*Eco Cities* (2021) Volume 2 Issue 2, *19 pages*.
doi: 10.54517/ec.v2i2.1880

Asia Pacific
Academy of Science Pte. Ltd.

ORIGINAL RESEARCH ARTICLE

# Changes in green area of two city halls in Mexico City from 1990 to 2015

***G. Maldonado-Bernabé[1*], A. Chacalo-Hilu[2], I. Nava-Bolaños[3], RM Meza-Paredes[4], AY Zaragoza-Hernández[5]***

*[*1] Universidad Nacional Autónoma de México, Mexico City 999085, Mexico. E-mail: G.Maldo_Biol@outlook.com*
*[2] Universidad Autónoma Metropolitana, Azcapozalco 684061, Mexico.*
*[3] Instituto de Investigaciones Económicas, UNAM 999056, Mexico.*
*[4] Facultad de Arquitectura, UNAM 999056, Mexico.*
*[5] Colegio de Postgraduados, Campus Montecillo, Mexico City 999085, Mexico.*

## ABSTRACT

Urban green spaces play a crucial role in urban sustainability because they provide a variety of environmental and social benefits, which is why every city claiming to be modern, safe, inclusive, and sustainable must ensure that its residents have access to and use these spaces. Mexico City has been upgraded to a city in transition to sustainable development, which is why it has launched various plans and actions focusing on environmental protection. Therefore, the main purpose of this study is to compare the AVU area of the two urban centers of the city from 1990 to 2015 using the census of the Geographic Information System (GIS) and the National Institute of Statistics and Geography. Information is used to understand the social situation of each mayor's office during the study period. The results show that although the social gap has narrowed in this period, there are great differences in area and quality between the two cities.

***Keywords:*** urban green space; GIS; sustainability; Mexico City

## 1. Introduction

At present, most of the world's population is concentrated in cities, which means that urban areas are expanding and many free lands will be used for urban purposes[1]. This is a huge increase for each of these cities in 2016. In order to maintain this production rate, many workers are needed, so the urban environment is the main source of job creation.

However, this population concentration has created a high demand for resources and services, so the current rate of urbanization has destroyed the natural environment and greatly changed the environment[2]. That is why there is now a vision to achieve the so-called "sustainable city", which stems from the definition of "sustainable development", that is, "development that meets the needs of contemporary people without compromising the ability of future generations to meet their own needs"[3]. In other words, in an urban environment, our goal is to improve the quality of life while maintaining the speed of production without compromising the natural and social resources on which high production depends.

Urban green spaces are key spaces for sus-

**ARTICLE INFO**
Received: September 10, 2021 | Accepted: October 22, 2021 | Available online: November 8, 2021

**CITATION**
Maldonado-Bernabé G, Chacalo-Hilu A, Nava-Bolaños I, et al. Changes in green area of two city halls in Mexico City from 1990 to 2015. Eco Cities 2021; 2(2): 19 pages.

tainable urban development because they provide environmental, social, and aesthetic benefits: they reduce noise, purify the air, allow water infiltration, minimize soil erosion and help regulate the microclimate[4,5]. Public health is also beneficial because of respiratory, circulatory and mental disorders associated with the lack of these spaces, such as chronic pain, insecurity, loneliness and lack of identity[6–8]. In addition, the high urbanization rate makes AVU more and more important as a space for human nature interaction, because it creates opportunities for social cohesion and outdoor activities[9,10]. This is why they must be integrated as an important part of urban planning, as in the United States, Canada, France, and the United Kingdom[5].

The environmental and social benefits of AVU are the reason why a modern, safe, inclusive, and sustainable city must strive to provide and ensure free access to and availability of these spaces for its residents[11]. In this regard, some cities have taken measures to increase and improve AVU, such as Malaga, Spain, which increased the green area from 14 million $m^2$ to 22 million $m^2$ between 2004 and 2012[7]. In addition, Beijing has increased the area of AVU after the 2008 Olympic Games. At present, the per capita green area is 44 $m^2$ (in $m^2$/H)[12]. However, in Latin America, the explosive and planned urbanization process in the second half of the 20th century resulted in a shortage of open and leisure space[10]. In Mexico, cities such as Toluca and Merida provide 6 $m^2$/H and 5 $m^2$/H, respectively[13,14]. In this regard, some studies have shown a correlation between social class and access to environmental benefits, including AVU[15]. This means that a city can accommodate space with more environmental benefits and services than other cities, which has a great impact on the socio-economic situation of its residents.

