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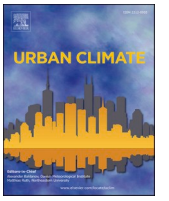

Urban and peri-urban agriculture in Goiânia: The search for solutions to adapt cities in the context of global climate change

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ABSTRACT

Goiânia is a city in the late 1930s, and one of the two cities constructedin the Brazilian savannah. In 2018, it had 1.4 million inhabitants and 2,05217 inhabitantsper km^2. With less than 100 years of age, the urbanization model associated with the effects of global climate change has led the city to live, in recent periods, with moments of water scarcity and flooding. In view of this, the urban municipal policy seeks to point out actions that aim to control land use and occupation from an environmental sustainability perspective. Urban and peri-urban agriculture (UPA) is one strategy and will be the main objective of this article. The urban municipal policy will indicate areas for the practice of UPA as a strategy for adapting cities in the context of climate change. As a secondary objective, the potential for carbon sequestration by this activity was analyzed. The methodology was based on the analysis of urban land use in a Geographic information system (GIS) environment. The database of the Municipality of Goiânia was used. The results indicated three levels of priorities, with a total of 10,650 hectares. In terms of carbon sequestration , this area would result in the capture of 5.536.764,60 tons of CO_2 from the atmosphere in 20 years.

1. Introduction

The Intergovernmental Panel on Climate Change (IPCC) estimates an average elevation of temperature on land between 2.6 to 4.8 °C by the end of the century if the current rate of greenhouse gas emissions is maintained (PBMC, 2016). Extreme weather events are designed and visualized on the globe with different effects on urban areas.

Although Brazilian cities are relatively new, changes in soil use and occupation patterns contribute to the change in local ecosystems, contributing, directly and indirectly, to the global climate changephenomenon In addition, such changes affect local weather-climate conditions, requiring local admininstrators to have a greater management capacity and technical knowledge.. Adaptation to the climate change scenario, as well as the construction of resilient cities has been an alternative pointed out in the scientific literature (Gonçalves, 2017). Resilience is defined as the ability of an ecosystem, population or species to recover after its initial condition has been perturbed (Holling, 1973)

The search for urban resilience remains a challenge in Goiânia. Between 2017 and 2019, the city revised its main normative framework of urban planning: the master plan, aiming at pointing out alternatives for environmental sustainability (PREFEITURA DE

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GOIÂNIA, 2018). Fifteen years earlier, the city presented its "Agenda 21" (PREFEITURA DE GOIÂNIA, 2004), which gave instructions on how to restructure and requalify urban areas, especifically along the water gutters. Although different urban planning projects were carried out during this period by the government, the city coexists with the urban sprawl, conurbation next to the adjacent municipalities and faces, in the metropolitan region, different moments of water scarcity (Hora and Salles, 2017).

Goiânia is a relatively new city and was designed and implemented in the late 1930s in the Brazilian savannah to be the new capital of the state of Goiás. Although recent, its urban growth and demographic was the result of migratory flows, which peaked between 1950 and 1990. This migratory process led to an unevenly constructed city, with emerging pockets of misery in the peripheral neighborhoods and irregular dwelings, especially in the valley edge of the capital. In 2018, Goiânia had a population of 1.4 million plus the population of the 21[1] municipalities that make up the metropolitan region, for a total of 2.4 million people. That is, over 1/3 of the state's population is concentrated in 21 of the 246 municipalities in the State of Goiás (IBGE, 2010, 2018).

The original planning of the city foresaw a network of parks and green areas. However, this has been compromised throughout its existence. The plumbing project of the water courses and the growing waterproofing of the urban mesh resulted in an increase in artificial drainage and in the compromise of the urban drainage system. In parallel, this growth resulted in the suppression of vegetation. Nascimento (2010) points out that the city's natural vegetation was reduced by 52.66% between 1986 and 2010, and the constructed are increased by 92.8% at the same time

Thus, becoming resilient and adapting to the current context, for Goiânia, means investing in urban drainage strategies and protecting the areas of water recharge., perspectives that integrate territorial management and, land-use patterns with emerging issues can point to innovative local and regional solutions. Urban and peri-urban agriculture (UPA) presents itself as a solution in this regard.

Urban and peri-urban agriculture can be understood as agriculture practiced within the urban perimeter or in the peripheries of this perimeter, in areas called periurban, where rural and urban activities are mixed and it is not possible to define the physical and social limits of these two spaces (Mougeot, 2005). It can be carried out by individuals, formal or informal organizations, and can take place either in public or private spaces.

According to Santandreu and Lovo (2007), the UPA contemplates multiple aspects: production (vegetable and vegetables, animal, inputs, and equipment), processing (processing and adding value), marketing; self-consumption; exchanges or donations; and the provision of service. The UPA allows for the control of land use, indicating new forms of use in the urban mesh, and can be an instrument against real estate speculation, as it develops in urban voids. Its practice helps to increase the permeability of the soil and createsmild microclimates by decreasing the temperature.

In addition to quantitatively and qualitatively corroborating environmental maintenance, UPA can become an important ally in carbon sequestration[2] and presents itself as a source of income, serving a portion of the population. Within the pillars of sustainability, pointed out by Sachs (2002), the UPA addresses spatial, social, economic and environmental (ecological) issues.

UPA practices cancontribute to lower temperatures, lower city densities and can also increase water percolation in line with the new global agreement to combat the effects of climate change, adopted at the 21st Conference of the Parties (COP -21), Climate Conference in Paris. *The COP-21 reports predict that global warming will remain below 2 °C and stresses the importance of ensuring that the temperature rises on the ground does not exceed 1.5 ° C above pre-industrial levels* (SUSTAINABLE CITIES PROGRAM, 2018, np.).

Even if human behavior changes, in an effort to prevent the increase in earth temperature from exceeding those indicated in the COP-21 reports, the GEO6 report (2019, p.44) clarifies that the world will experience "a certain level of warming compromised due to the past CO_2 emissions". Therefore, it is a characteristic of climatic inertia. Climate change is related to CO_2 emissions that has been occurring since the Industrial Revolution period, over approximately 220 years, which represents an increase of 50% over the last40 years. In Brazil, there has only been an increase in CO_2 emissions after 1990 (GEO6, 2019).

Despite the pessimistic picture presented in GEO6, the fact is that human behavior has to change in the way we treat the environment. Even if climate inertia occurs for the next 25 years, (GEO6, 2019, p. 45 apud FIGUERES et al., 2017, p. 595) or if the CO_2 emission proposed by the paris agreement is not met, the temperature may still increase by 3 °C or more, causing natural disasters, such as polar ice melting level of water and creating an even greater environmental imbalance. Even if we guarantee sustainability in land use and land-use patterns, we must consider its restricted impact over the period of thermal inertia, since we will be under the influence of past emissions (GEO6, 2019, p.45). In this case, it is estimated that the temperature could be kept below 2°C.

UPA is an action that can contribute positively to the adaptation of the city to the climatic changes, due to the maintenance of permeable areas, control of land use of the soil, temperature decrease with the contribution of carbon sequestration, the balance of the hydrological cycle and contribution to a local microclimate amene.

In view of this scenario, the main objective of the study is to indicate areas for the practice of urban and peri-urban agriculture (UPA) integrated with the dynamics and territorial management as a form of social inclusion, production of healthy food, and mitigation of global warming in Goiânia. This action aims to provide municipal public management with information that can support the promotion of diversity,social and cultural inclusion. It also aims to cooperate with the provision of environmental services in a balanced and sustainable manner, and to contribute to improving the productivity of the city and food security of vulnerable groups. As a secondary objective, we sought to compute the carbon sequestration that would be provided if all the identified areas were entirely

[1] The Metropolitan Region of Goiania was created in 1999, from the eight municipalities that comprised the Urban Cluster of Goiania. In 2019, Complementary Law n° 149, of May 15, 2019 changed its compositions to contain 21 municipalities. See: https://legisla.casacivil.go.gov.br/pesquisa_legislacao/101136/lei-complementar-149. (GOVERNO DO ESTADO DE GOIAS, 2020)

[2] According to Renner (2004, citado por MONTEIRO, 2018, pg. 29) "the carbon sequestration refers to an atmospheric CO_2 absoption and storage processor that has the intention of minimizing its impacts on the environment, and since it is a greenhouse gas (GHG) we aim to reduce that effect."

destined to the UPA.

The methodology used was based on the analysis of data in a Geographic Information System (GIS) environment using the projected land use and land-use patterns database of the Municipality of Goiânia and the legal references of the master Plan. As follows: i) survey of UPA experiences in Goiânia; ii) identification of the characteristics necessary for the implementation of the UPA, and application of these conditions in the mapping of the municipality of Goiânia; iii) establishment of criteria for prioritizing areas, their development, and application of criteria in a region of the municipality to validate the proposal; iv) note of guidelines for public policy of UPA in Goiânia to propose recommendations in the revision process of Law No. 171/2007 (Municipal Master Plan). For the secondary objective, the methodological proposal of an exploratory study for calculating carbon sequestration was considered and applied to the amount of area found in step ii, considering its total destination for UPA in a 20-year scenario.

To describe this, the article presented here is structured in 1. Introduction; 2.Urban and Peri-urban Agriculture in urban voids as an alternative to the territorial management of Goiânia; 3.Materials and methods, where 3.1.study area is presented, 3.2.Mental study map, 3.3.Normative Perspective 3.4.UPA experiences in Goiânia; 3.5. Necessary characteristics and their criteria for implementing the UPA, 3.6. Calculating carbon sequestration to reduce GEE emissions, 4. Results and Discussions with sub-items: 4.1. Selection and prioritization of areas for UPA in Goiânia, 4.2. Carbon sequestration in UPA practices, 4.3. UPA as an alternative to Goiânia and item 5. Final considerations.

