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# Urban Agriculture: Potential to Rehabilitate Spaces and Edifices Without Use and its Contribution to the Sustainable City

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**SUMMARY**

*The world's urban population is on a constant growth, which generates food supplying issues. Other than this, the common agricultural practice causes pressure on the natural ecosystems, for it requires a great amount of arable land. In a near future, there won't be enough land available for plantations in the rural area to meet the needs of an urban population that is on an exponential growth. Therefore, this research has the objective to understand how urban agriculture aids the sustainable city, and how it can contribute to the requalification of unused buildings and spaces throughout the cities. The methodology adopted has a qualitative theoretical approach, based on the revision of existing bibliography related to the theme, such as Dickson Despommier's theoretical concept of vertical farm, and Toyoki Kozai's practical studies on the same matter. As part of the research, study cases will be mentioned regarding the use of urban agriculture in vacant spaces, with the purpose that these will give a new meaning for obsolete spaces and buildings that exist in the urban perimeter. A solution for this problem is to produce perishable food inside the cities, which is known as urban agriculture. Results demonstrate that urban agriculture has a fundamental role regarding city's sustainable growth worldwide. As a conclusion, urban agriculture on top of buildings is the most prominent solution to give use to unutilized spaces in the cities.*

**KEYWORDS:** Urban Agriculture. Sustainable City. Requalification of Buildings and Idle Spaces.

## 1. INTRODUCTION

Soon, conventional agriculture will not be able to supply urban centers with food. A solution to this problem is to include agriculture within the city, which minimizes the demand for arable land, pollutes less the environment and offers fresher and healthier perishable products to its residents. This concept of urban agriculture contributes to cities being more sustainable, self-sufficient and with greater possibilities of employment, precisely where most of the population resides. A solution to achieve this ideal consists in the use of idle spaces that always exist in its premises, as is the case of abandoned buildings, green areas, and unused roof slabs. In this way, the requalification of these spaces and buildings is essential to dynamize the forgotten spaces that interfere with the harmony of the city. After all, it is necessary to find news areas for agriculture around the world, because by 2050, according to projections made by the World Resources Institute, another area the size of Brazil will be needed to account for the forecast of a 70 percent increase in food production for supply the growing world population (WORLD RESOURCES INSTITUTE, 2013). Not surprisingly, food waste rates all over the world must still be reduced to avoid the demand for productive lands, after all, in Brazil alone, food waste amounts to about 7.8 percent of the Brazilian gross domestic product (MARTINS; FARIAS, 2002, p. 22). An alternative to circumvent this issue refers to the maximization of food production in small spaces that can be found in urban areas.

There is a worldwide trend that consists in the increase of food production on small lands, to facilitate transportation and production logistics and to obtain abundant harvest. Many hefty farms are moving away from production over vast areas by adopting greenhouses instead of conventional plantation. Greenhouses allow the control of numerous parameters, such as temperature, humidity, and adequate insolation.[1] If in the countryside, agriculture is using

[1] An example is in the production of tomatoes in a property in Itabirito, Minas Gerais. In this one, a greenhouse was implanted to produce five varieties of tomatoes. It has an area of one hectare, which is glazed to maximize the entry of natural light, and also has an automated system which screens under the cover to open and close to maintain temperature of internal air as desired. According to the agronomist responsible for the plantation, Luiz Santos, the tomato plants are kept in pots and receive the ideal amount of water, with the general consumption of water at planting being half of what it would be if it were planted in the open air (GLOBO RURAL, 2017). There are several benefits of this system, such as the reduction of water use, the use of natural lightning, the non-use of pesticides and increased productivity, in which production is optimized in a space smaller than that of custom.

technology to increase the production, why not insert agriculture in cities to reduce the ecological footprint of food production, increase food security and create jobs where most of the people live?