Mexico City has studies to estimate the total area of its territory, but the evaluation criteria are different, so these studies cannot be compared. For example, 2.4 $m^2$/H was reported in 1987[16], while a recent study noted 14 $m^2$/H[11]. However, the area ratio index per capita does not explain the accessibility and distribution of these spaces in cities[10]. In addition, despite research, few green lists can reliably determine the location, area and vegetation of Mexico City, which will contribute to the management, maintenance and planning of these spaces[11,17].

This is why the purpose of this paper is to analyze the AVU of vegetation area and quantity of Miguel Hidalgo (AMH) on four dates. In addition, the location map of AVU is also made to visualize the distribution of the mayor's office. Finally, the findings are relevant to the information from the census to show the potential relationship between socio-economic conditions and the quantity and quality of green space, but it must be noted that this study does not intend to determine whether such a relationship exists.

The main guideline is to answer the following questions: What is the area of urban green space? How did the vegetation in these areas change? Is the amount of green space enough to accommodate the population of the municipal government?

This work includes a section that outlines the efforts of CDMX in AVU, and then briefly introduces the method. Then it describes the study area, focusing on determining the main characteristics of space and population. Then the results and discussion are given, and finally a section of conclusions is given.

## 1.1. Mexico City is transitioning to sustainable development

Mexico City (CDMX), the capital of the Republic of Mexico, covers an area of 1,485 square kilometers[18] and is divided into 16 cities and towns: Alvaro Oberegon, Azkapozarko, Benito Juarez, Coyokan, Kujimarpa, Kuhetmok, Gustavo Madro, Izakarko, Izapalapa, Magdalena Contreras, Miguel Hidalgo, Mirpaarta, Travak, Trapan, Vinustiano Klanza and Xochimilco[18]. The development of cdmx is gradual. In 1930, CDMX was mainly concentrated in the territory occupied by the municipal government: Benito Juarez, Kutemok, Vinustiano Kalanza, and Miguel Hidalgo, which is why they

are called central cities[19]. Other regions were subsequently merged through different urbanization processes; from 1930 to 1950, the mayor's office constituting the first contour was merged, while the second contour was merged from 1950 to 1970, and finally, Mirpa Alta was added as part of the third contour (**Figure 1**)[19].

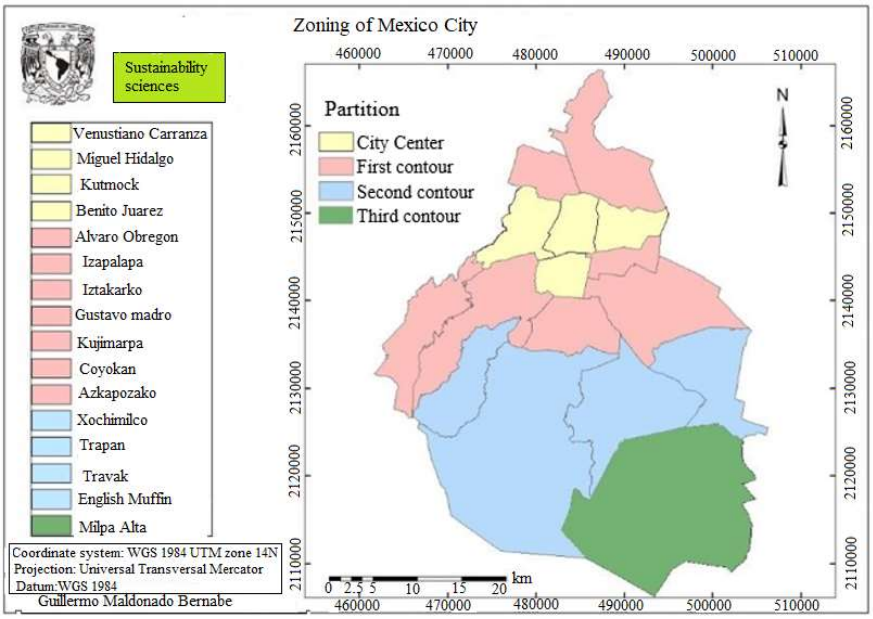


**Figure 1.** The outline of the central city and Mexico City.

CDMX is crucial to the country because it generates huge revenue for the gross domestic product (GDP), accounting for 23.9% of total revenue in 1990, but over the years, this figure fell to 16.7% in 2015[20,21]. The high economic output of CDMX is one of the reasons why its people's quality of life is considered to be one of the best in the country because the marginalization, poverty, and social backwardness rates of CDMX are generally low[22]. Of the 32 entities in the country, 30% are poor, and 31% are extremely poor[22].

