instability in the diet of the residents (the concern about the possible inability to obtain food soon and compromise of food quality or low food insecurity). In 14,9% there was already a report of insufficient food to meet the needs of their residents (moderate food insecurity) and 15% were living with starvation experiences (intense food insecurity) (Graph 01). 15.4% of the interviewees did not eat breakfast every day, 10% did not eat lunch every day, and 19.9% did not eat dinner every day (PENSSAN, 2022).

Given the above data, the vulnerability raised if the interviewee was: a woman, not white, with less than 8 years of study, with per capita income ≤ 1/4 minimum wage (even in the presence of social support), living in the North, or Northeast (PENSSAN, 2022).

[4] The results came from two major reasons: food guarantee: a) the free meals in public schools were mostly provided by local/family agriculture; b) granting title to land ownership (771 thousand families between 2003-2016); and c) food stocks to avoid the raise of the prices; and income guarantee: a) income supplementation program ("Bolsa Família"); b) the systematic and annual increase in the minimum wage; c) economic growth, low unemployment, and inflation control (FAO, 2014).

Graph 01 - Percentage distribution of food security levels in Brazil



Source: PENSSAN, 2022.

The largest number of residents aged up to 18 years in households is also related to intense food insecurity in Brazil (PENSSAN, 2022). It represents immediate negative effects on their health and well-being conditions and there is a warning of future impacts that compromise the physical and social potential of these young people (UNICEF, 2021).

The report also revealed that 15.9 million Brazilians were forced to use socially and humanly unacceptable strategies to obtain food, thus violating their **right to dignity**, and **right to food** (PENSSAN, 2022).

However, as already described, the different levels of undernourishment are not the only items to be observed to achieve food security (FAO, 2022). The quality of what is eaten is affected by an inadequate diet with easy access to ultra-processed foods, generating comorbidities; by reducing the diversity of products offered; and food contamination - 474 pesticides were registered in Brazil in 2019, of which 20% are extremely toxic (GRIGORI, 2020).

The long distances of space/time between distribution-consumption of traditional agriculture to urban centers is another problem because of the gas emissions during transport, and the food waste (the production, post-harvest handling, and storage of agricultural products represent 54% of food waste, complemented by 46% of the transport and consumption phase) (FAO, 2017). In Rio de Janeiro, for example, the distance between the sources of distribution and collection ranges from 150km to more than 1,000 km (CEASA, 2017).

Also, Brazilian agribusiness intensifies soil depletion: erosion, waterproofing, compaction, acidity, loss of biodiversity, salinization, and contamination (use of pesticides and fertilizers), which generates the unsustainable replacement of forest cover and the savannah by more arable spaces (MOUTINHO et al., 2016; ALENCAR et. al., 2020).

Furthermore, for the future of the global food system is necessary to observe climate change as a factor in increasing the frequency, and intensity of events related to heat waves, droughts, floods, tropical storms, forest fires, and other occurrences that generate impacts on agriculture on a global scale, but the effects are being more intense on the equatorial and tropical zones of the planet, where the countries in developing are located, especially when environmental, economic, social, and institutional vulnerabilities are there (IPCC, 2014).

Climate risks also involve anomalies caused by increased temperature and reduced precipitation with direct effects on the flow of water resources and, consequently, on agriculture. For example, by 2040 are expected negative effects on the Brazilian crops (soybean, corn, beans, sugarcane, coffee, etc.) (GHINI et al., 2008; FAO, 2015; BRAZIL, 2018a).

Conversely, the reduction of rural labor in the countryside is consolidated in Brazil[5] (IBGE, 2017) and the urban environment continues to expand and the population moves to cities reinforcing the imbalance between what the Earth can support from the exploitation of resources for consumption by a certain population (ecological footprint): while the world in 2014 already had 54% of its population in the urban area, Brazil contained more than 80% in the year 2000 and reached 84.6 % in 2014. For instance, by 2030, Rio de Janeiro and São Paulo are expected to be the two Brazilian megacities (out of 43 in the world) with more than 10 million inhabitants. In 2050, the Brazilian urban population should reach the mark of 92.4% 2050 (about 218 million people) (UN, 2018).

So, what can be done to mitigate the already established problems of the food system and prevent more negative impacts?

3. URBAN AGRICULTURE TO PROMOTE RIGHT TO FOOD

The World Food Summit of 1996 proposed to encourage, “where appropriate, school gardens and urban agriculture, using sustainable technologies, and encourage the sustainable utilization of unused or underutilized fish resources as policies aimed at eradicating poverty and inequality and improving physical and economic access by all, at all times, to sufficient, nutritionally adequate and safe food and its effective utilization” (FAO, 1996).