It is advantageous to produce food in environments that lack space or that are not in use in the cities. It is common to find forgotten land, buildings, and terraces in them. Reflect on places in your city that are underused or unused, which could be revitalized/requalified. It is precisely in these environments that agriculture can be inserted into the urban fabric, or even be considered in new projects. The advantage of requalifying idle urban environments with the use of urban agriculture refers to the creation of new activities, which are new employment opportunities, new areas of leisure and recreation for the population, which guarantees the integrity of buildings and decreases the vandalism that commonly occurs in these locations.

The first impact on the urban population with the adoption of urban agriculture in cities refers to the generation of employment. According to the IBGE[2] census, in the year of 2010, the Brazilian rural population represented a percentage of 15.63 percent of the total population. Previously, in 1960, this same rate was 54.91 percent (IBGE, 2021). Every year, the trend is for the population of the entire terrestrial globe to be increasingly urban, which justifies the creation of jobs in the city. Conventional, automated agriculture does not generate as many jobs in the countryside as it did fifty years ago. As a result, the Brazilian population has migrated to urban centers in search for jobs and a better quality of life. In this sense, urban farms bring with them a range of economic opportunities for city residents.

Food production within cities cooperates to make them more sustainable. The incorporation of agriculture in its premises contributes to several factors, such as the reduction of fossil fuel emissions that occurs in transportation from the countryside and the urban region. To reduce the use of water, rainwater is used and reused in the production itself. In addition, the food is produced close to where its destination eventually is, which provides freshness and, even better, organic nourishment.

## 2. OBJECTIVES

The general objective is to contribute to the knowledge of urban agriculture, its methods, and benefits for the sustainable development of cities around the world. The specific objectives aim to identify solutions to implement agriculture in the cities.

## 3. METHODOLOGY / METHOD OF ANALYSIS

This study is carried out from a qualitative point of view. Since it is from the area of human sciences, there is no need for a quantitative in-depth study (GIL, 1993). Research on urban agriculture, from a macro methodological point of view, will consider society and the environment. To this end, qualitative research is not concerned with numerical representation, but with the deepening of understanding of a social group, an organization, and so forth (GERHARDT; SILVEIRA, 2009).

The study in this article has an exploratory approach. About this, Gil (1993) says: “although the planning of exploratory research is quite flexible, in most cases it takes the form

[2] Brazilian Institute of Geography and Statistics.

of bibliographical research or case studies […]"[3] (GIL, 1993, our translation). Therefore, this research constitutes a bibliographical review study. According to Gil (1993), bibliographical research corresponds to the study of works already prepared, such as books and scientific articles. Thus, the theoretical reference will explore existing literature and scientific research related to urban agriculture.

As a research structure, it is initially necessary, to understand what the problems regarding conventional agriculture are. Then, define what urban agriculture is and separate it into three possible solutions for implementation in cities. An example is the case of planting carried out at ground level, as in public areas and private lots. Another one, when occurred on terraces. Finally, its implementation inside buildings, which is called vertical farming. In all situations, real cases will be demonstrated where these models have already been performed around the world.

## 4. RESULTS

### 4.1 The Problems Regarding Conventional Agriculture

To better comprehend agriculture in current days, it is necessary to analyze a few historical facts. Despommier (2009) points out that twenty-first century agriculture depended on four historical events. The American Civil War, the discovery of oil, the invention of the internal combustion engine and the invention of dynamite (2009, p. 79). All these events are interconnected. The American civil war ended slavery in the south, which required new means of production in the countryside that did not make products more expensive with wage labor. The discovery of oil in Poland in 1854 (DESPOMMIER, 2009, p. 83), which would fuel future engines, such as tractors that do the work in the field demand fewer workers. Dynamite, on the other hand, emerged to facilitate the breaking down of inhospitable terrain that could intimidate agriculture. Any land could be turned into arable land. In short, these are the facts that have leveraged today's agriculture. Unfortunately, this positive side of technological advances that have driven contemporary agriculture has generated numerous environmental problems (DESPOMMIER, 2009).