Nevertheless, there are still some problems in service coverage, improving public transport, insecurity, and the availability and improvement of green space. In this sense, CDMX promotes a sustainable or transitional urban image, starting with the action of soil protection. Air quality management and monitoring, more effective liquidity, and saving and protecting green space[18]. According to AVU standards, various plans have been implemented, focusing on the care, maintenance, restoration, and improvement of these spaces (**Figure 2**). Because of the shortage and allocation of public spaces and AVUs, these spaces are generally abandoned and invaded to a considerable extent by informal businesses and street people[23].

**Table 1.** CDMX green area plans and projects

| Full name | Target |
|---|---|
| Mexico City Green Plan (Minister of Environment, 2012b) | Guide the city towards sustainable development and ensure that it is a space suitable for residents. |
| CDM reforestation Program (environment Secretariat, 2017). | Clean up and re-forestate the city's main streets and camels. |
| Green city, urban life (environment Secretariat, 2016) | Make the city a green, modern, competitive, and successful city and provide its residents with the best quality of life. |
| Protection of DF buildings and urban heritage Act (regional Legislative Council) Sixth Federal Legislature, 2014). | Protect the real estate declared to affect the urban architectural heritage (PUA), which can be: streets, canals, chinampas, playgrounds, orchards, botanical gardens, gardens, urban parks, and walking. |
| Regional environmental standards Federal nadf-001-rnat-2015 (Minister of Environment, 2015b). | It stipulates the requirements, standards, norms, and technical specifications that must be observed by authorities, and natural or legal persons to promote, improve and maintain public green space. |

The project in **Table 1** has a common goal, which is to have a greener city with open space, allowing leisure, coexistence, and promoting outdoor activities. In this regard, it is natural to believe that the actions taken should be implemented in the same way on urban territory to ensure that all residents have access to and enjoyment of these sites.

However, through social media and newspapers, allegations abound of indiscriminate logging and loss of green space in cities, where vehicle and housing projects are directly identified as the cause of these space losses, reductions, and destruction[24–26]. In order to achieve the goal of this study, a method based on aerial photos and satellite image analysis is used to identify AVU and determine the area of these spaces in two towns. In addition, the estimation of standardized vegetation index helps to identify areas with high vegetation coverage in AVU, so that it can be compared every year to calculate vegetation area and detect the increase or decrease of vegetation area. For this purpose, QGIS 2.12, ENVI, and Google Earth software are used.

It must be emphasized that these techniques are one of the most commonly used techniques for analyzing surface and vegetation changes[27–30].

CDMX has different types of green space, including AVA (environmental value area), gullies, water and soil conservation, urban green space, etc. This study uses the latter category, which is divided into two categories according to the following characteristics.

(1) Public green space: gardens, parks, children's areas, and other public places, including benches, corridors, gyms, toilets, etc., to promote outdoor activities.

(2) Road green areas: roundabouts, camels, and vegetated gardeners, which are located on public roads and have designated functions (camels) or are only used for meditation.

This work does not include areas of environmental value, soil and water conservation, gullies, wastelands, and other types of spaces. Although these spaces have vegetation, not all of them can enter public places, have entertainment, or use functions on public roads. However, Miguel Hidalgo City Hall has some gullies equipped with leisure furniture, so although it is AVA, it is also included in the analysis.

The aerial photograph was taken in 2008 with a resolution of 30×30 m per pixel and was provided by the Office of the Prosecutor for Environment and Territorial Planning (PAOT). Satellite images are taken from Landsat missions in February (1990 and 2000) and March (2010 and 2015), and then any program is processed in ENVI software using radiation and atmospheric correction methods to reduce acquisition errors, information loss, or atmospheric interference. Therefore, the detected changes can be attributed to actual changes in the surface[31–33].

By using QGIS, AVU is identified with the support of aerial photos, so that the amount of space can be calculated and the total area and single area of AVU can be estimated. Subsequently, NDVI was performed on the satellite images to show the vegetation in the previously determined space.