2. Urban and peri-urban agriculture in urban voids as an alternative to the territorial management in Goiânia

For authors such as: Aquino and Assis, 2007; Santandreu and Lovo, 2007; Branco and Alcântara, 2011; Monteiro and Monteiro, 2006, urban agriculture presents itself as an alternative to the problems of food and nutritional security, since it facilitates the occupation of idle urban spaces, vulnerable groups and contributes to the sustainable development of the city.

Urban and peri-urban agriculture can be presented as an increase in cover vegetation as a way of mitigating climate change through "carbon sequestration (main anthropogenic greenhouse gas) through reforestation with native vegetation", (RODRÍGUEZ, 2015, p.4). In a study by Monteiro (2018), it is highlighted that the cover plants used "[...] sequester carbon and with superior quality of organic matter, when compared without the vegetation cover".

In addition, the promotion of urban and peri-urban agriculture strategies enables the reconstruction of green areas by rebuilding small forest ecosystems. These ecosystems alsocontribute to an increase in the areas of infiltration, and are ecologically viable and sustainable. Thus, the UPA can help in the construction of resilient environments contributing to the improvement of natural drainage systems and contributing to reduce the surface drainage of urban rainwater, among other advantages, besides acting as a form of global warming decrease, as it will contribute for CO_2 elimination, still functioning as a green[3] infrastructure in the city.

Urban and Peri-urban Agriculture (UPA) presents itself as a growing phenomenon on the world stage. In developing countries, such as Cuba, Argentina, Ecuador, and Mexico, UPA practices build a survival alternative for the most socially vulnerable groups, functioning as an income increase, contributing to the food security of these groups (Aquino and Assis, 2007), and is economically and socially sustainable. While in developed countries, UPA becomes an extremely important and highly competitive production method and is anchored in solutions from resilient cities and nature-based solutions. Examples of this can be seen in European Union countries, such as Portugal (DELGADO, 2015) and France[4].

In Brazil, UPA practices began to stand out in the 1980s with the support of state governments and local institutions (Farfán, 2008). According to FARFÁN (2008), the initiatives had the support of municipal governments and local institutions, which sought to use idle areas, aiming to rescue the social function of the land and promote food security for the population. Santandreu and Lovo (2007), when studying 11 metropolitan agglomerations in five regions of the country, realized that UPA practices include plant production (46%), trade (22%), service (15%), and animal production (10%). In general, the initiatives are more concentrated in the south and southeast (59%), followed by the midwest (23%) and north and northeast (18%).

However, there are still no legal norms that regulate, subsidize, or invest in UPA in Brazil. Many of these initiatives tend to be financed by civil societies, universities, or the private sector, with little or no government action. Although there is a lack of public policies that favor its broad implementation, UPA has been highlighted in specific programs in some municipalities, such as the one in São Paulo (SP), Brasília (DF) and Teresina (PI).

In the city of São Paulo, the Youth Environment and Social Integration Program in the Green Belt Biosphere Reserve (YESIP/GBBR), instituted in 1996, was responsible for promoting the training and integral formation of socioeconomically disadvantaged adolescents, in the age group from 15 to 21 years old. They are inhabitants of urban and peri-urban areas of the Green Belt of São Paulo who, through workshops that include Sustainable Agricultural Management and Forest Production, Sustainable Tourism and Artisanal Agroindustry, find some occupation and income (Rodrigues et al., 2006).

In Brasília, the Small Agricultural Production Verticalization Program (SAPVP), since 1995 legally enables the creation of small agro-industries by supporting the production, processing and commercialization of UPA products (CARVALHO, 2005). In Teresina, UPA practices started with an occupational therapy program for underprivileged children through the cultivation of vegetable gardens, which expanded to include disadvantaged families. The "Integrated Multisectoral Project Vila-Bairro" still in operation, served in 1999, about 2,503 low-income families with 117 hectares and 38 gardens, becoming a national reference (Aquino and Assis, 2007). In

[3] According to Vasconcellos (2015, p.22), the green infrastructure aims to "develop sustainable conservation solutions with an emphasis on the integration of economic and environmental interests".

[4] Conferir a plataforma: http://www.parisculteurs.paris/en/about/acessoem04/07/2020.

Goiânia, Santandreu and Lovo (2007) highlighted four associations financed by civil society, university, and the private sector that are dedicated to UPA practices. In the municipality, Complementary Law No. 171, of May 29, 2007, which establishes the Master Plan (PREFEITURA DE GOIÂNIA, 2007a), the main urban planning law, included the subprogram for the promotion of urban and peri-urban agriculture with actions aimed at implementation of projects with organic and sustainable bases throughout the municipal territory and the encouragement of the cultivation of urban gardens in public areas and, mainly, vacant lots. The above examples allow us to conclude that the use of vacant lots for the practice of UPA has been a common strategy in the municipalities where this activity occurs in Brazilian cases.

In Goiânia, it is possible to identify vacant lots and parceled areas that have not been build, the so-called urban voids.. These are defined in Article 5 of the Complementary Law No. 181, of October 1, 2008 (PREFEITURA DE GOIÂNIA, 2008), in Goiânia, as non-parceled properties, that is, lands, parts, and areas, located in Macrozona Constructed [urban area], with public access consolidated and served by at least three basic infrastructure services. That is, the urban voids are portions of the territory that could be parceled out and offered for sale on the market, but were not in the interest of the owner. Their idleness increases the cost of urban infrastructure since it makes it underutilized. At the same time, it causes a financial overvaluation of these benefiting areas, identified by the phenomenon of real estate speculation.

Social pressure exerted by the population in search of cheaper and more accessible housing leads to the growth of the urban mesh. The permanence of urban voids encourages the conversion of the use of rural areas bordering the urban perimeter for urban activities. In this process, there is an induction of the occupation of the urban fringe or peripheries by the population. The most vulnerable, low-income population settles in these rural-urban transition territories when looking for housing alternatives in more distant areas of the urban centers. Since they lack infrastructure, these locations become cheaper and more attractive.

This situation, coupled with real estate speculation, promoting urban voids, accentuates the non-fulfillment of the social function of property provided for in both the Land Statute (BRASIL, 1964 - Law No. 4.504, of November 30, 1964) and the City Statute (BRAZIL, 2001 - Law No. 10,257, of July 10 of 2001)). Both laws are envisaged in the Brazilian legal normative framework. Ensuring the right to a sustainable city and decent living conditions for such social groups is one of the premises of the City Statute.

The areas to be destined for UPA, now proposed for Goiânia, will be the urban voids. To this end, article 186 of the 1988 Federal Constitution, which defined the criteria for the social function of rural property, is used as a reference. The ambiental production was considered a requirement to be used for urban areas, in context of facing real estate speculation, for the adoption of strategies to adapt cities to the effects of climate change and in the production of healthy food. Regarding this last aspect, it is important to highlight the initiatives to combat hunger and promote healthy eating advocated by the National Food and Nutritional Security System (Sisan) created by Law No. 11,346, of September 15, 2006 (BRASIL, 2006). Law 11346/06 aims to promote the fundamental human right to adequate food and Sisan indicates the need to serve vulnerable populations[5].

Finally, another aspect to be highlighted for the selection of urban voids for UPA practices is anchored in the need for urban arborization strategies to maintain microclimates with mild temperatures. Goiânia is located on the central plateau, whose climate is characterized by high thermal amplitudes, as explained in the following item. The suppression of vegetation over the decades raised the surface temperature at the same time that islands of heat were formed (NASCIMENTO, 2010). This is seen in the difference between the average temperature of the central and peripheral areas whose values vary between 2.5 ° C (minimum) and 3.4 ° C (maximum), with 2.3 ° C (average), between 1979-2009 (Farias et al., 2012). It is understoodthat the practice of UPA in the urban voids could contribute to the local microclimates with the increase of vegetation and permeable area if it were stimulated in central regions of the city.

3. Material and methods

3.1. The are of study

Goiânia is located in the central plateau of Brazil, and has the geographical coordinates Latitude: -16.6799, Longitude: -49.255 16 ° 40 ’48 "South, 49 ° 15’ 18" West. The municipality accounts for 774.12 km^2 –46.8% of the rural area. The population, in 2018, was 1,466,105 inhabitants (IBGE, 2018).

The city is at 760 m of altitude the climate classification is tropical with a dry season, type Aw, according to Köppen-Geiger climate classification. Fig. 1 shows the location of the municipality and highlights the urban area, called Macrozona Constructed, and the rural area, according to the Master Plan of the municipality of Goiânia, established by Law n° 71/2007.

In addition to physical and locational characteristics, the municipality has different green areas, of which the squares total 732 units, the conservation units (CU) total 744.36 hectares, the permanent protection areas (PPA) totalling 9,177.61 hectares and the environmental buffer zones (EBZ) are 7,992.78 hectares.

The 2010 Demographic Census registered 1,302,001 people with a density of 1,776.74hab/km^2. In 2020, the population estimate was 1,536,097 people. Planned in 1933 for 50,000 inhabitants, in the 1950s the city there registered more than 53,000 people. However, it will be in the period between 1960 between 1980 that the city will live the largest proportional growth, when the population goes from 151,000 to 380,000 in 1970 and in the following decade exceeds 711,000. Urban growth leads to conurbation

[5] Embora o presidente do Brasil, em 2019, tenha promulgado legislação que extinguiu o Conselho Nacional de Segurança Alimentar e Nutricional (CONSEA), instituição de debate das políticas públicas no âmbito do Sisan, as municipalidades e, mesmo, alguns Estados, mantém seus Conselhos Municipais e Estaduais atuando neste temática.