One of the main problems of world agriculture is the constant demand for area for food production. According to Despommier (2009), by the year 2050, an area equivalent to the Brazilian territory would be necessary to account for the future world population, which is increasing constantly (2009, p. 96). Currently, the arable area destinated for the world population is equivalent to the size of the continent of South America (DESPOMMIER, 2009). Therefore, it is necessary to create new means that differ from current solutions to make it possible to feed the world population.

Despommier (2009) also reports that agriculture consumes approximately twenty percent of all fossil fuels in the United States (2009, p. 85). It is a lot of fuel for the machines in the rural area and for the trucks that move the goods produced to the cities. This distance between the urban center and the countryside, consumer to producer, causes pollution from the burning of fuels, which contributes to the degradation of the ozone layer, a fact that raises the earth's temperatures. According to Despommier (2009):

[3] "embora o planejamento da pesquisa exploratória seja bastante flexível, na maioria dos casos assume a forma de pesquisa bibliográfica ou de estudo de casos[...]"

> Our planet is developing a 'fever', an obvious indication that something is wrong with the entire system. Global warming, also referred to as climate change, is an unanticipated consequence of the unprecedented growth in our population. The ice is melting all over the globe: Earth is suffering from a colossal case of 'bipolar' disorder. It's directly linked to our penchant for using more and more fossil fuels to accommodate our increasing demand for food and manufactured goods. If we continue with our current food-producing strategies, getting enough high-quality, safe produce to 8.5 billion people will define the next crisis we must address and remedy if the human species is to survive. How did things get so out of control? To answer this question, we have to understand how agriculture arose to begin with (2009, p. 37).

Therefore, agriculture does not contribute to the preservation of the ozone layer, and it is necessary to encourage new ways to reduce the use of fuels for food production. In addition, conventional agriculture depends on large companies that dictate the market and have dominion over producers. According to Anger, Fiebrig, and Schnyder (2013):

> "In the constant race for higher yields and standardized produce, conventional farming and the agrochemical industry have grown to become completely dependent on each other. This includes the seed industry, as often so-called hybrid seed is produced, which often doesn't crop well without use of agrochemicals. This form of cultivation has disastrous consequences, and not only in the economically weaker countries of the world. Individual farmers have to go into debt in order to buy chemicals and seed, often as expensive imports. The price of the produce, months later, is dictated by retailers without regard for the farmer's production costs. The use of genetically modified seed is even more insidious, depending on expensive technology and leading to monopolies of companies with patented seed varieties." (2013, p. 2).

Each land has unique characteristics, and many do not have the nutrients required for certain crops. Today it is possible to plant essentially anything anywhere. The land receives chemical products to adapt the soil to the need of the harvest. The seeds are genetically modified to suit a locality; a microclimate; a soil. Therefore, producers are dependent on this monopoly, which makes seeds more expensive and dictates what and how they should plant. And, as for the environment, it is harmed by the solutions that these companies offer to producers, which basically boil down to doing what they dictate.

Conventional agriculture causes several damages to the environment. It is rainwater runoff and irrigation runoff that carry out polluted water from agriculture with pesticides and agrochemicals to the water table, rivers, and oceans. According to Despommier (2009):

> However great the contribution of urban waste is to the destruction of terrestrial and aquatic ecosystems, it is agricultural runoff, that wins the gold medal for pollution worldwide. [...] Farm runoff despoils vast amounts of surface water and groundwater. Some 70 percent of all the available freshwater on earth is used for irrigation, and the resulting runoff, typically laden with leftover salts, herbicides, fungicides, pesticides, and fertilizers leached from nutrient-depleted farmed soil, is returned to countless rivers and streams. Runoff that reaches the oceans untreated has potential to disconnect other ecological systems through its nutrient-loading and oxygen-scavenging agrochemicals, particularly nitrates and nitrites (2009, p. 31).