The result of NDVI is an image in which the value of each pixel can range from -1 to 1. Values below 0 are interpreted as areas without vegetation, while values above 0 are considered areas with vegetation[34,35]. However, aerial photos are used with NDVI images for random point sampling to determine the actual value of vegetation. It can be compared every year to calculate vegetation area and detect the increase or decrease of vegetation area. On the basis of this sampling, the images were reclassified to show areas with vegetation in green and other areas without vegetation in yellow (**Figure 2**).

Finally, through QGIS[29,36–38], this information was used to compare and quantify the changes in green space in the selected study year. As long as the images are taken at the same time of the year, the values obtained from the analysis can be com-

pared because the differences in vegetation behavior are reduced during the year[34]. For the images used, under similar atmospheric conditions, the acquisition date is at the same time of the year.

**Figure 2.** NDVI image of AMH. In green areas with vegetation and yellow areas without vegetation.

Finally, considering the living conditions of the population in the study year, the AVU results of the two selected towns are discussed.

## 1.2. Research field

This work focuses directly on the urban green space, which is why Miguel Hidalgo (AMH) and Iztakarko (AIZ) were elected mayors mainly because they have similar development times as part of the central city (AMH) and the first urbanization contour (AIZ). In addition, as described below, the urbanization processes of the two regions are different, which may have an impact on the planning and improvement of their territory.

These towns cover an area of about 46.9 km$^2$ (AMH) and 23.3 km$^2$ (AIZ) (accounting for 3% and 1.5% of the urban territory), respectively, in the northwest and east of the city (**Figure 3**).

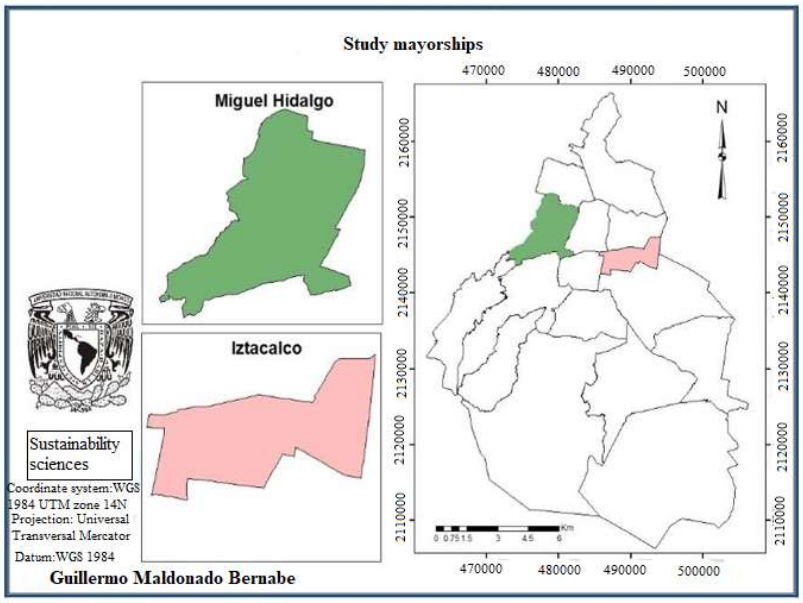


**Figure 3.** Mexico City and the mayor's office.

At present, AMH has occupied the territories of Tacuba, Tacubaya, and Chaptepec, the three highest-ranking villages under the former Spanish rule. The area had rivers and allowed the construction of aqueducts and mills, so it was used as a king's settlement in pre-Spanish and colonial times. Subsequently, during the tenure of Porfirio DíAZ Ordaz, urbanization began with the construction of trams and the establishment of residential colonies such as San Rafael and Nueva Santa María[39].

AMH is positioned as an area with high economic income. Residential and commercial areas are concentrated here. In addition to areas with environmental value, such as Chapultepec Forest[39], it also has a 200$^{th}$ anniversary park that opened in 2011. In addition, it has buildings of national importance such as the Mexico City Observatory, the National Conservatory of Music, the National Auditorium, the Army University, and the Air Force [40]. In addition, AMH is a region with a socio-economic level higher than the urban average because most of

its basic geographic statistical area classifies it as having very low poverty[41].

AIZ, on the other hand, originated in the agricultural area that provided food for the city of Tenochtitlan during the pre-Spanish period, as it was an area of the Mexican Empire[42]. In 1929, a decree was issued to divide the then Federal District into 13 delegations and set up the mayor's office, because the area was previously part of Trapan, Izapalapa, and even some towns in Mexico. The development of IDA began with people's colonies and informal settlements, and industrial zones and housing units were initially mixed[43].