Later, for the “Planning and managing urban spatial development” section, the UN-Habitat New Urban Agenda (2017) final report presented the commitment “to support urban agriculture and farming, as well as responsible, local and sustainable consumption and production, and social interactions, through

[5] Between 2006 and 2017, while in non-family farming there was the creation of 702 thousand jobs, family farming lost a contingent of 2.2 million workers in Brazil.

enabling and accessible networks of local markets and commerce as an option for contributing to sustainability and food security" (UN, 2017). In 2020, urban agriculture was listed as a tool to make cities healthier and more sustainable (FAO, 2020).

Thus, urban food growing is internationally recognized as a potential solution to promote food security, food system resilience, and sustainability (OPITZ et al., 2016; CLINTON et al., 2018; WALSH et al., 2022) by the "production, processing and marketing of food on all types of publicly and privately held land and water bodies dispersed throughout urban and peri-urban areas, mostly destined to consumers residing in these areas" (PEARSON et al., 2010; SMIT et al., 2001), like 800 million people worldwide have been doing (FAO, 2020).

To identify what is urban agriculture in Brazil, the legal-institutional system has an answer centered on local urban planning, the tax system (different between urban and rural), and the responsibility of specific public agencies, such as the National Institute for Colonization and Agrarian Reform (INCRA), Brazilian Institute of Geography and Statistics (IBGE), and Brazilian Agricultural Research Corporation (Embrapa).

The new National Program of Urban Agriculture in Brazil, established by Federal Decree Number 11.700 on September 12, 2023, defines urban and peri-urban agriculture as activities encompassing production, processing, distribution, and commercialization of various goods. These include food, medicinal plants, and organic waste management processes (BRAZIL, 2023). The decree institutionalizes urban agriculture at the national level, integrating efforts across federal, state, and local governments, civil society, and the private sector. Emphasizing principles of inclusivity and prioritizing vulnerable populations, the program aligns with the **human right to adequate food** and the **right to the city**. It signifies a legal nexus between urban agriculture, human rights, collective organization, and sustainable food production.

According to IBGE (2017), an agricultural establishment is any unit of production or exploitation dedicated, totally or partially, to agricultural, forestry, or aquaculture activities, regardless of its size, legal form (whether it belongs to a producer, several producers, to a, to a set of companies), or its location (urban or rural area), with the objective of production, whether for sale (commercialization of production) or subsistence (support of the producer or his family).

The IBGE Agriculture Map of 2017 does not specify any urban agriculture data, but it informed relevant numbers of rural agriculture: 77% of agricultural establishments in Brazil (around 3.9 M of 5.M

establishments) are **family farming** (the property is less than or equal to 4 fiscal modules[6] with shared management by the family, and the agricultural production activity is the main source of income). 67% (10.1M people) of people doing agriculture is related to family agriculture, responsible to produce 107 billion Reais. The occupation tax of agricultural land by family farming is 23% (80.9M of 351M hectares). Of that, 48% were destined for pastures, while the area with forests, forests, or agroforestry systems occupied 31% of the areas, and finally, crops occupied 15.5% (IBGE, 2017).

Even cultivating a smaller area than non-family farming, family farming is primarily responsible for ensuring the country's food security (BRAZIL, 2010) because it produces 87% of cassava, 70% of beans, 46% of corn, 38% of coffee, 34% of rice, and 21% of wheat in Brazil. In livestock, it is responsible for 60% of milk production, in addition to 59% of the swineherd, 50% of the birds, and 30% of the cattle in the country (IBGE, 2006) – 80% of the food eaten in the World comes from family agriculture (FAO, 2019). Thus, it has economic importance linked to supplying the domestic market and controlling the inflation of food consumed by Brazilians (IBGE, 2006).

Embrapa determined the practice of urban agriculture as "the exercise of various activities related to food production and conservation of natural resources within urban centers or in their respective peripheries" (EMBRAPA, 2002). It has three main contribution areas: well-being, environment, and economy.

> The increase in food security, improving nutrition, and human health in poor communities added to better sanitary conditions reduces diseases and is related to the well-being of the population; environmental conservation of natural resources, mitigation of environmental impact resulting from human occupation, and communities transformation seeking sustainability, reuse, and recycling; increase in the generation of jobs and the incentive to the young people, adults, and elderly with job opportunities. Urban agriculture strengthens the economic base, reduces poverty, and fosters entrepreneurship, generating work for women and other groups marginalized (EMBRAPA, 2002).