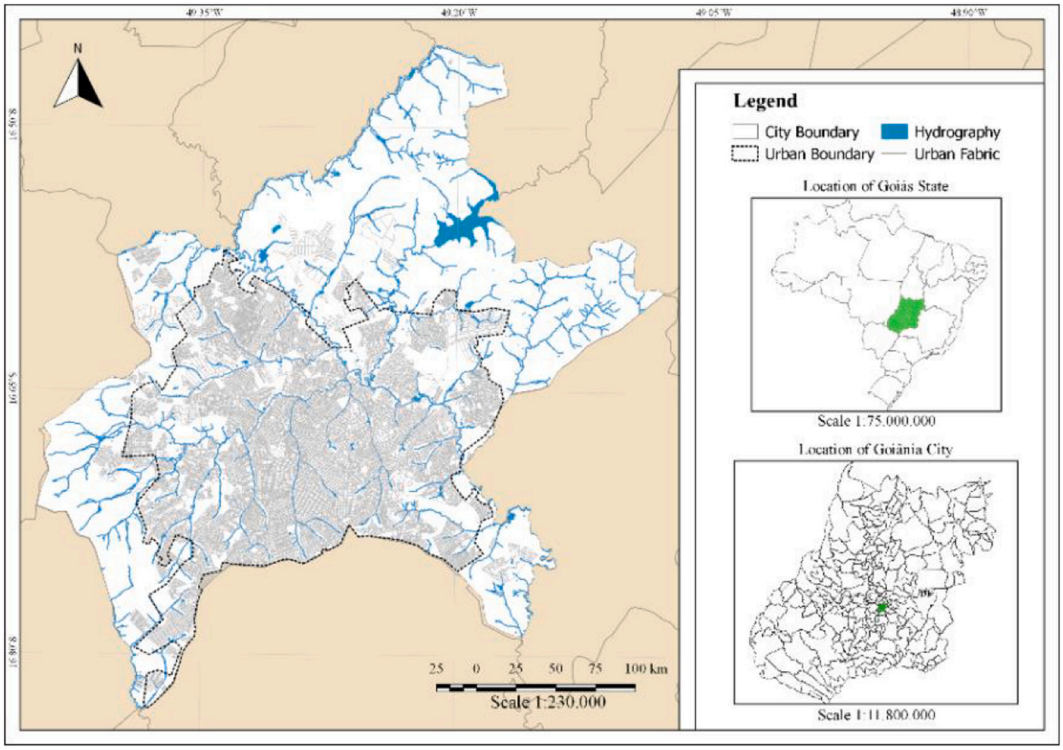

Fig. 1. Map showing Goiania's municipality
Source: Goiânia, (2007); Goiânia Municipality, Digital Urban Map of Goiânia-MUBDG (PREFEITURA DE GOIÂNIA, 2017, 2020). Adapted by the authors pelos autores.

with the municipalities bordering the south still in the 1960s, thus intensifying in the following two decades.

At the same time, there is an increase in the urban network and the reduction of vegetation. Between 1986 and 2010 the built area of the municipality of Goiânia increased by 92.8%. In the same period the area of natural vegetation reduced by 52.7% (Streglio, Ferreira, Oliveira, 2013). According to Lino (2013), between 2000 and 2011 the urban area of Goiânia increased by 31.75%. In this same period the population grew by 19%. The authors, studying the projection of urban growth of the municipality, estimates that in 2060 the municipality will reduce its rural area by almost 100%. The decades of 2030 and 2040 indicate the occurrence of occupation of the northern areas of the municipality, a region of greatest environmental vulnerability and a place of protection of the main water catchment basin of Goiânia and its Metropolitan Region.

The diagnosis of the Integrated Development Plan of the Metropolitan Region of Goiânia – PDI/RMG (UFG/SECIMA;, 2017; UFG/SECIMA, 2017) indicates a reduction in the population growth rate in the region for the decades of 2030 and 2040, including Goiânia. Still, it notes the trend of municipal master plans expanding their urban areas including new allotments. Such urban growth will have a decisive impact on vulnerable areas, in addition to expanding soil waterproofing and contributing to the reduction of native vegetation. The PDI/RMG points out, among its guidelines, the need to expand plant areas and greater protection of its water catchment basins (GOIÁS, 2018).

These observations, in a way, are presented in the proposal for revision of the Goiânia Master Plan, which was discussed throughout 2020 at the City Council. Concern with urban expansion, interference of the population questioning the increase in the construction index and social pressure for greater protection of municipal watercourses were part of the different debates on the subject. Even so, both the legislature and the executive did not reach a consensus on the new law and it was withdrawn from a vote in September 2020.

The municipality, in the last three years, has lived with periods of prolonged drought leading to water scarcity and the need for legislative decrees indicating the priority use of water for human consumption. The periods of rainfall peaks have alternated and, although the average rainfall remains over the last 30 years, there is greater intensity in the periods from December to February and an increase in drought in the period from July to October.

3.2. The study's mental map

The study considered the existence of the databases of the city of Goiânia on the use and occupation of the municipality's soil and the experience of social actors in UPA practices. These two conditions were central to selecting, classifying, and prioritizing the areas of UPA. The processing of this information was carried out by the Geographic Information System. The mind map with the steps is shown in Fig. 2 (a, b).

3.3. Normative perspective

The UPA molds itself as an alternative occupation for idle and empty urban spaces aiming, according to the Bill n° 906-B of 2015, to institutionalize the National Policy of Urban and Peri-urban Agriculture (NPUPA), to provide food and nutritional security to vulnerable urban populations; create alternative income and occupational activities for the urban population; systematize food production in cities with institutional food programs in schools, daycare centers, hospitals, nursing homes, popular restaurants, penal establishments, and others; encourage family work, cooperatives, associations and organizations of the popular and solidary economy aimed at urban agriculture; facilitate environmental education and organic food generation in cities and spread the use of organic waste and wastewater in cities in agriculture.

Besides, if the practice of UPA is recognized as a permitted use in urban areas, it can be inserted as a criterion for fulfilling the social function of property under the terms defined by the Federal Constitution of 1988 and the City Statute, Law 10257/2010.

Under the terms described by the Bill for the creation of NPUPA, UPA will also contribute to the fulfillment of other laws and programs, both at the federal level, such as the Land Statute, the City Statute, and Sisan, as well as municipal government, such as the

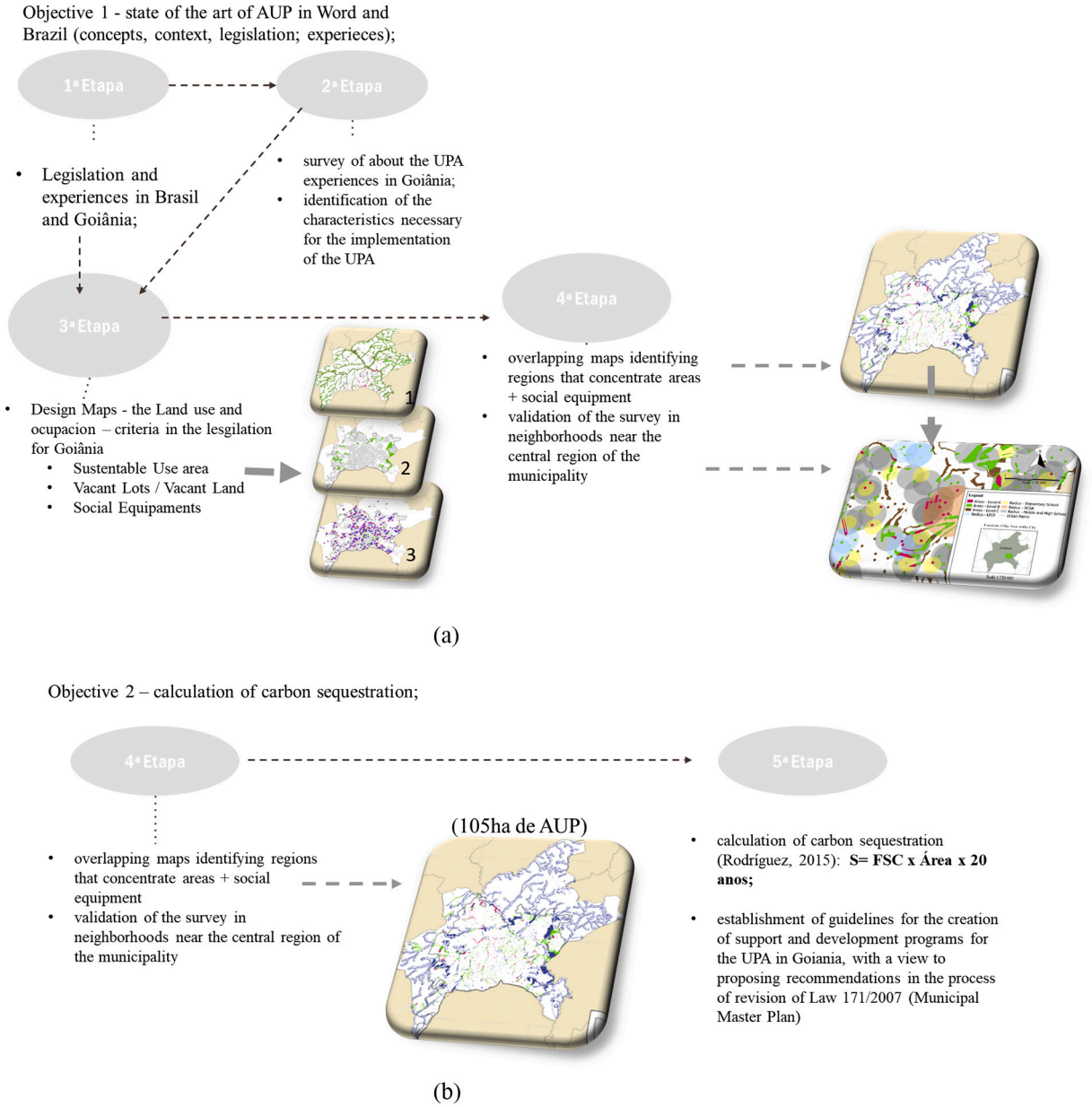

Fig. 2. Mental map outline of the different steps in the study
Source: The authors

Goiânia Master Plan and Law N° 171/2007 and the Organic Law of the Municipality of Goiânia, 1990, updated by Amendment to N° 051, of July 12, 2012, and the Local Agenda 21 of Goiânia, prepared in 2003.