This situation has led to problems in the supply of services, coupled with weak territorial planning, resulting in a lack of public space and green space. However, on the territory of the city, in addition to buildings such as the sports palace, the sports city, the Rodriguez brothers' racetrack, and the interdisciplinary professional unit of engineering, social and administrative sciences[43], temples and monuments of historical value are retained, such as the former monastery of Santa Matthias, the chapel of Santa Cruz, and the temple of Santa Anita. For the mayor's office of Iztapalapa Fernández Alvarez[41], it is classified as a moderately poor area.

Although the urbanization process and territorial composition of the two municipalities are different, the economic resources allocated to them are similar. In theory, this is beneficial for IDA because it has enough income to meet the needs of its people and is committed to achieving development similar to that of the Ministry of Health.

However, since the priorities and social conditions of each mayor's office vary, this similarity in the budget cannot be directly interpreted as an equal investment in public works, social programs, and the maintenance of green space. As an example, the population of each country can be cited, because historically, the population concentration of IDA has been higher than that of AMH, although the population decreased between 1990 and 2015 (**Table 2**). In the 2015 intercountry survey[44], the Agency for International Development reported an increase in the population as the population may be resettling, but current data do not guarantee this trend.

**Table 2.** The total budget allocated to the mayor's office

| City hall | Budget (%) | | | |
|---|---|---|---|---|
| | 1990 | 2002 | 2010 | 2015 |
| Alvaro Obregon | 7 | 7 | 7 | 7 |
| Azkapozako | 5 | 5 | 5 | 5 |
| Coyokan | 8 | 6 | 6 | 6 |
| Kujimarpa | 5 | 3 | 3 | 4 |
| Gustavo madro | 11 | 12 | 12 | 11 |
| Iztakarko | 3 | 5 | 5 | 5 |
| Izapalapa | 11 | 14 | 13 | 13 |
| English Muffin | 3 | 3 | 3 | 3 |
| Mirpa Alta | 3 | 3 | 3 | 3 |
| Travak | 3 | 4 | 4 | 4 |
| Trapan | 5 | 6 | 6 | 6 |
| Xochimilco | 7 | 5 | 5 | 6 |
| Benito Juarez | 5 | 5 | 5 | 5 |
| Kutmock | 10 | 9 | 10 | 9 |
| Miguel Hidalgo | 7 | 6 | 6 | 6 |
| Vinustiano kalanza | 7 | 7 | 7 | 7 |

Source: 1990 Federal Register, Federal District Register, 1999, 2009, 2014.

**Table 3.** Population comparison between the two towns

| | Residents in 1990 | Residents in 2000 | Residents in 2010 | Residents in 2015 | Growth rate (1990–2015) |
|---|---|---|---|---|---|
| Miguel Hidalgo | 406,868 | 352,640 | 372,889 | 364,439 | −0.439 |
| Iztakarko | 448,322 | 411,321 | 384,326 | 390,348 | −0.551 |
| Mexico City | 8,235,774 | 8,605,239 | 8,851,080 | 8,918,653 | 0.319 |

Source: National Institute of Statistical Geography and Informatics, 1997, 2000, 2011, 2015a.

Although the population density of AIZ (1.69 people per 100 $m^2$) is more than twice that of DMH (0.77 people per 100 $m^2$), the living conditions of the population in the two territories are differ-

ent, but they are balanced. If considering the scope of services and the characteristics of housing, in terms of building materials (**Tables 3–6**).

**Table 4.** Characteristics of urban housing

| | Miguel Hidalgo | | Iztakarko | |
|---|---|---|---|---|
| | 1990 | 2015 | 1990 | 2015 |
| Total number of houses | 98,051 | 128,042 | 93,816 | 110,174 |
| Floor grounding | 0.24% | 0.03% | 0.92% | 0.10% |
| Wooden floor, mosaic or other | 58% | 89% | 40% | 74% |
| Cardboard wall | 0.11% | 0.08% | 0.53% | 0.03% |
| Partition | 94% | 99% | 96% | 98% |
| Roof board | 3.2% | 0.6% | 6% | 0.21% |
| Roof slab | 85% | 96% | 78% | 95% |

Source: National Institute of Statistical Geography and Information, 1997, 2015b.