The legal-institutional system can also be exclusionary and outdated, generating problems for the development of (urban) agricultural activity due to the lack of reach of public policies. Thus, recent studies informed urban agriculture in Brazil categorized into (WILKINSON; LOPANE, 2018; LIMA, 2019):

- traditional farmers, that occupy the transition zone where the urban gives way to the rural to preserve agrobiodiversity or replicate conventional agriculture;
- backyard agriculture, a small extension of land related to those classified in the category of traditional farmers, there is a significant production both for self-production;

[6] The size of a fiscal module varies according to the municipality where the property is located. The value of the fiscal module in Brazil varies from 5 to 110 hectares. (EMBRAPA, 2022).

- initiatives by urban collectives, different social profiles that seek to preserve green spaces in the city, environmental education, and food production in public spaces;
- agriculture promoted or linked to the government, like public policies to provide work or gardening educational activities in schools; and
- business and commercial agriculture.

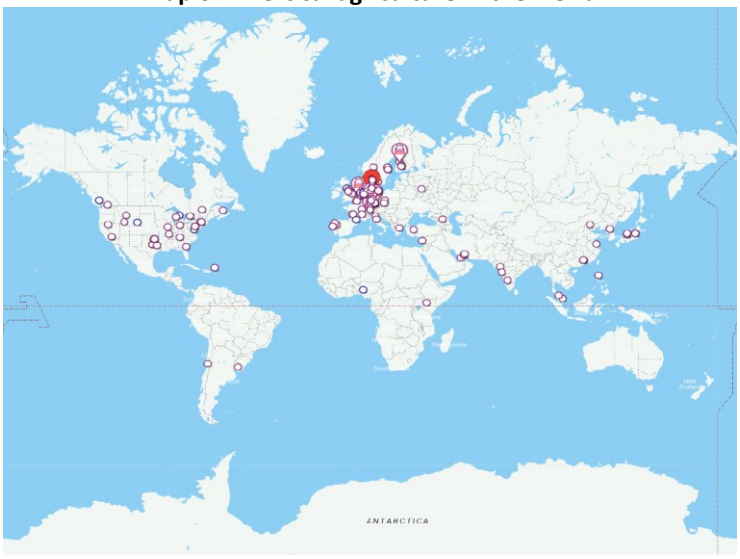
Among the examples of urban agriculture in Brazil, there is “Hortas Cariocas”, a public policy of the city of Rio de Janeiro listed by the United Nations (UN) as an essential policy to achieve the Sustainable Development Goals (SDGs) (#SDGAction36763). Since 2006 the city hall gives support (financial, human resources, tools, professional knowledge, and monitoring) to the community food production in idle areas of extreme social, environmental, and economic vulnerability (favelas, ghettos). In comparison with the other public policies from the city hall, it is a simple and cheap way to raise food security by free access to healthy food, generating income, stimulating social inclusion (dignity), and environmental education/preservation (JARDIM *et al.,* 2022).

4. VERTICAL URBAN AGRICULTURE: CONCEPTS AND MOTIVATION

Vertical urban agriculture is the practice of producing food on vertical surfaces, in different stacked layers, commonly integrated into other structures, such as buildings, containers, or warehouses, in open or closed environments (but with artificial control of humidity, lighting, etc.), to maximize production in a limited space (PAYEN *et al.*, 2022).

The idea of vertical farming can be related to the history of the Hanging Gardens of Babylon (around 600 BC). At the beginning of the 20th century farmers already got ways to protect the crops (flat glass roofs above the crops on the field, small-scale greenhouses big-scale greenhouses). In 1915, Gilbert Ellis Bailey wrote a book titled “Vertical Farming” arguing the benefits of hydroponics, which was in the 1930s, by William Frederick Gericke developed at the University of California at Berkley. In the early 1970s, scientists found a way to grow crops without soil using a growing medium made from stones or rocks. In the 1980s, Åke Olsson invented a spiral-shaped rail system for growing plants (AL-KODMANY, 2008; COLSTEE, 2016). At the end of the 20th century, vertical urban agriculture expanded in high-development countries and/or with severe territorial limitations for traditional agriculture (JUN-HO, KYUNGRYONG, 2016), In 1999, Dickson Despommier (2010, p.15), described the vertical farm as “the mass cultivation of plant and animal life for commercial purposes in skyscrapers. Using advanced greenhouse technology such as hydroponics and aeroponics, the vertical farm could theoretically produce fish, poultry, fruit, and vegetables.”

Map 02 - Vertical agriculture in the world



Source: ASSOCIATION FOR VERTICAL FARMING, 2022.