For this study applied in Goiânia were considered municipal legislation for the definition of urban voids (Complementary Law No. 181/2008) and the parameters of land use for the installation of social equipament (Law No. 171/2007) were considered. These two parameters will be used to identify i) areas for implementing UPA and ii) prioritization criteria for the practice of UPA. To the latter, other aspects will be added, as mentioned below.

3.4. UPA experiences in Goiânia

3.4.1. Actors and subjects

Collective institutions or organizations that lead the implementation processes of UPA initiatives were considered as actors, and the UPA's target audience is the subject who are the beneficiary and maintainer individuals or institutions.

The survey of actors and subjects who practice UPA in Goiânia was carried out by consulting the organizations, previously identified by Santandreu and Lovo (2007), namely: the Association for the Development of Organic Agriculture in Goiás (ADOA); the Association for Recovery and Conservation of the Environment (ARCE); Goiânia City Hall. Two additionalvorganizations were identified that work with UPA in the municipality in consultation with the previous four, totaling six organizations.

Through this methodology, six actors were reached, whose subjects are people in a situation of social vulnerability. The summary of this survey is shown in Table 1.

3.4.2. UPA mapping platforms

The practices of UPA in Goiânia are also disseminated in Collaborative Mapping Platforms made available by digital applications that allow interactions between actors and subjects, as well as the population in general, that can enjoy the benefits of urban gardens.

The collaborative mapping platform "Cidade (In)visível", for example, is an open platform for everyone to add, discover and discuss places in the city, architecture, urban art, urban voids, and aspects that make Goiânia an edible city.

As for the collaborative digital map available virtually, there is a specific section for 'Edible City', where it is possible to consult, add or manage information about the places where there is the cultivation of fruit trees. The same model could be used for the management and democratization of urban gardens existing in the municipality.

In addition to the existing mapping platform, groups of UPA actors articulate and disseminate their actions using social media, such as Facebook, Instagram, and WhatsApp.

3.4.3. Subject location

The identification of the subjects attended by the UPA practices in Goiânia was carried out through contact with the institutions that develop this practice in the city. In general, it was noticed that the subjects who attended the most are individuals who are in a situation of social vulnerability, inserted within the urban perimeter and in the urban expansion areas of the municipality. In this group, the following stand out: poor women, the unemployed, rural migrants, those with special needs, children, the elderly, peri-urban producers, traditional communities, and others. These groups can be characterized by low educational levels and low income.

In Goiânia, these subjects are located, mainly, in the vicinity of the central region and the northwest region of the municipality. The municipality has 81.9 ha of subnormal agglomerations (slums) occupied by about 3,495 people. This area is divided into seven clusters, they are Quebra Caixote, in the East University Sector (851 people); Jardim Guanabara (733 people); Botanical Garden II (515); Vila Lobó, in Jardim Goiás (508); Emílio Póvoa, in the Eastern Crimea (341); Rocinha, in the Amazon Park (298); and Jardim Botânico I (249) (DINIZ, 2017).

The Northwest region is formed by 46 neighborhoods. Of these, the Vila Mutirão, Vila Finsocial, Vila Roriz, Jardim Primavera, Floresta, São Carlos neighborhoods stand out, among others with the highest percentage of poor population (MOYSÉS and BORGES, 2009).

Analyzing the neighborhoods using the Human Development Index (HDI) in 2010, the following stood out: Madre Germana, Itaipu, Esmeraldas, Residencial Ytapuã, Monte Pascoal, Setor Eldorado Oeste, Lírios do Campo and Jardim Primavera; Dourados, Residencial Buena Vista, Residencial Jardins do Cerrado, Residencial Mundo Novo and São Domingos (UFG, 2014).

Therefore, this region would be a region to be considered for stimulating UPA.

3.5. Necessary characteristics of the areas and criteria for implementing the UPA

3.5.1. Criteria for selecting areas for the implementation of UPA in Goiânia

For the implementation of the UPA in Goiânia, taking as a reference the normative aspects of land use (Law 171/2007), two conditions were listed for the selection of eligible areas—those that contain natural heritage or urban voids. The areas in such a situation were identified from municipal legislation and their spatialization was subtracted from the Spatial Model of Land Use in Goiânia, given by Law 171/2007 and made available in digital format by the City Hall through the Digital Urban Map of Goiânia (MUBDG).

3.5.2. Natural Heritage Areas

Article 108, of the Goiânia Master Plan, explains that the "Sustainable Use Units have the objective of making nature conservation compatible with the sustainable use of the soil" (PREFEITURA DE GOIÂNIA, 2007a). For this activity, items I and IV of article 108,

Table 1
Actors and subjects who develop UPA in Goiânia

Actores	Objective and summary of its performance	Subjects served	Activity location
Association for the Development of Organic Agriculture in Goias (ADOA)	A non-profit civil entity linked to the development of organic agriculture in Goiás. It promotes the production, commercialization, and conscious consumption of organic products, contributing to the environmental, social, and economic balance.	Consumers in general.	Buy products directly from family farmers.
Association for Recovery and Conservation of the Environment (ARCE)	A non-profit organization, founded in 1982, whose staff is concerned with planning focused on sustainability, with the promotion of citizenship and the insertion of the community in the discussion of issues related to the place and the circumstances in which they live.	Vulnerable population, population served by public social assistance policies, schools.	Vacant lots and schools
Agroforestry Goiás	A social group whose objective is the dissemination of topics and activities related to agroforestry systems and syntropic agriculture. It is articulated through social networks and interfaces with the actions of UPA.	Vulnerable population. Groups interested in UPA or Family Farming.	Vacant lots, urban voids, rural properties.
Agrosintropia	An organization that works on the development of ecological solutions for rural producers through syntropic agriculture taught by the Swiss Ernst Götsch. Agrosintropia is structuring itself to offer a qualified service to rural producers who intend to work with syntropic agriculture. Thus, training courses in Succession Agroforestry Systems (SAS) are given and technical visits are carried out, as well as consultancies for the implementation and monitoring of SAS.	Vulnerable population. Groups interested in UPA or Family Farming.	Vacant lots, urban voids, rural properties.
EcomAmor	An organization of volunteer people (students, professionals, technicians in general) in the city of Goiânia that promotes the implantation of urban gardens in public spaces according to the demands of the community.	Vulnerable population. Groups interested in UPA. Schools.	Vacant lots, urban voids, squares, schools.
Goiânia City Hall	Municipal public power works in partnership with other institutions. The partnership with the National Rural Apprenticeship Service in Goiás (Senar) resulted in the "Horta para Todos" program, which aimed to teach and encourage the population to grow their food based on the practical example of the urban vegetable garden in the Paço Municipal de Goiânia. Thus, contributing to the sustainability of the city, filling urban voids in public or private spaces, to public health and the generation of environmental services.	Vulnerable population. Young people from the outskirts of the city.	City hall areas.

Source: Organized by the authors.

indicate Environmental Protection Areas (APP), Private Reserves of Natural Heritage, buffer zones adjacent to the Integral Protection Units and the Green Areas in the Municipality of Goiânia, as squares, open spaces, playgrounds, sports parks, urban parks, theme parks, public gardens, road system labels and ornamental plants for public places.

It should be noted that the green areas present in the cities are a reflection of the tastes and customs of society, being historically marked by the needs of each era (Loboda and de Angelis, 2005). In this sense, the functions performed by the green areas were defined by Bargos and Matias (2011) as social, ecological, aesthetically pleasing, and educational. Thus, based on the current scenario of diffusion and promotion of UPA practices, the productivity function can be added to these areas.

Under this premise, the practice of urban gardens can function as a sustainable use activity contributing to the multifunctionality of the landscape and the establishment of sustainable attitudes to the structure of society, as described by Amato-Lourenço *et al.* (2016). Furthermore, UPA is able to equalize land use and nature conservation, which improves the quality of life in urban centers.

Fig. 3 shows the Units of Sustainable Use, categorized in Heritage Areas - Municipal Natural Parks (UC - PNM); APP; Squares and buffer zones adjacent to the Integral Protection Units (ZA) and urban squares, part of the green area group. APA was not included in the map.

3.5.3. Urban Voids

Urban voids are a problem for the development of the capital of the state of Goiás. The existence and permanence of urban voids contribute to the increase in property value and the underutilization of infrastructure. The Technical Report of the Axis of Territorial Planning (RATP) of the Master Plan of Goiânia shows that, according to data from the Real Estate Registry of Goiânia, in 2017, the urban voids correspond to approximately 26.75% of the Macrozona Constructed of the municipality, with a total area of 262.89 km^2. (PREFEITURA DE GOIÂNIA, 2017). This situation is shown in Fig. 4.

To avoid and discipline the formation of these areas, which do not fulfill their social function as established by Law n° 10.257 / 2001 (BRASIL, 2001), the city of Goiânia has made efforts to establish instruments of prioritization and made them compulsory for its proper use.