The above figure shows that houses with floors, walls, and cardboard roofs are almost non-existent, while in 2015, access to services such as drinking water, electricity, natural gas (containers and casings), and basic drainage exceeded 98%, which is a significant improvement in housing quality and access to services compared with 1990.

**Table 5.** Housing service coverage of municipal government

| Access to services | Miguel Hidalgo | | Iztakarko | |
|---|---|---|---|---|
| | 1990 | 2015 | 1990 | 2015 |
| Power | 99% | 100% | 99% | 100% |
| Drinking water | 99% | 100% | 74% | 99% |
| Drainage | 83% | 99% | 97% | 98% |
| Gas | SD* | 98% | SD* | 98% |

National Institute of Statistical Geography and Information, 1997, 2015b, 2015 * SD: No data.

On the other hand, the characteristics of employment do not reflect significant differences in the number of employed people or areas of employment, as most of the population of the two municipalities works in the third sector.

Taking into account that the characteristics analyzed have changed from high inequality to low inequality, it can be explained that although mayors have different origins, their living conditions begin to undergo a process of homogenization, which is not reflected in their territorial structure.

**Table 6.** Classify economic activities

| | Miguel Hidalgo | | Iztakarko | | Mexico City | |
|---|---|---|---|---|---|---|
| | 1990 | 2015 | 1990 | 2015 | 1990 | 2015 |
| Population over 15 | 301,209 | 305,043 | 314,656 | 315,498 | 6,217,435 | 7,128,836 |
| Economically active population | 54% | 63% | 51% | 58% | 47% | 58% |
| Employed population | 98% | 97% | 97% | 95% | 97% | 95% |
| Primary sector | No data | 0.09% | No data | 0.18% | No data | 0.49% |
| Secondary sector | 23% | 11.06% | 27% | 13.72% | 2.69% | 14.86% |
| The service sector; the tertiary industry | 71% | 68.65% | 69% | 62.03% | 68% | 61.57% |

Based on the calculation of the National Institute of Statistical Geography and Informatics, 1997, 2015b.

In general, the CDMX population enjoys a good quality of life because it is one of the entities with the least poverty and social backwardness. In this regard, the study cities follow a similar trend, as AMH and AIZ are listed as political and administrative units with a small number of poor and socially backward people[22].

# 2. Results and discussion

The results show that the AVUs of the two cities are very different. In AMH, these spaces account for about 19% of the territory, while in AIZ, they account for about 10% of the territory. As can be seen from **Table 7**, the AVU of AMH is more than three times that of AIZ.

**Table 7.** Comparison of the AVU surface area in Miguel Hidalgo and Iztacalco with previous studies: Environmental and Territorial Planning Office, 2010; Ministry of the Environment, 2003

| | MOE, 2003 | ETPO, 2010 | Proprietary data |
|---|---|---|---|
| Miguel Hidalgo | 8,890,000 $m^2$ | 14,673,613 $m^2$ | 9,109,625 $m^2$ |
| Iztacalco | 2,500,000 $m^2$ | 2,885,196 $m^2$ | 2,400,746 $m^2$ |

On the other hand, compared with the previous AVU research results for CDMX, there are significant differences between them, mainly due to their respective evaluation standards. Although they all reflect the significant differences between mayors, AMH always accounts for the majority of AVU, so this phenomenon has not been ignored, but the actions taken to solve this problem are ineffective (**Table 7**).

These huge differences in the area occupied by AVU in each region may have an impact on the social development of the population. If considering the small area of the city, but the population concentration is higher than DMH, the situation of fewer AVUs in AIZ is more serious, because AVUs are not enough to provide necessary environmental services for residents. The lack of AVU may lead to increased insecurity, disease, and demographic pressure, not to mention the entertainment of minors in the territory.

In this case, there is no significant socio-economic difference at present, but the origin and development of the two cities are different. Therefore, this special urban history has an impact on the number of AVUs in these areas.

The following map shows the green space of the two cities and towns. It must be emphasized that they all have a main space. On the one hand, there is Chapultepec Forest in AMH, which covers an area of 6.7 km$^2$ and is the largest green space in the city[39]. This space contributes most of the municipality's AVU and provides great benefits to its population. In addition, the bicentennial park was recently created in the AMH, increasing the green area of the municipality.