During the 21st century hydroponics, aeroponics, and aquaponics methods were improved and the artificial LED lightning optimize growing conditions and paved the way for farming crops indoors (COLSTEE, 2016) so countries that are not highly developed or without territorial limitations for traditional agriculture are also investing in the sector (Map 02), such as the United States of America, because although the disadvantage of higher initial costs, electrical consumption, complex solutions for production, if compared to an ordinary horizontal model, the vertical urban agriculture has a shorter production cycle time; better space/production ratio; absence of pesticides; production, packaging and direct delivery, with an integrated production chain and already located in urban centers; more varied culture; lower transport cost; there is a paradigm change based on conditional sales because the quantity products can be selected before production (DESPOMMIER, 2010; PAYEN et al., 2022).

5. V. VERTICAL URBAN AGRICULTURE: LEARNING WITH INTERNATIONAL AND LOCAL EXPERIENCES

From above Map 02, a few experiences can reveal pros and cons that must be observed to identify what roles could vertical urban agriculture represent in Brazilian food security:

5.1. JAPAN

Since 2005 the Pasona company (human resources agency) is based in a 20.000m² building built in the 60s in the center of Tokyo. The new facade (Photo 1) followed an old trend of incorporation and integration of vegetation with the city through cutting-edge technologies (YIN, 2022). Furthermore, level

B2 (Photo 2), a former bank vault, has 4.000m² of the farm with 200 species including fruits, vegetables, and rice harvested by employees with the help of an agricultural specialist. The food is prepared and served at the cafeterias within the building (YIN, 2022).

Photo 1: Pasona Company (Japan)

Source: Kono Design, 2022.

Photo 2: Pasona Company (Japan)

Source: Kono Design, 2022.

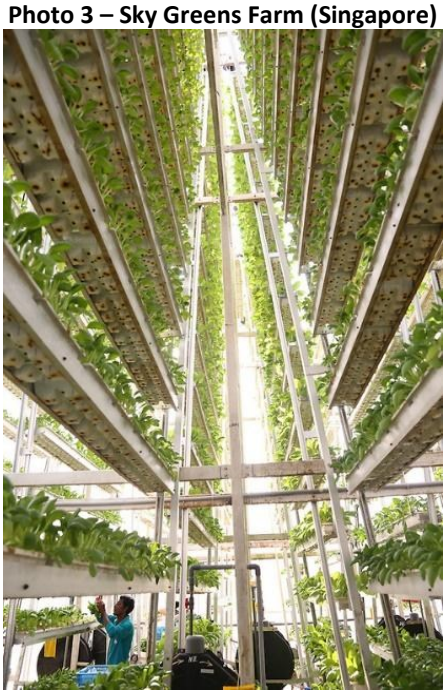
Thus, Pasona offers not only a direct farm-to-table but also a variety of seminars and training programs and a hideaway for physical and mental relaxation. The biggest challenge is the huge amount of electricity needed for the lighting system (YIN, 2022).

5.2. SINGAPORE

In October 2012 Sky Greens Farm (Photo 3) opened the commercial operation of the first company of low carbon hydraulic farming system, with a 3.2-acre-collection of 100 three-story glass towers housing

racks of Chinese cabbages, pak choi, and other leafy green vegetables. On August 2014, it has grown to 600 towers (SKY GREENS FARM, 2022).

Photo 3 – Sky Greens Farm (Singapore)



Source: Sky Greens, 2022.

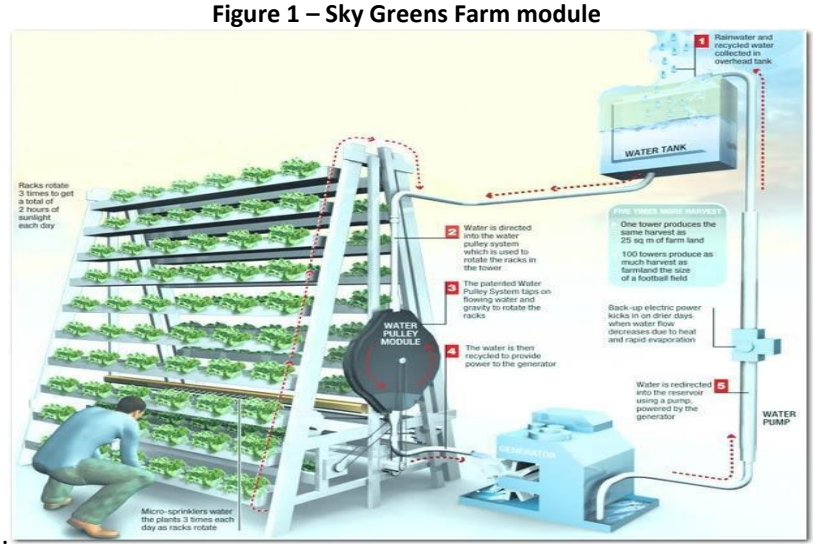
The project required heavy investments, motivated by the desire to compensate for Singapore's (island of 5 million inhabitants for 721.5 km) (2020) dependence of up to 90% on food imports for its supply.