In the municipality, Complementary Law n° 246, of May 29, 2013 (PREFEITURA DE GOIÂNIA, 2013), which amends Law n° 171/ 2007 (PREFEITURA DE GOIÂNIA, 2007b), in its art. 110-A, informs that this use can be made in different ways, not being restricted

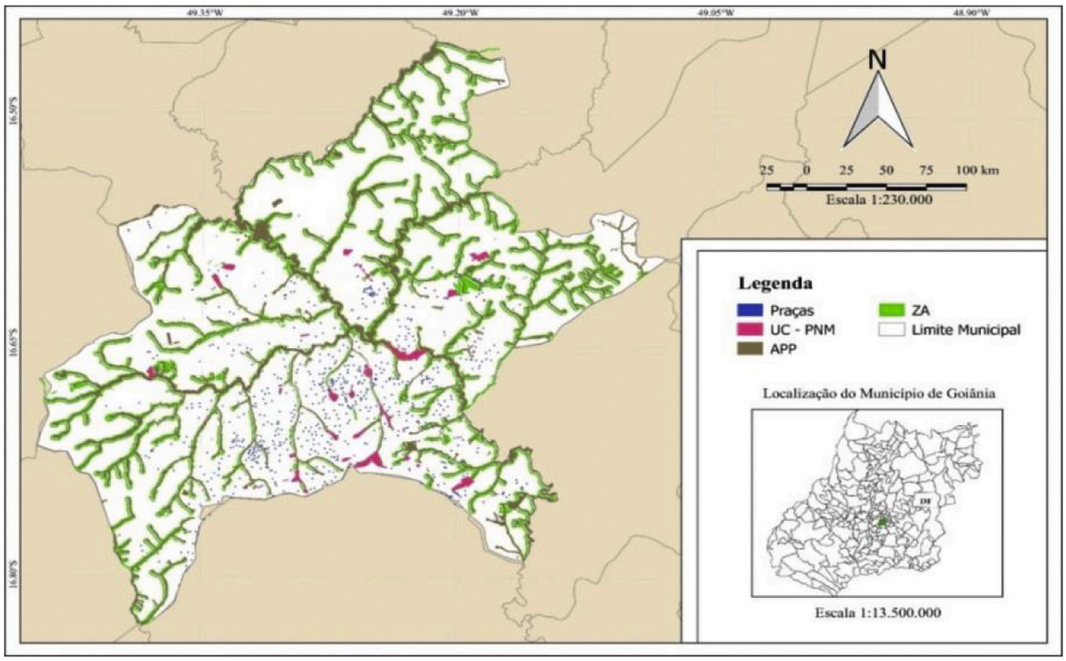

Fig. 3. Map Units for Sustainable Use Goiânia.
Source: MUBDG (PREFEITURA DE GOIÂNIA, 2017). Adapted by the authors.

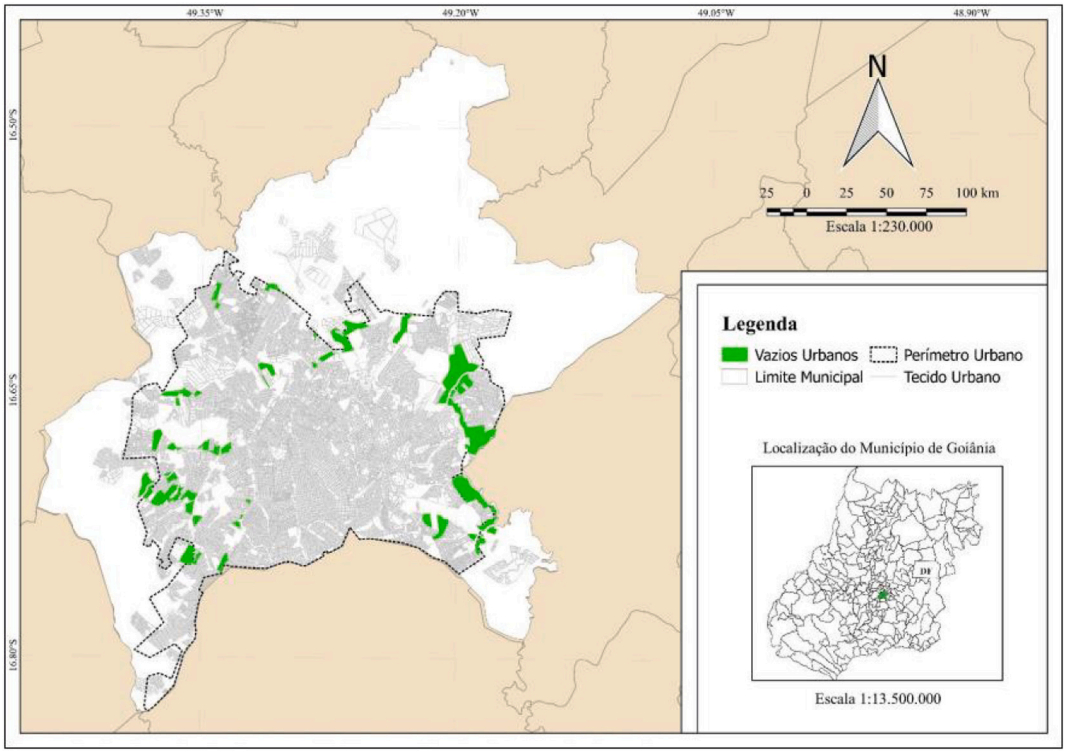

Fig. 4. Map of urban voids in Goiânia.
Source: MUBDG (PREFEITURA DE GOIÂNIA, 2017). Adapted by the authors.

only to the promotion of occupation with housing use, but providing opportunities for various types of uses that meet regional demands.

One of the most recent examples of the diversification of these uses was the approval of a project in the City Hall of Goiânia, in 2016, which foresees the occupation of urban voids with cultural projects of the Creative Economy (DAMASCENO, 2016). The proposal is to establish a Term of Conduct Adjustment (TAC) in which owners of properties and spaces in disuse or underutilized, give these places to hold shows, workshops, exhibitions, fairs, among others. In compensation, the owners would be exempt from progressive IPTU[6].

Another example is the Urbanistic Project of Social Interest[7], approved by the Constitution and Justice Commission in June 2018, whose objective is to establish a social function for vacant lots. Thus, in these places, squares, playgrounds, sports courts, and community gardens could be built. In return, instead of paying ITU, the owners of vacant lots would pay for IPTU, which has lower rates.

From this perspective, the UPA also presents itself as a possibility for occupying the urban voids in Goiânia, as it sets up a new social function that meets regional demands, providing social and environmental benefits, such as the production of food for the autonomy of vulnerable groups, improving environmental quality and contributing to ecosystem services, as well as improving the landscape.

According to the data collected, the vegetation cover of the municipality of Goiânia, considering the areas of natural heritage and urban voids, corresponds to 286.91 Km^2, approximately 37% of the entire territory of the municipality. Complementarily, considering only the areas subject to UPA, this correspondence is reduced to 106.5 km^2, that is, 13.8% of the territory.

3.5.4. UPA areas prioritization criteria

The prioritization of the selected areas was based on the experience of the social actors who develop UPA in Goiânia, whose most successful practices are in areas close to community facilities, that is, schools, places of social assistance for the elderly and young people. Thus, for criteria for prioritizing areas, those that, described in item 3.4.1, are located in the vicinity of community facilities, were considered. Public facilities for education, culture, health, leisure and the like are considered by Federal Law No. 6,766, of December 19, 1979 (BRASIL, 1979), to provide for the urban land parceling and other measures, such as communal equipment.

For communal education equipment, urban gardens can function as a tool for the development of various pedagogical activities in the context of environmental and food education, as experienced by some projects cited by Pimenta and Rodrigues (2011); Eno, Luna and Lima (2015) and Silveira-Filho et al. (2011). Also, the products generated in the urban gardens can serve as an input for schools, mainly in the public network, stimulating the improvement in the children's diet (MAGALHÃES, 2003).

Such equipment has a high potential to receive UPA actions within their spaces, since access to these spaces is facilitated by the proximity of the target audience responsible for maintenance, making the mobilization of these groups more effective. This condition favors the maintenance and continuity of urban gardens, in addition to the benefits generated for the target audience of these locations.

In Goiânia, the non-governmental organization (NGO) EcomAmor already develops some works for the implantation of vegetable gardens in public spaces. Most places willing to receive are schools. In 2017, 11 vegetable gardens were implemented. Up to the month of June 2018, 6 vegetable gardens were implemented. (Fig. 5a and 5b).

In Long Term Care Institutions for the elderly, an occupational and therapeutic predicament is perceived in urban gardens, in addition to functioning as a source of quality food for these institutions. Within the perspective of food production, from the perspective of Sisan, the development of UPA actions aimed at the public attending the Social Assistance Reference Centers (CRAS) meets the program's objective of contributing to the food autonomy of vulnerable groups, since the CRASs are located in areas of vulnerability and social risk.

The city of Goiânia maintains an online platform, namely: https://goianiadofuturo.goiania.go.gov.br/documentos/, in which it is possible to access the locations where this equipment is located. This database served as information that resulted in Fig. 6.

3.6. Mitigation and adaptation measures to climate change

Climate change has been linked to human and natural factors since 1750 and these factors generate greenhouse gases. As PBMC (2016), p.2) explains that, climate change "[...] is any change that occurs over time, whether due to natural variability or due to human activity, this differs from the *United Nations Framework Convention on Climate Change*, where the term climate change is directly or indirectly related to human action, which alters the global atmosphere, in addition to the natural climatic variability observed over comparable periods of time."