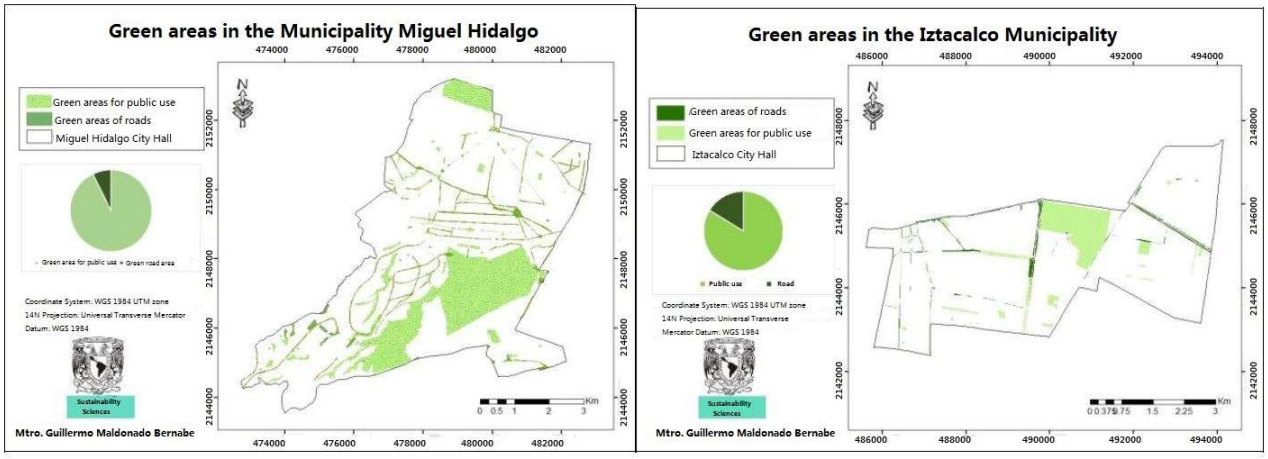


**Figure 4.** The green spaces of Miguel Hidalgo and Iztakarko.

On the other hand, AIZ has 920,000 m$^2$ of Sports City as a representative AVU, which is much smaller than Chapultepec Forest. Therefore, it can be said that AIZ residents do not benefit from the environmental services of parks and urban AVU in the same way.

Nationwide, the greening area of AMH is larger than that of Monterey, as are Merida and Toluca. It must be noted that this comparison is made between different territories. On the one hand, AMH and AIZ are part of a city, while Monterrey is a complete city. However, these results are meaningful because they show that the lack of green space is a common problem in the country, and there is evidence that AMH is one of the largest AVU areas in Mexico (**Figure 4**).

In addition, both AMH and AIZ have less land and population than other cities, which affects the way people benefit from AVU, because AMH's AV/H index is 25 m$^2$, while other examples only exceed 6 m$^2$. If the recommended minimum green area per capita is between 9 m$^2$[10,12,45] and 20 m$^2$[46], only AMH meets this standard.

Obviously, in this case, different regions (cities and towns) are compared, so if you consider the

whole of Mexico City or only the area with the greenest space in the city, the results will be different. However, since no studies have accurately determined these data, these comparisons have been made to determine whether the selected territories are good or bad in terms of AVU. By doing the same work internationally, AMH can be even higher than Berlin and Leipzig in AV/H ratio compared with London and other cities, which means that the city is in a very favorable position in terms of AVU coverage (**Table 8** and **Table 9**).

**Table 8.** Green space in different parts of Mexico

| City | Area ($km^2$) | Green area ($m^2$) | Relationship with territory | Resident | AV/H ($m^2$) | Author |
|---|---|---|---|---|---|---|
| Mayor Miguel Hidalgo | 47 | 9,109,625 | 19.23% | 364,439 | 25 | Proprietary data |
| Monterrey City | 969 | 7,042,400 | 0.7% | 1,135,000 | 6 | Jiménez, Cuéllar, and Treviño, 2013 |
| Yucatan, Merida | 209 | 5,120,925 | 2.45% | 830,732 | 6 | Pérez-Medina and López-Falfán, 2015 |
| Toluca Valley | 452 | 4,097,805 | 0.9% | 819,561 | 5 | Galindo-Bianconi and Victoria-Uribe, 2012 |
| Mayor of Izakarko | 23 | 2,400,716 | 10.43% | 390,348 | 6 | Proprietary data |
| Durango City | 10 | 1,178,307 | 11.78% | 468,468 | 2 | Durango, 2006 |