These runoffs have altered the pH of ocean water in locations where rivers meet them. This change in pH has caused major disasters. Corals are not as rich as they should be, harming the food available for fish, which leads to a reduction in their population in places where fishing was considered the flagship of the local economy. This occurs in the rest of the globe where

conventional agriculture is used. In addition, soil is being impoverished with the use of so many agrochemicals, and such action can lead to the desertification of ecosystems that were once prosperous with diversity of fauna and flora. Mentioning these, agriculture in the rural area deforests the local vegetation, which drives away birds and animals important for the maintenance of life (DESPOMMIER, 2009). Weather in forests or in the savannah, agriculture degrades any ecosystem.

Pesticides used in conventional agriculture constitute a social threat. According to Bombardi (2012), in 2009, Brazil became the world's leading producer of pesticides. In line with Pires, Caldas and Recena (2011), for each reported case of pesticide poisoning in Brazil, there are another fifty that are not reported by the population (BOMBARDI, 2012, p. 5). This fact demonstrates that the population knows little about the harm caused by pesticides. However, according to the SINITOX agency, from the Brazilian Ministry of Health, from 1999 to 2009, there were a total of 1,876 deaths resulting from the use of pesticides on Brazilian soil, which represents 170 deaths per year (BOMBARDI, 2012, p. 8). Therefore, in addition to pesticides causing damage to the environment, the population also suffers negative consequences, such as recurrent deaths.

In this sense, it is evident that conventional agriculture causes drastic damage to the environment. The large companies that produce seeds and agrochemicals control the producers and offer solutions that only harm the ecosystems. The burning of fossil fuels both in production in the countryside and in the transport of food to the cities interferes negatively with global warming. Fresh water used in irrigation is contaminated with the use of agrochemicals that are drained into the water table, rivers, and oceans, which causes damage to the aquatic systems. In addition to the waste from the inadequate use of quality water that isn't reused, the water discarded by agriculture continues its course, contaminating all the places where it passes through. In short, it is necessary to create solutions for agriculture, and urban agriculture plays a decisive role in favor of the environment and the preservation of the quality of life of the population of the world.

### 4.2 Urban Agriculture and its Implantations

For Mougeot (2000), urban agriculture is much more than just producing food in the city. A new meaning is given to the production of food, for example, the interaction with the inhabitants of the cities, the new technologies and the knowledge that are summed. And the main difference is the interaction with the urban ecosystem. Urban agriculture occurs in several ways and can be used as an instrument to inhabit areas that are not in use: "[…] as public areas: public roads, squares, parks, and idle areas, such as lots and vacant lots, which can be transformed into productive environments, thus enabling their best use by local communities"[4] (COMELLI, 2015, p. 41, our translation).

The understanding of how urban agriculture manifests itself in cities contributes to the planning of its installation in the urban environment, so that the benefits of its use are achieved. There are three most common occurrences around the world nowadays, which are: urban

[4] "[...] como áreas públicas: as vias públicas, praças, parques e áreas ociosas, como lotes e terrenos baldios, que possam ser transformados em ambientes produtivos, possibilitando, assim, o seu melhor aproveitamento pelas comunidades locais."

agriculture at ground level (such as in backyards or lots), rooftop agriculture (on building's terraces) and vertical agriculture (inside buildings).

### 4.2.1 Urban Agriculture in the Level of the Terrain

Agriculture on the ground floor represents the most elementary means of its occurrence, which uses the site's soil for planting. In cities, it usually occurs in the backyard of houses, lots, and public areas. According to Herzog (2013), urban agriculture began when rural workers migrated to cities during the nineteenth century, bringing to them the customs of growing food for subsistence consumption or even commercial use (ROSETTO, et al., 2017. p. 584). According to Almada and Souza (2017), the figure of the backyard can be traced back to the beginnings of agrarian practices that happened with the Neolithic Revolution, which has since brought the domestication of different species to backyards.