In this way, human activities that generate *Greenhouse Gases* (GHG) are largely responsible for climate change. Of these gases, only those that contain carbon are mentioned in this study, they are: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), chlorofluorocarbons (CFCs) and hydrofluorocarbons (HFCs). According to Rodríguez (2015) and PBMC (2016) these gases are in proportions well above pre-industrial levels, as shown in Table 2

And according to Table 2, the most polluting activities are the burning of fossil fuels by vehicles, which in Brazil its fleet increases every year, and in 2010, Brazil had 64,817,974 vehicles, and in 2018, its fleet moved to 100,746,553, an increase of 35.66%. In Goiânia, in 2010, its fleet increased from 870,900 to 1,172,648 vehicles in 2018, an increase of 25.73%. In addition, deforestation and changes in land use for the expansion of Brazilian agriculture have aggravated the picture of climate change in the last August,

[6] Progressive IPTU: the urban instrument that punishes the owner of the urban property that is little or not used with the annual increase in the IPTU rate, established by Complementary Law n° 181/2008. (PREFEITURA DE GOIÂNIA, 2012)

[7] Projeto de Lei Complementar n° 42/2017. (PREFEITURA DE GOIÂNIA, 2017)

Fig. 5. Actions for the implantation of vegetable gardens directed by EcomAmor.
Source: Facebook page @EcomAmor

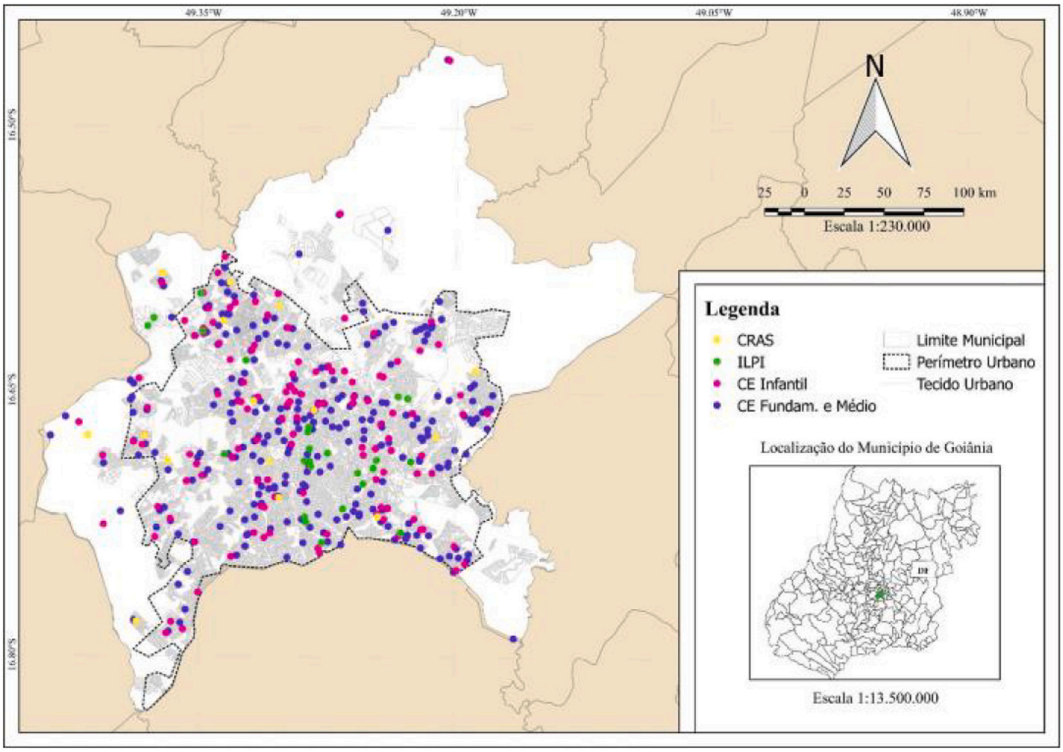

Fig. 6. Map of community facilities in Goiânia.
Source: Goiânia (2017) and State Geo information System of the State of Goiás (SGEI) (2013). Adapted by the authors.

September and October 2020. (IBGE, 2020a, 2020b)

Thus, measures to mitigate and adapt to climate change are necessary so that the temperature increase does not exceed 1.5°C in relation to pre-industrial levels. One of the ways of mitigating and adapting to climate change is carbon sequestration, which removes carbon, which is present in GHG, from the atmosphere when it is retained in the soil, it can reduce CO2 from the atmosphere, one of the gases most released into the atmosphere and contributing to the non-increase of the temperature in the atmosphere.

In this sense, this study proposes an alternative for this mitigation and adaptation to climate changes through the UPA, due to the benefits it presents in the context of the Brazilian municipality of Goiânia, as will be explained in Chapter 4.

Table 2
Concentrations of GHG and its variations in two different periods of time due to anthropogenic activities.

Greenhouse gases (GHG) affected by human activities.					
TIME	CO_2	CH_4	N_2O	CFCs	HFCs
Pré-industrial	280 ppm	700 ppb	270 ppb	0	0
In 1998	365 ppm	1.745ppb	314 ppb	268 ppt	80 ppt
Production human activities	Deforestation, changes in land use and burning of fossil fuels.	Rice production; landfills; leakage of fossil fuels and natural gas; and biomass burning.	Burning of oil and waste and manufacture of substances for agriculture.	Used in refrigeration.	Do not affect the ozone layer.

Source: adapted from IPCC (2007 apud RODRÍGUES, 2015, p.17)

3.7. Calculation of carbon sequestration to reduce Green House Gases (GHG) emissions

Greenhouse gases are responsible for global warming, they include carbon dioxide (CO_2), methane CH_4, chlorine fluorine carbon (CFC), nitrous oxide (N_2O), according to Rodríguez (2015) and Monteiro (2018) and that according to ODUM, Eugene P.. (1988) and IPCC (2007) there is an imbalance in the emission of these GHGs to the atmosphere, in the last century, post-industrial period, caused by deforestation, fires, and consumption of fossil fuels, the increase in the garbage that generates gases during its decomposition, some household appliances, and industrial processes, as well as fertilizers used in agriculture.

Therefore, carbon is the chemical element most present in GHG and, therefore, to mitigate its effects, the Kyoto Protocol[8] defines targets for reducing GHG emissions and the countries that ratified it committed themselves at first "[.. .] in reducing GHG to an average of 5% in relation to 1990 levels" and in a second moment the reduction would be 18% in relation to the same period in eight years. (MINISTÉRIO, 2020).

One of the ways to reduce or mitigate GHG is with the sequestration of CO_2 present in the atmosphere because although Rodríguez (2015) comments that there are several carbon deposits on the planet besides the atmosphere, the Intergovernmental Panel In Climate Change (IPCC, 1996 cited by MONTEIRO, 2018) clarifies that the largest land deposit is soil. And yet according to Monteiro (2018), there are possibilities to add and maintain carbon in the soil and generate carbon credits, for example, with reforestation or also afforestation, helping to reduce GHG, it also contributes to this reduction, the use of more sustainable means of transportation restricting the burning of fossil fuels, among others.

Thus, the Kyoto Protocol created mechanisms so that the countries that sign it can meet the goals to mitigate GHG emissions, they are: emissions trading, joint implementation, and the Clean Development Mechanism (CDM) (MINISTÉRIO, 2020).

Considering that GHG emissions have become a new commodity, establishing themselves as levels or quantities of emissions over a while and would be divided into units of assigned quantity and so those countries with surplus emissions could sell their excess capacity to countries that are above your goals. Since CO_2 is one of the main GHGs, carbon becomes a commodity and the "carbon market" starts, according to United Nations Climate Change (UNCC, 2020).

In the carbon market, according to Rodríguez (2015, p.31), Brazil has benefited from the "CDM with projects in the energy, transport and forestry sectors. [...] reforestation, which allows carbon, by the growth of trees, to be removed from the atmosphere. Thus, the planted forest promotes 'carbon sequestration'.

Still, according to Rodriguez (2015, p.31), "[...] 'sequestration' is possible because vegetation performs photosynthesis, a process during which plants remove carbon from the atmosphere, in the form of CO_2 and incorporate in its biomass [...]", that is, the organic matter used in the production of energy. Thus, carbon sequestration is a way of storing atmospheric CO_2 reducing the effects of GHG. (MONTEIRO, 2018).

The IPCC (2007) pointed to a CO_2 increase (present in the GHG) from 280ppm[9] pre-industrial value to 379ppm in 2005. The natural range, considered for the author, in 650,000 years, that is, the Günz Glaciation period or Nebraska is in the concentration range of 180 to 300ppm. Also according to the author, this concentration increased by 0.5ppm per year in 10 years (from 1995 to 2005), with is a considerable increase in global warming over 50 years.

A note in the reports of COP-21 (PROGRAMA CIDADES SUSTENTÁVEIS, 2018, np.) Is the need of the planet to keep the values of global warming below 2°C, that is to say, that there must be a great effort of the countries to "insure that the temperature in the earth does not exceed 1.5°C above pre-industrial levels".

In this sense, carbon sequestration as a form of mitigation to comply with the COP-21 report can be an alternative, since CO_2 is removed from the atmosphere by replanting vegetation, which can be native vegetation or as presented by Monteiro (2018) through cover plants.

For this exploratory analysis, as in the studies of Monteiro (2018), we will consider the carbon sequestration calculation presented by Rodríguez (2015) to eliminate the CO2 emitted in the city, using the formula:

[8] Created in 1997, but entered into force in 2005 and Brazil only ratified it in 2002, "the Kyoto Protocol constitutes a complementary treaty to the United Nations Framework Convention on Climate Change, defining emission reduction targets for the developed countries and those that, at the time, had an economy in transition to capitalism, considered the historical responsibility for the current climate change. " Ministério (2020)

[9] ppm- parts per million which according to IPCC (2007) "is the ratio of the number of greenhouse gas molecules to the total number of dry air molecules."

S = FSC x area x 20 years;

Where:

- FSC[10] is 25,9942 TCO_2/ha/20years;
- Area is established in hectares (ha)
- And the period is 20 years to cancel CO_2 in the environment, responsible for global warming.

4. Results and discussions

4.1. Selection and prioritization of areas for UPA in Goiânia

The municipality of Goiânia has several UPA initiatives, either guided by the municipality or stimulated by third sector institutions. However, there is no record of experiences or areas converted and used for the practice of UPA.