The implementation of urban vertical farms had strong support from the Agri-Food and veterinarian authority of Singapore (AVA) and includes special training for farmers. Productivity reaches more than ten times that of conventional processes, with improved product quality and reduced waste of resources and energy to protect plants against pests and adverse environmental conditions. An important factor for the success was the good use of artificial lighting technologies: LED lamps capable of emitting light in specific waves that favor the photosynthesis of the plantations, generating great energy savings (AVA, 2017).

The system works from platforms arranged on several levels connected by a set of pulleys that allow access to the plants without the need to use stairs. Rotation is carried out by gravity thanks to the circulation of water, whenever possible, captured from rainfall. The water itself also activates the generator that reuses water from the plantations and feeds it back into irrigation (Figure 1) (THE NEW

PAPER, 2011). A 1.7-ton equipment can be moved with 500mL, and this water returns to the system. According to the company, the consumption of an entire station (Figure 1) is 40W.

Figure 1 – Sky Greens Farm module



Source: The New Paper, 2011.

The maximum height of the module is 9m with 38 planting levels and the minimum productivity reported is ten times the same space occupied in the traditional process. Another advantage is that the system does not require the use of water for washing products for consumption (AVA, 2017).

5.3. GERMANY

A) EFFICIENT CITY FARMING

The Efficient City Farming (ECF) (Photo 4), in Berlin, was created in 2012 and used a container as the prototype for its implementation. The construction of the greenhouse took six months and cost more than 1 million euros. The project was financed by a capital fund and a private investor (EFC, 2022).

The place can generate 25 tons of fish every year and up to 35 tons of vegetables (mostly tomatoes, cucumbers, peppers, and eggplant, but it can produce around 400 species). Through modern techniques are leveraged 70% of rainwater is. In addition, the system also recycles the water where fish are bred because the water is rich in nutrients such as CO^2. That way, it is possible to combine fertilization, irrigation, and water conservation with an integrated system (EFC, 2022).

Photo 4 - Efficient City Farming (Germany)

Source: FLUENCE, 2022.

B) INFARM

The startup Infarm is innovating not only in the way how to produce food, but also in how to get access: to herbs, leafy vegetables, and lettuce growing vertically directly in the supermarket (Photo 5) (including Aldi Süd, coop, Edeka, Safeway, Intermarché and Metro) are ready to be bought within two to three weeks (SCHIMITZ-NORMANN, 2021).

The company started in 2013 in a shared flat in Berlin (Neukölln). Three years later they started production in an old Siemens washing machine factory **abandoned** in the nineties. Currently, they have 15 centers worldwide and more than 1,400 farms operating in 11 countries of the global north with a monthly harvest of over one million plants being cared for by more than 1,000 employees worldwide. For that, the company has already received over 300 million dollars in funding (SCHIMITZ-NORMANN, 2021).

Photo 5 – Infarm (Germany)

Source: Infarm, 2022.

Each block takes around six weeks to be built and one independent farm produces 500,000 plants a year on 40 square meters of floor space – the harvest equivalent of 10,000 square meters of farmland. In the future, the company expects to produce mushrooms (shiitakes, oyster mushrooms, king trumpet mushrooms), fruits (strawberries), and other vegetables (SCHIMITZ-NORMANN, 2021).

5.4. THE UNITED STATES OF AMERICA

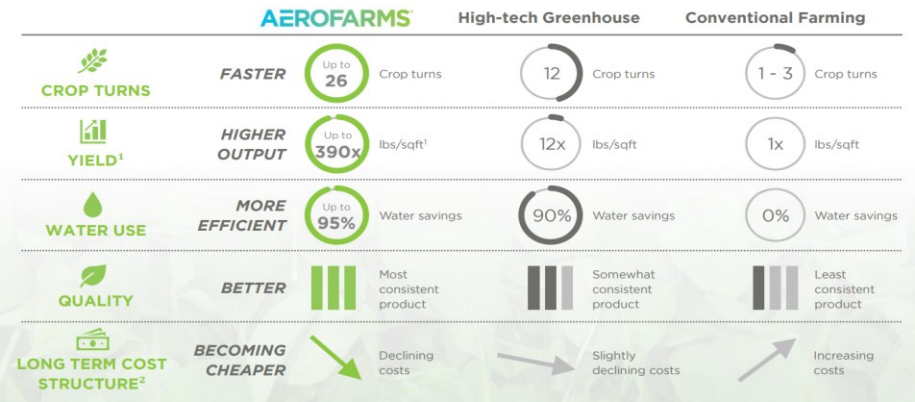
The Public-Private Partnership spawned in 2004 AeroFarms (Photo 6), in New York City, in an abandoned steel factory in a highly urbanized region, from the partnership between Goldman Sachs Urban Investment Group, Prudential Financial Inc., AeroFarms, and the City Economic Development Department, with a contribution of 50 million dollars (MCKAY, 2017).