In Brazil, the incentive to urban agriculture can be seen since the 1980s. In Curitiba, in 1986, the city hall developed the "Nosso Quintal"[5] program, whose ideal was to support and encourage urban producers to plant in small places, as in backyards, kindergartens and schools. The prefecture provided inputs and technical advice to the producers. According to Carriel (2009), the planted urban area exceeded 225 hectares, fed around 5,000 children and 7,800 adults (COMELLI, 2015, p. 72). Similar cases occurred in other Brazilian cities, such as Belo Horizonte, also in 1986, with the emergence of the Alternative Technologies Exchange Network (ONG-REDE) (COMELLI, 2015, p. 75).

Figure 1 – Edible landscape at VF Outdoor

Source: Wiley publisher (PHILIPS, 2013, p. 209)

Figure 2 – Detail of a landscape with edible goods at VF Outdoor

Source: Wiley publisher (PHILIPS, 2013, p. 180)

The Federal District is aware of the relevance of urban agriculture. On February 24, 2012, it created the law 4,772 to establish support for urban and peri-urban agriculture. Amongst several guidelines, there is the intention to take care of unused spaces. In article number two of this law, paragraph XI, it is noted the importance that urban agriculture must make use of unused spaces in the city, where it is written that it must "promote the use and cleaning of idle public spaces"[6] (SINJ-DF, 2012, our translation). Namely, the Department of Agriculture, Supply and Rural Development states that in the Federal District, there are approximately 120 community gardens. Juliana Contaifer (2018) says, in a report by *Metrópoles*, that several are inside schools, but others also occupy abandoned spaces in the city, with the residents of the neighborhood themselves being responsible for carrying for the gardens, which aim to harvest organic food for their own consumption (CONTAIFER, 2018). And, in Brasilia,

[5] Meaning: our backyard.
[6] "promover utilização e limpeza de espaços públicos ociosos"

there are cases where residents of residential buildings are using the public green area to grow community gardens. An example is at 115 of "Asa Sul Neighborhood", where a multifamily residential building has pots with vegetable seedlings under its stilts. It is the residents of the building themselves who take care of and consume the production. Right in front of the edifice, in the green area, vegetable gardens were also made in pots from used tires. This action on the part of the residents exemplifies how small attitudes transform spaces without much use, which previously served only with the bucolic function[7], and now, with a subtle gesture of implementing small vegetable produce in pots, brings food and recreation to the local population.

However, such solution in public areas that are not in use can create a difference of opinion as to user acceptance. Some people are fond to see gardens, others are not. Those who do not like it are those who find it ugly to see vegetables in the urban environment. As is the case of a medicinal garden that existed for twenty years in Block H of 216 of the "Asa Norte Neighborhood" in Brasilia. This one for instance, was deactivated after the building's manager filed a lawsuit claiming that the space was a total disorder and should be revitalized with a landscaping project. He states that in the new project, pots will be reserved for residents to plant and care for the plants (FUZEIRA, 2018). In Brazil, it is not common to see this occurrence in public areas. Although, abroad, some landscapers like April Philips got around this problem by using geometric designs with vegetables, for example, as can be seen in the edible garden of VF Outdoor, in Alameda, California, which values the aesthetics of the landscape and reduces the dissatisfaction of those who do not care about the gardens (see figures 1 and 2).

### 4.2.2 Urban Agriculture in Edifices at the Level of Terraces

Lauren Mandel (2013) says,

> In cities, forgotten parcels such as vacant lots, sidewalk strips, and park fragments historically served as prime poaching grounds for urban farmers and gardeners to plant their seeds. During recent years, however, land insecurity and contaminated soils demand creative solutions that allow urban agriculture to creep up walls and balconies, and onto rooftops. Broadly speaking, rooftop agriculture is the cultivation of plants, animals and fungi on rooftops for the purpose of human use and consumption. (MANDEL, 2013).