By the methodology used, we updated the survey using Santandreu and Lovo (2007), six main actors were identified who are dedicated to UPA in the city. UPA practices mostly occur in vacant lots in the urban mesh. Analyzing the Goiânia legislation, it is possible to find areas of sustainable use and urban voids where this activity could occur. The methodology used identified 17,914.75 hectares in this condition, represented in Fig. 7.

The areas of urban voids without vegetation cover, that is, anthropized, were considered for the practice of UPA. This is justified, as the remaining vegetation should not be suppressed for the practice of UPA. This remaining vegetation improves the quality of life in cities by contributing to environmental services and promoting environmental conservation.

After identifying which areas that could be used by the UPA, it went on to the selection and prioritization stage. Identifying the existence of community facilities, such as Teaching Centers (CEI, CEF and CEM), Long-Term Institutions for the Elderly (ILPI), and Social Assistance Reference Centers (CRAS). This subsidized criteria is in the literature review and indicates that successful UPA practices are linked to projects of social inclusion or to encourage family farming.

The existence of these community facilities in the vicinity of the previously selected areas was accepted as criteria for prioritizing the most promising regions for the implementation of UPA, respecting their respective maximum influence rays established by Annex VII of the Goiânia Master Plan (Law n° 171/07) and considering the mobility capacity of the groups, as shown in Table 3.

The location of the CEs was obtained by the State Geo-information System of the State of Goiás (SGEI), while the CRASs were mapped based on information from the Social Assistance area of the city of Goiânia. ILPIs have been identified through Google searches.

The categorization was carried out in accordance with the situational state of the area and three distinct levels of prioritization were defined: i) Level A, high priority, for areas within the zone of two or more distinct community equipment; (ii) Level B, medium priority, for areas within the zone of one or more equipment of the same category; iii) Level C, low priority if the area is not within the range of influence of any community equipment. The result is shown in Fig. 8.

This categorization was defined so that investments for the implantation and maintenance of urban agriculture projects are directed mainly to areas with more community equipment, because, in addition to more people being benefited, more people can collaborate with the maintenance of UPAs.

According to the applied criteria, the areas subject to the implementation of the UPA and their respective priority levels total 10,650ha, which can be classified as 5,800ha in level A (high priority); 1,800ha at level B (medium priority) and 82,700ha at level C (low priority).

Finally, spatial detailing for a region of Goiânia was carried out, aiming to reduce the scale of representation and identify how this would happen at the neighborhood scale. Fig. 9 presents this representation with an area close to the central region of the municipality, which includes neighborhoods such as Bairro Novo Mundo, East University Sector, Vila Bandeirantes, East Sector Vila Nova, Vila Santa Isabel, Vila Colemar Natal e Silva, Chácara Elísio Campos, Vila Oswaldo Rosa, and Goiânia Industrial Park. The colored circles are the radii of influence for each type of social equipment and the points are the areas identified for UPA and its priority levels.

It is important to highlight that criteria, such as water availability, type of soil, and the location within the different types of territorial units of the Macrozona Constructed established by the 2007 Master Plan were disregarded in this study because there is no database with such information.

4.2. Carbon sequestration in UPA practices

As previously explained, according to Rodríguez (2015), p.4), the increase in cover vegetation as a way of mitigating the effect of GHG, with carbon sequestration is “through reforestation with native vegetation”. However, studies by Monteiro (2018) with the cover plants Brachiaria decumbens; Brachiaria ruziziensis; Pork beans; Calopogonio and Milheto, some of them Non-Conventional Food Plants (PANCs in portuguese) pointed out that "[...] sequestered carbon and with superior quality of organic matter, when compared without vegetation cover".

[10] The carbon sequestration factor of native vegetation for vegetables and vegetables was used in the calculation, considering the sustainable potential of family urban and periurban agriculture.

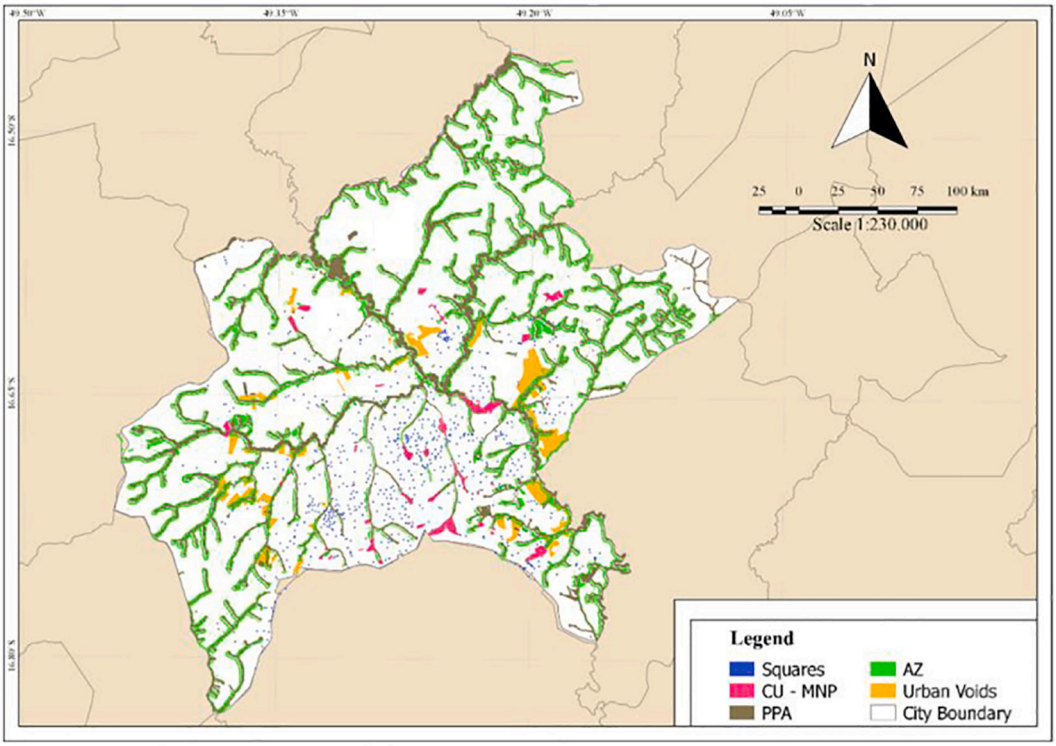

Fig. 7. Location of the natural heritage areas of Goiânia and overlapping urban voids.
Source: Goiânia, (2007). Adapted by the authors.

Table 3
Rays of influence aimed at prioritizing areas for Urban and Peri-Urban Agriculture (UPA) activities.

Community Equipment	Ray of influence (m)
Center for Early Childhood Education (CEI)	300
Center for Elementary and Middle Education (CEF and CEM)	500
Institution of Long Stay for the Elderly (ILPI)	500
Regional Council of Social Assistance (CRAS)	1000

Source: Annex VII to the Goiânia Master Plan (Law No. 171/07) (PREFEITURA DE GOIÂNIA, 2007)

Starting from the characteristics of the city of Goiânia, which has 17,914.75 hectares of areas in UCs, ZAs, APPs; obtaining, together with the identified urban voids, 10,650 hectares that could be used for urban and peri-urban agriculture practices. It is important to highlight that this total area considered urban voids without vegetation cover and proximity to some social equipment, an assessment of the potential for carbon sequestration is presented.

Applying the Carbon sequestration calculation to eliminate the CO_2 emitted in the city of Goiânia through the UPA in the urban voids previously selected through the methodology proposed by Rodríguez (2015) we have:

$$S = 25,9942\ (TCO_{2)}x\ 10,650\ (ha)\ x\ 20\ (years);$$

Based on the criteria proposed, we arrive at the data in Table 4:

The calculation for carbon sequestration is 1,494,926.44tC, which is equivalent to the significant removal of 5,536,764.60tCO_2 from the atmosphere for 20 years in 10,650 ha of the area proposed in this study and intended for the implementation of UPA. The carbon sequestration helps in the climate adaptation of Goiânia together with other GHG reduction strategies, since these are responsible for the increase in global temperature.

4.3. UPA as an alternative for the city of Goiânia

The prioritization of the selected areas was based exclusively on the proximity to community facilities, because of the maintenance and continuity of urban gardens, in addition to the benefits generated for the target audience of these locations. Public facilities for education, culture, health, leisure, and the like are considered by Federal Law No. 6,766, of December 19, 1979, which provides for the subdivision of urban land and provides other measures, such as communal facilities.

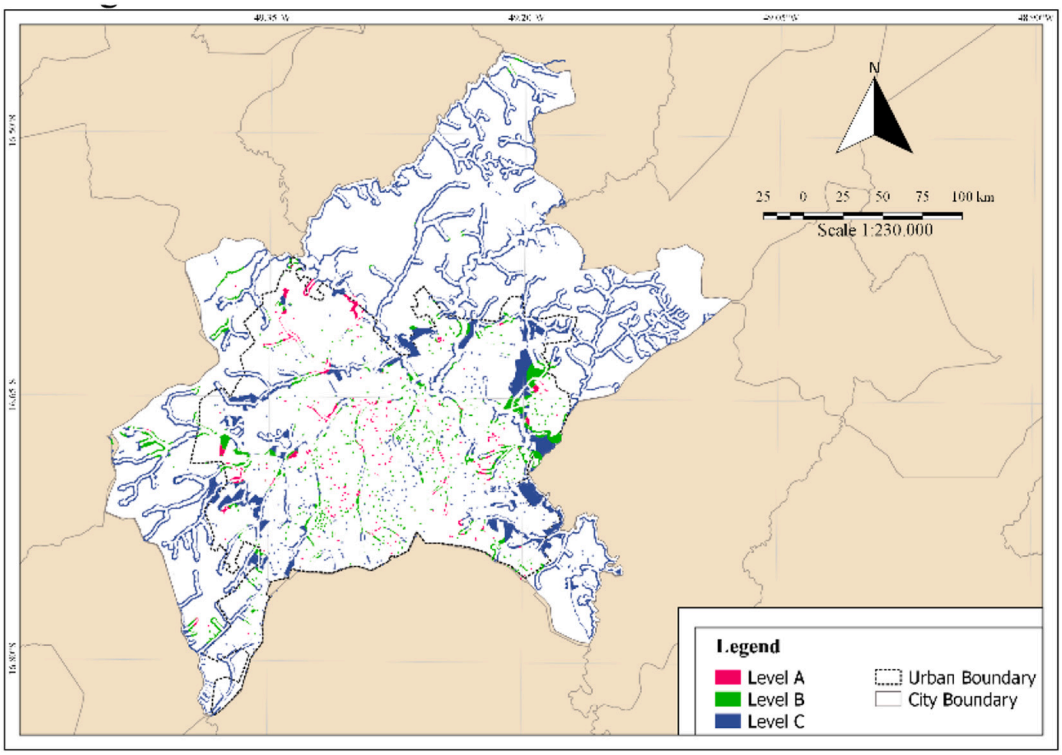

Fig. 8. Priority level of the areas for the implementation of UPA.
Source: Prepared by the authors.