Photo 6 - AeroFarms (USA)

Source: AEROFARMS, 2022.

Now it is the world's largest and most technologically advanced aeroponic indoor vertical farm with better results than high-tech greenhouse systems or conventional farming (Figure 2).

Figure 2 – AeroFarms Sustainability and Productivity



Source: AEROFARMS, 2021.

The AeroFarms differential is a new partnership with the World Economic Forum, Jersey City, and EcoSpaces Education to build the first-ever municipal vertical farming program, already established at Philip's Academy Charter School (PACS) (Photo 7) where "students harvest their greens from an AeroFarms Community Farms Unit in their cafeteria while learning important lessons like food sovereignty and food access through hands-on education lessons from professional science educators" (AEROFARMS, 2022a).

Photo 7 - Philip's Academy Charter School (USA)

Source: AEROFARMS, 2022a.

Further than schools, the Community Farms program could also work in the housing unit, hospitals, or other local community centers (AEROFARMS, 2022a).

5.5. BRAZIL

Despite not being registered on Map 02 (Vertical agriculture in the world) – maybe because a new map entry requires a paid register – Brazil has cases of vertical urban agriculture that could be a model for other Brazilian cities and countries.

A) PINK FARMS

Since 2017 the largest vertical farm in Latin America (Pink Farms) (Photo 8) has been based on indoor agriculture in São Paulo.

Photo 8 – Pink Farms (Brazil)

Source: PINK FARMS (Instagram), 2021.

They have artificial lighting, 95% less use of water, and 170 times more production for each squared meter of soil than conventional agriculture using aeroponics and aquaponics systems, no pesticides, and automated/controlled production of 10 products (vegetables, and microgreens).

In February 2021, thinking about expanding the services, even with its restaurant, Pink Farms raised R$ 4 million in a crowdfunding and online system.

B) AGROFAVELA

Unlike the private target audience and commercial character of Pink Farms, based on an institutional partnership arrangement between the Stop Hunger Institute and Sodex, the G10 Favelas group, through the Agrofavela project implemented two ghettoes (favela) areas in São Paulo that integrates the horizontal and vertical system: in Paraisópolis (Photo 9 and 10), since October 2020, in a planting space of more than 900m² where, until December 2020, 300kg of vegetables were collected, directly benefiting more than a thousand people with 60 species of vegetables and fruits; and in Heliópolis, since February 2021, with a 19m of a productive wall for 750 plants of 15 species each round.

Photo 9 – Paraisópolis Agrofavela (Brazil)

Source: GLOBO RURAL, 2020.

Photo 10 – Paraisópolis Favela (in the background) (Brazil)

Source: PARAISÓPOLIS (Facebook), 2021.

In this way, the project aims to improve the food security of the poorest, in addition to raising awareness against food waste and training women to plant gardens in their own homes.

C) COMUNIDADE DOS PEQUENOS PROFETAS

The Non-Governmental Organization Comunidade dos Pequenos Profetas (CPP) (Photo 11) works in a house in a poor area in the center of Recife with different actions (social, legal, psychological) focused on childhood (around 400 children supported). One of them is Telhado Ecoprodutivo (Eco Productive Rooftop) (Photo 9) with 400m² of organic gardens with food and environmental education functions.

Photo 11 - Comunidade dos Pequenos Profetas (Brazil)

Source: Jornal do Commercio, 2016.

The food growing project was created to avoid more cases of criminal invasion by the rooftop. The estimated production of half a ton annually is carried by the kids with adult supervision and collected by mothers benefiting 1,500 people (the children and their families, neighborhoods, and homeless people) (CPP, 2022).

The project is transferring cheap low-tech knowledge to people that live in extreme poverty, like the ones in “Palafitas” (ghettos constructed over the river) (Photo 12 and 13).

Photo 12 – Palafita in Recife

Source: Jornal do Commercio, 2021.

Photo 13 – Vertical food production inside Palafita

Source: GLOBO, 2021.