A study carried out in 2011 by the Urban Design Lab identified that in New York City alone there is a potential of 1,214 hectares available for plantation in rooftop terraces. This under a selection-criteria, whose intention was to delimit the research, which includes, among others, only buildings whose structure supports the weight required to have activities related to urban gardens and that are up to ten meters high, to facilitate access and transport of goods (NOVAK, 2016, p. 11). Therefore, there is a large potential to implement urban agriculture on rooftop terraces (see figure 3) in megalopolises around the world, as, for example, is the case of the city of Sao Paulo in Brazil. Such implementation would represent a significant advance towards the sustainable growth of this city, as of others worldwide.

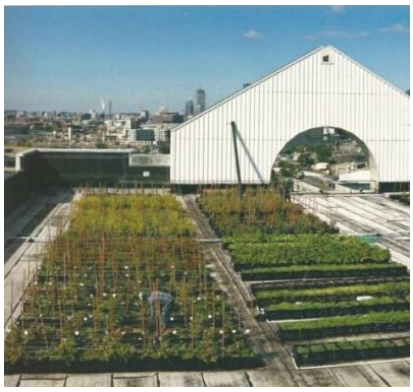
The first commercial rooftop farm in the United States was the Eagle Street Rooftop Farm, established in 2009 (NOVAK, 2016, p. 13). It is located on top of a building in Brooklyn, New York, and has a floor area of 557m². Its carbon footprint is zero, due to the non-use of

[7] In reference to the bucolic scale of Brasilia.

electricity and no need for transportation dependent on the combustion of fossil fuels, whereas goods are transported using bicycles. The main consumers are restaurants in the neighborhood, located within a radius of five kilometers from the rooftop farm. The waters used for planting come from rainwater, which occurs entirely at open sky. Most of the production is organic, consisting of fruits, vegetables, and roots. There is also the raising of chickens and rabbits whose residues provide nutrients for the soil. There is also an area for composting organic waste from the farm itself to contribute to the fertilization of the produce (ROOFTOP FARMS, 2021).

In addition to the Eagle Street Rooftop Farm, there are other notable ones in the United States. One is the Gotham Greens company, which has eight facilities, the first being created in New York's Brooklyn in 2011 (GOTHAM GREENS, 2022). Its mission is to produce organic food, in greenhouses on top of existing building slabs, using one hundred percent clean energy. This is a company with private capital that has approximately 15 hectares of plantation (GOTHAM GREENS, 2022). In Canada, there is Lufa Farms, which had its first unit opened in 2011, in Montreal, with about 0.3 hectare of greenhouse-built area (see figure 4). It feeds approximately ten thousand people every week throughout the year, and its greenhouses maintain the ideal parameters for planting even during winter, which allows the snow to be kept off-bounds, so it won't interfere with the production. In its three units, the planting area is approximately 1.3 hectares (LUFA FARMS, 2021).

Figure 3 – Higher Ground Farm in Boston



Source: Ten Speed Press publisher (NOVAK, 2016, p. 19)

Figure 4 – Lufa Farms during winter at Montreal

Source: Pop Up City (POP UP CITY, 2012)

### 4.2.3 Urban Agriculture Inside Edifices (Vertical)

Vertical farms are farms that are located inside buildings in cities. This theme is imbued with the theme of vertical farms. There are two terms that define vertical farm: vertical farm[8] and plant factory with artificial lighting[9] (KOZAI; NIU; TAKAGAKI, 2015, p. 3), the last one being specific for cases where artificial illumination is used. One of the forerunners of the vertical farm concept (see figure 5), is Dr. Dickson Despommier, professor emeritus of microbiology at the Columbia University, United States, who between 1999 and 2009 solidified the term "vertical farm" together with his students. According to Despommier (2009), vertical farm: "it is a concept whose premise is easy to envision: Stack up 'high-tech' greenhouses on top of each other and locate these 'super' indoor farms inside the urban landscape, close to where most of us have chosen to live." (2009, p.23). Another specialist is Dr. Toyoki Kozai, emeritus professor at the University of Chiba, in Japan, responsible for several studies regarding plant factories with artificial lighting (PFAL's) (WILLIMAS, 2017). Kozai et al. (2015) define PFAL's as follows:

[8] "Vertical Farm (VF)"
[9] "Plant Factory with Artificial Lighting (PFAL)"

> The term 'plant factory with artificial lighting (PFAL)' refers to a plant production facility with a thermally insulated and nearly airtight warehouse-like structure (Kozai, 2013). Multiple culture shelves with electric lamps on each shelf are vertically stacker inside. Other necessary equipment and devices for a PFAL are air conditioners, air circulation fans, CO2 and nutrient solution supply units, and an environmental control unit. Stacking more culture shelves vertically increases the efficiency of land use. (KOZAI; NIU; TAKAGAKI, 2015, p. 3).

Despommier (2009) deals with the subject in a more visionary way, as a theorist, who is responsible for solidifying the concept by pointing out the advantages of urban farms. Kozai et al. (2015) are responsible for technical research on the subject, which has solid studies with plants with artificial lighting that are already in full operation.

Vertical farms are innovative, but some already exists around the world. In 2016, there were more than twelve vertical farms in operation in the United States (BIRKBY, 2016, p. 7). That same year, the largest vertical farm in the United States at that period, AeroFarms, opened in New York (AEROFARMS, 2021). This company operates both with projects that were designed to be vertical farms, that is, built to suit, as well as with the retrofit of existing sheds (AMARAL, 2018, p. 9). The unit in Newark, New Jersey, in 2018, was "considered the largest indoor urban farm in the world, with an area of 6,500 square meters and a production of 2,000 tons per year"[10] (AMARAL, 2018, p. 9). Another example of a successful vertical farm, which is also one of the most promising, is Sky Greens, located in Singapore. It has developed a system that is like a bookcase, but mobile, capable of moving up and down with plantation so all plants can receive natural light provided by the sun (see figure 6). By using the sun for plant growth, this is one of the most economical solutions, which makes it a great potential to be a successful model for future vertical farms (SKY GREENS, 2021).

It is necessary to rethink the use of water at all levels, and it is also necessary to reduce its consumption to reuse it, thus, making the most of it. In all cases, vertical farms contribute to this, whether artificial or naturally lit, they don't require soil, only running water with the addition of nutrients, with aeroponics and hydroponics being the main planting methods used. These systems are capable to reduce water use at planting by up to seventy percent when hydroponics is compared to the conventional system used at the fields, and by other seventy percent when aeroponic is compared with hydroponics (DESPOMIIER, 2009, p. 208). In addition, all the water used in the system to irrigate the plantation is captured to be reused. This does not occur in the countryside, where the water follows its course to the water table and rivers, oceans, being prone to pollute these. Therefore, vertical farms collaborate with the environment by reducing and reusing water consumption, which eventually avoids polluting rivers.

Vertical farms, in the case of enclosed cases, maximize the production and reduce waste. There is no need to worry about climatic factors, as they are sealed greenhouses, and there is no risk of the harvest not receiving enough and adequate rainwater or sunlight, as in conventional production (DESPOMMIER, 2009, p. 148). With this, it is possible to produce more and faster, as the climatic conditions are optimized for each harvest. According to Mirai, its artificially lit vertical farms produce a hundred times more than in the conventional system

[10] "é considerada a maior fazenda urbana coberta do mundo, com área de 6.500m² e produção de 2.000 toneladas por ano"

(MIRAI, 2021). As a result, there are no crop losses; They do not run the risk of spoiling. Therefore, there is a reduction in food waste rates and the producer is not wronged by time.