Such equipment has a high potential to receive UPA actions within their spaces, since access to these spaces is facilitated by the proximity of the target audience responsible for maintenance, making the mobilization of these groups more effective.

For community education equipment, urban gardens can function as a tool for the development of various educational activities in the context of environmental and food education, as experienced by some projects cited by Pimenta and Rodrigues (2011); Eno, Luna, and Lima (2015) and Silveira-Filho et al. (2011). Also, the products generated in the gardens can serve as an input for schools, mainly in the public network, stimulating the improvement in the children's diet (MAGALHÃES, 2003).

Considering the variables presented, the final result indicated different areas that could be implemented by UPA at different levels of priority. These results indicated that 10,650ha can be used for collective UPA practices in Goiânia, with 5,800ha classified as level A, a high priority; 18,000ha , level B, medium priority, and 8,270ha, level C, low priority, as shown in Fig. 8.

The possibility of institutionalizing UPA in Goiânia with actions to control land use and soil occupation, social inclusion, and recovery of green areas, can present itself as an alternative to the context of the environmental urban crisis that is now being presented. In this case, a second analysis was to consider the existence of some collective equipment in the vicinity of these areas, resulting in Fig. 9.

Taking into account public and social policies, national and international climate agreements, the UPA is one of the guarantees for the right to sustainable cities, as it gives the right to urban land and works for the present generation and future generations as provided by the Statute da Cidade (Law No. 10,257, of July 10, 2001- BRASIL, 2001), which is in line with international agreements in pursuit of climate reduction.

The increase in areas of organic vegetable production, used in family farming in urban and peri-urban areas such as the one that has been occurring in Goiânia [and in a legislated manner], contributes significantly to the reduction of CO_2 emissions, since vegetables need CO_2 to develop, as well as help with soil percolation, and therefore are strategies for adapting the city of Goiânia to climate change, as part of the green infrastructure system in Goiânia, together with the parks city, squares and other green areas, making it a resilient city.

With 1,494,926.44tC being the result of the calculations presented for carbon sequestration to eliminate CO_2 in the atmosphere emitted in the city considering the area of urban voids selected for UPA, as areas currently without vegetation cover, which are close to UPA subjects, taking 10,650ha, in a period is 20 years to cancel CO_2 in the environment, responsible for global warming.

Other strategies, such as reforestation of areas destined for environmental preservation, deforested and burnt areas, would increase the value of carbon sequestration to eliminate CO_2 emissions in search of reducing global warming.

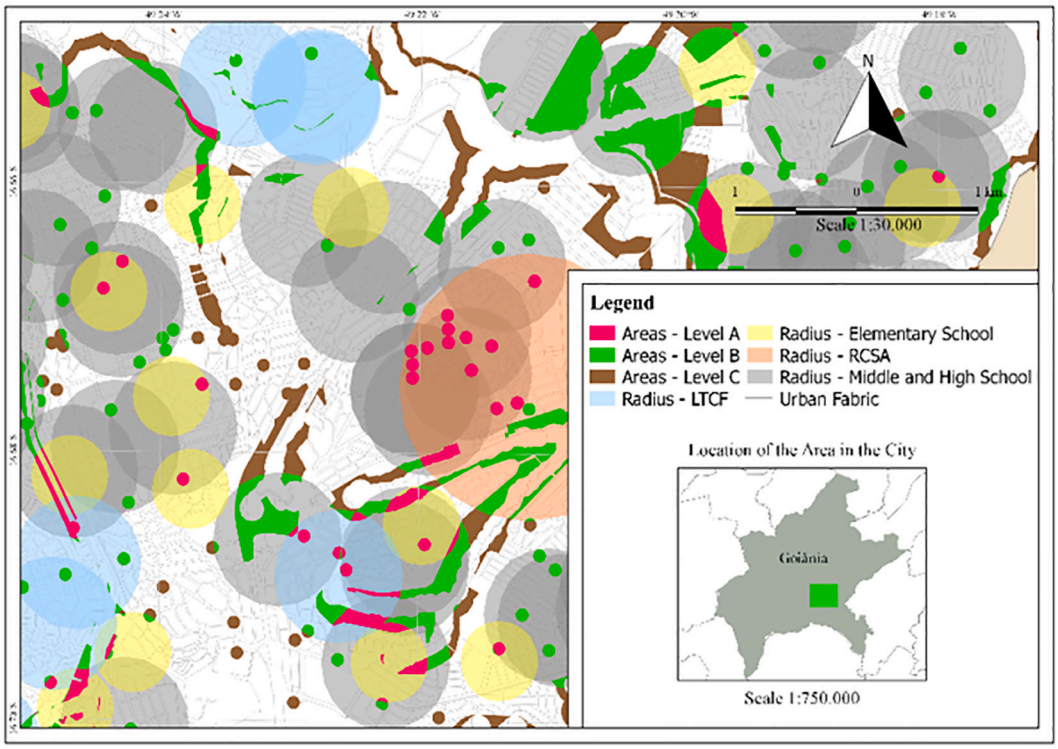

Fig. 9. Categorization of areas based on the radius of influence of community equipment.
Source: Prepared by the authors.

Table 4
Carbon Sequestration Values.

Time	Sequestration Factor Value [S] (tCO_2/ha/ano)	Total urban empty area (ha)	Value (t CO_2)	Value (tC)
20 years	25,9942	10,650	5,536,764.60	1,494,926.44

Source: IPCC (2006 apud Rodríguez, 2015, p.96). Adapted by the authors.
Note: 1 ton of CO_2 equals 0.27 ton of carbon

5. Final considerations

Even though presenting as a potential climate adaptation, an UPA Program needs to include other criteria for selection and prioritization of areas, such as water availability, soil type and dispersion of activity in the different territorial units of the constructed macrozone. In this case, a database on the physical-environmental conditions beyond use and occupation is necessary. In Goiânia, there are two draft Laws for the subsistence of UPA practices: Bill 906-B / 2015, which institutionalizes the National Policy for Urban and Peri-urban Agriculture (NPUPA) and the Urban Social Interest Project 42/2017), the purpose of which is to establish a social function for vacant lots.

The main guidelines to be considered in designing UPA support and development programs in Goiânia should include, in particular, the articulation between public authorities, academia, and civil society, the registration of existing and future gardens, training people for sustainable agricultural practices in the UPAs, as well as the monitoring of activities. In terms of adaptability to climate change, mention is made of the possibility of maintaining such areas as green areas with social inclusion and healthy food production, so if new perspectives for urban sustainability are considered, such proposals can be included in order to increase carbon sequestration, and to reduce global warming to the levels proposed by the Paris Accord in 2015.

UPA is a tool that can stimulate the formation of a more sustainable and resilient cities, fulfilling environmental functions, such as the increase of infiltration areas, water and soil conservation, improvement of local microclimates, improvement of the urban landscape, environmental education, recovery of degraded areas, CO_2 reduction in food distribution, among others.

Given the data presented, it is possible to consider that:

- There is feasibility and a need to implement an Urban and Peri-Urban Agriculture program in Goiânia since the presence of isolated actions in this practice is already a reality in the municipality;

- In some states, such as Piauí, São Paulo, and the Federal District, programs to encourage this practice have already been implemented, which show results linked to the improvement in the quality of life of those involved and the organic expansion of the initiative;
- In Goiânia, entities that promote the activity in isolation were identified, such as *EcomAmor*, *Nós Mais Árvore*, *Agroflorestas Goiás*, among others, which, for the most part, do not receive government support;
- The subjects or beneficiaries of the UPA in Goiânia are characterized by social vulnerability, low educational level, and low income;
- The main problems mentioned by the UPA actors in Goiânia are within the scant social mobilization and the absence of government support;
- Based on the criteria established in this study, 10,650ha of the municipality of Goiânia can be occupied by UPA activities;
- There are two Bills that are essential for the survival of UAP practices: Bill No. 906-B/ 2015 that institutionalizes the National Policy for Urban and Peri-Urban Agriculture (NPUPA) and the Urbanistic Project of Social Interest (PLC Municipal n ° 42/2017), whose objective is to establish a social function for vacant lots;
- The main guidelines to be considered when designing support and development programs for UAP in Goiânia must include, mainly, the articulation between public authorities, academia and civil society, the registration of existing and future gardens, as well as the monitoring and inspection of these activities
- It is recommended, for future studies, to evaluate the productive capacity presented by the areas subject to the implementation of UPA, as well as the income generation potential of this practice in a scenario of full use of the areas, relating the results obtained to the basic demands of the municipality and its limitations, for example, restriction of water use and presence of contaminated soils.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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