6. LEGAL, ECONOMIC, ENVIRONMENTAL, AND SOCIAL PERSPECTIVES OF VERTICAL URBAN AGRICULTURE IN BRAZIL

Financial movements of high-tech vertical farming in recent years demonstrate the growing investments in the sector: in July 2017, Softbank invested US$200 million in Plenty (San Francisco); in August 2017, IKEA and a Dubai Sheikh invested $40 million in AeroFarms; in December 2018, Google Ventures invested US$90 million in Bowery Farming (New York). It represents the creation of jobs, and the development of the local economy, and it also could be an opportunity to produce medicinal plants or to recover the local biodiversity. On the other hand, it is necessary to remember the importance of evaluating the financial agents involved so that there is no harm to small producers, especially peri-urban ones, through the adoption of mitigating and inclusive measures.

In terms of bioethics, if vertical farming structures can dispense with toxic products, not least because they are indifferent to climatic variations and attacks by parasitic organisms, new opportunities can be explored by private companies, government, and universities in the field of genetic development to create organisms that are more adapted to the new process, demanding more investments and adequate regulations for these purposes. In any case, the sustainability of the system can be increased using organic residues for fertilization. However, the use of new substances, techniques (3D food printer, for example), or other unnatural processes is a risk that must be regulated to allow objective accountability for unforeseen effects (MUKAI, 2010), even if the new technologies allow the use and inspection of harmful potentials remotely – which highlights the qualification of the workforce and the robotization of production in cutting-edge technological models.

Regardless of that, 13,6M people (LOCOMOTIVA; CUFA 2022) lives in favelas (ghettos, overpopulated areas without basic housing infrastructure, like water, electricity, and sanitary system (LUZ, 2011), and 9 out of 10 families in favelas depended on donations during the pandemic

(LOCOMOTIVA; CUFA, 2022). So, for sure the positive results of high-tech vertical farms deserve prestige, but they cannot be constructed and maintained in the same way as the private companies do, for example, by the 33.1M people in food insecurity situation in Brazil.

So, for the vertical food growing play the role of allowing a better urban food system (AL-KODMANY, 2018) in vulnerable areas, changes and adaptations must be done to assist local community food security, resilience, and empowerment in limited spaces, such as already is happening in Hortas Cariocas (Rio de Janeiro), where the (horizontal) urban agriculture is also related to other Human Rights (Dignity, Work, Health, Social Inclusion, Education, Environmental Preservation, Leisure) (JARDIM *et al.*, 2022).

A key in the transformation process is the reduction in production costs, and Brazil already has successful cases using photovoltaic cells (MAIA, 2019) and thermal plates, even in low-income housing (MAIA *et al.,* 2019). Furthermore, combining the social housing projects with community urban agriculture, and communal kitchens is a strategy for the multidimensional achievement of Human Rights (ROCHA; JARDIM, 2022). Public management (through financing research, tax reduction, or partnerships) is also important. Another possibility would be using cheaper versions of existing planting systems, such as Torpedopots[7], such as reusing plastic bottles (Photo 11). In this way, the people can create, maintain, and repair the system in a low or no-cost procedure.

The public management can also contribute doing adjustments to the city design, the local legislation on **(vacant) land use and occupation**, and the environmental control systems, especially if different layers are planned to produce animal derivatives for subsistence (MCHARG, 1969). Also, if urban agriculture is included in the urban zone, it could collaborate to equalize the impacts caused by the increase in densities and intensities of land use and can be one of the solutions to attenuate the failure to fulfill the social function of the city/real estate from the occupation of idle areas.

7. CONCLUSIONS

Urban vertical agriculture is increasingly taking a leading role in the scenario of key possibilities for the sustainability and resilience of the planet in terms of food production by contributing to the

[7] Torpedopots are pots made of recycled polypropylene that is biodegradable that comes in various sizes. They are soldered as part of a kit, somewhat like a Lego system, that is easily put together with no machinery or tools. Water is provided through each pot that is specially contained in tubing to resist degradation from mildew, algae, fungi and biofilm that can accumulate on the inside or outside of the tubing. A timer, included in the kit, controls the amount of water used that is more than 90% less than the water required in commercial farming. Small batteries run the timer; thus there is no need for access to electricity. The Torpedopot system blocks entry from rodents and other pests (TOPEDORPOT, 2022).

mitigation of the worsening of environmental, social, and economic imbalances already established. However, Map 02 revealed the majority of vertical production in Global North.