Figure 5 – Proposal of a vertical farm in Seattle

Source: Picador Publisher (DESPOMMIER, 2009)

Figure 6 – Elevatory vertical plantation in Singapore

Source: Sky Greens Website (SKYGREENS, 2021)

Although there are several advantages in the use of vertical farms, the technical complexity, as well as the high values of investment to initiate the system, delay the emergence of new units around the world. As the vast majority is done in closed buildings or sheds, the need for artificial light compromises the ecological footprint and increases the expenses with electric bills. However, the economy and energy efficiency of the new LED lamps contribute to an optimistic future for the emergence of new vertical farms. And, as plants depend only on the red and blue spectra, not using other colors contribute to reducing electricity costs by 15 percent (BIRKBY, 2016, p. 5). The high expenses to implement the system can also make the projects unfeasible, as a lot of infrastructure is required, such as equipment related to production from an engineering and mechanical engineering logistics (see figures 7 and 8). The economic challenges, as they innovate ventures that start their activities with several uncertainties, led some vertical farms to abandon their activities, as in the case of FarmedHere, whose unit in Chicago failed to be profitable enough (CHICAGO TRIBUNE, 2017). On the contrary, other cases such as Aerofarms and Sky Greens are profitable and continue to expand.

Figure 7 – Aerofarm's vertical farm

Source: Aerofarm's website (AEROFARMS, 2021)

Figure 8 – Sanitized employee at Mirai´s vertical farm

Source: Academic Press Publisher (KOZAI, et al., 2015, p. 208)

## 5. CONCLUSION

The research demonstrated urban agriculture and how it may be utilized to requalify idle spaces and edifices. With references based on bibliographical research, it was possible to comprehend terms related to the theme of urban agriculture as well as cases where this agriculture may be used. On regards to its implantations in the city, urban agriculture may be inserted in the terrain's level, in terraces or inside edifices. The most economical and practical of these is the one at the level of terrain, which is also the most vernacular. Nevertheless, this method is quite demanding, due to vandalism, especially amongst people that do not appreciate agriculture in the urban limits, as to free ranging animals, such as abandoned dogs, that may damage the harvest. Plus, when not associated with a landscaping project, the visual aspect of the image of the city could upset citizens that aren't used to edible gardens in urban surroundings. Regarding its use in terraces of edifices, there is a great potential to insert urban agriculture in the cities. Slabs normally represent idle spaces, therefore, if used as a harvesting tool, these are isolated places that guarantee the integrity of the production of goods without worries related to vandalism. More so, exposure to constant sun contributes to the plant's growth, dismissing the need for artificial lighting. When associated with greenhouses, there is a gain in production all year long and insects and other pesticides are better controlled, despite adversities the weather may cause. Regarding the production in closed areas, vertical farms are the most challenging of them all, but it has the potential to contribute more efficiently with the environment. The buildings require appropriate infrastructure, such as artificial lighting, treatment of solid waste and a system that reuses water, all of which demand for a great deal of investments. Nonetheless, its implantation in megalopolis, such as Sao Paulo, New York, and Tokyo, for example, is recommended. These, arranged in strategic locations, in large scale cities, amongst others, minimize the necessity for fuel consuming transportation to distribute perishable goods, which also guarantees the integrity of food, minimizes waste and fossil fuel consumption. Therefore, vertical farms in the cities avoid pollution and there is no need for pesticides, and the technique of aeroponics is capable of reutilizing water from the production of the harvest. Accordingly, urban agriculture has a great potential to contribute to the development of sustainable cities.

In short, agriculture should be inserted in the urban environment in favor of sustainable development. Urban agriculture reduces the need for transportation from the field to the city, that eventually reduces the air pollution and minimizes the use of fossil fuels, collaborating to an ecological footprint of the cities. It is also prone to the reduction of pesticides and irrigation to harvest edible goods. However, it offers the population healthy produce that are ecologically correct, which increases the quality of life of consumers as well of producers of organic goods. Furthermore, urban agriculture is capable of requalifying idle spaces, or even abandoned buildings, that are functionless and tend to be deteriorated without appropriate maintenance. Therefore, it is important to understand the existing options that urban agriculture offers to city planners to give use to places that aren't currently in use in cities premises, which enhances the ecological footprint and resilience overall within the urban environment.

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