The Japanese case (Pasona) is a great example of food growing as a well-being tool in the workplace and to renovate buildings, despite high costs and limited access (to employees). The case from Singapore (Sky Greens Farm) is a model for big-scale vertical food production without the energy problem and exposes the great governmental role. The case of EFC-Germany reveals that is possible to use containers, although a big amount of necessary investment. The second German case (Infarm) releases that more transparency about the origin of the food and direct access to supermarkets can be possible, even if they are also part of the food system crisis (transport, food waste, prices, etc.). The USA's case (AeroFarms) is an interesting example of social action by associating food production with the community and education. In most cases, great production results of high-tech models reviewed are being redirected to people not in economic vulnerability (buying in supermarkets), and, presumably, out of food insecurity.

The Brazilian cases are not registered by the Association for Vertical Farming yet, but they are relevant to check different sides of vertical urban agriculture in the same city (São Paulo): Pink Farms reproduces the high-tech, and high-cost model focused on profits (as the others above), and Agrofavela's low-tech farm is focused to support the poor community. In Recife, the Comunidade dos Pequenos Profetas is another case of social motivation to supply nutritional, educational, and social use and knowledge transfer.

Through cases review and photographic observation, Agrofavela and Comunidade dos Pequenos Profetas represents another side of vertical agriculture in terms of less capital to create, maintain, and reproduce; easily maintained; community integration; local democratic administration, and control; not obliged to provide profits; related to community needs (and these are not only food – Comunidade dos Pequenos Profetas have an aspect of preventing theft and they are recycling plastic bottles). It is a way of vertical urban agriculture, especially in large cities, meets the possibilities that urban agriculture can provide, and can be adopted to overcome the dichotomy city-countryside, nature-society.

So, to help to promote the right to food in Brazil due to the great results of production capacity, not becoming one more tool of social exclusion of food access, and capital accumulation, the vertical urban agriculture must overcome costs (of implementation and maintenance) and be spread in poor areas – Hortas Cariocas Program in Rio de Janeiro can offer insights –, otherwise there is no compatibility with food sovereignty if there is an external economic, financial and technological dependence. After guaranteeing food security, people can give a further step: food sovereignty, which means "the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems" (FAO, 2007).

The process to overcome costs can be facilitated offering bank credit, funding scientific research, city management (public/private partnership), and applying urban law (Progressive Urban Territorial and Real Estate Tax, and Collect of Idle Land). The universities can lead a knowledge transfer role (courses), investigating ways to make the system cheaper and adapted to the local reality. To improve the results, vertical urban agriculture could be associated with government social housing programs for poor people.

In any case, as recognized by Pink Farms (2021) answering if "vertical agriculture fights again hunger?", "**verticalizing agriculture is ONE of the ways to help fight hunger**. Family farming is also important to generate income. Reducing food waste at home can save up to 1.5 million tons of food a year. Job creation, income distribution programs… all this helps in the fight against food insecurity. […]." Consequently, on the one hand there is the contribution of vertical urban farming to **right to food** (promoting food security) and **right to city** (occupying vacant land, etc.). On the other hand, considering that **family farming keeps with the major responsibility in Brazilian food security using only 23% of agriculture land,** in Brazil vertical agriculture should be complementary to "horizontal" agriculture. Additionally, the discussion about access to rural land cannot be left out in a country with extremely inequal distribution of land.

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Sobre os autores:

Felipe Jardim
Doctor in Law (State University of Rio de Janeiro, Brazil) & Doctor in Sociology (Friedrich-Schiller University Jena, Germany). Masters in Urban Development (Federal University of Pernambuco, Brazil). Bachelors in Law (Catholic University of Pernambuco, Brazil). DAAD scholarship holder from Bi-nationally Supervised Doctoral Degrees/Cotutelle Program 2020/21 (57507869).
State University of Rio de Janeiro (Brazil) and Friedrich-Schiller University Jena (Germany)
ORCID: https://orcid.org/0000-0001-7364-3662
E-mail: felipejardim@outlook.com

Eduardo Alberto Manjarrés Trelles
Masters in Law (State University of Rio de Janeiro, Brazil). Bachelors in Architecture (Universidade Santa Úrsula, Brazil).
Universidade Federal do Rio de Janeiro
Lattes: http://lattes.cnpq.br/0507335700759124 ORCID: https://orcid.org/0009-0002-0202-9424
E-mail: ed.urbandesign@gmail.com

Caren Freitas de Lima
Masters in Public Policy and Development (Federal University of Rio de Janeiro, Brazil). Post-Graduate specialization in Urban and Regional Planning (Federal University of Rio de Janeiro, Brazil). Bachelors in Economics (Federal University for Latin American Integration, Brazil).
Universidade Federal Rural do Rio de Janeiro
Lattes: http://lattes.cnpq.br/5912622040524110 ORCID: https://orcid.org/0000-0002-1168-4183
E-mail: carenfreitas.lima@gmail.com