**Table 9.** Comparison with international cities

| City | AV/H ($m^2$) | Author |
|---|---|---|
| Beijing* | 44 | Hinojosa, 2014 |
| London | 27 | Cvejic *et al*., 2015 |
| AMH | 25 | Proprietary data |
| Leipzig | 10 | Berlin. Not applicable. |
| Santiago, Chile | 2.4 | Reyes Packe and Figueroa Aldunce, 2010 |
| Malaga, Spain | 7.6 | Urban Environment Observatory, 2015 |
| Berlin | 6 | Berlin. Not applicable. |

The above comparison reflects the differences between AVUs in each mayor's office because national and international situations are different. These results are examples of a comparison between the planning of one region (AMH) and the unorganized urbanization (AIZ) of another region, even if they are located in the same city and have a similar development time.

The above results refer to the sum of AVUs, i.e., two categories (public and road use), but the categories are then analyzed separately.

## 2.1. Miguel Hidalgo and Iztacalco public green space

The following maps (**Figure 4**) show the spaces in which each mayor's office is regarded as a public green space and significant differences are again found in the number and area of these spaces.

The results show that compared with AIZ, the AVUP of AMH is about twice that of AIZ, but its area is about four times that of AIZ. This means that in AMH, these spaces are richer and larger than in AIZ (**Figure 5**).

**Table 10.** The greening area and total area of each municipal government

| City hall | Total AVM | AVU area ($m^2$) |
|---|---|---|
| Miguel Hidalgo | 108 | 8,440,450 |
| Iztakarko | 52 | 2,011,247 |

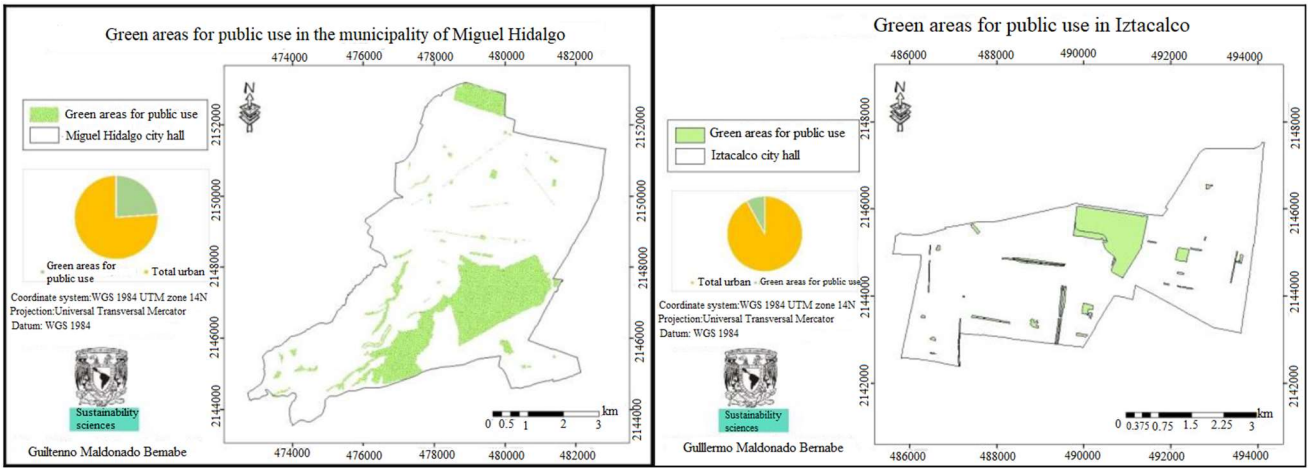


**Figure 5.** Study urban public green space.

This brings two realities to the study of cities: more AVUP in AMH creates more opportunities for leisure, coexistence and social cohesion for the residents of the city[47–49]. This reduces the risk of health problems such as anxiety, depression, obesity and even diabetes, as these spaces are used for exercise and other outdoor activities[6,47,48,50].

On the other hand, the social behavior of AIZ may be affected by the lack of AVUP, because various studies have shown that people living in places with less vegetation 1 km away from home feel lonely and have poor social skills[49], while people living near AVUP (800 m) are more likely to socialize[51].

Therefore, there are various suggestions in line with AVUP's ideal, namely, that the per capita area of a city should be 9 $m^2$[10,12,45]. In Europe, it should be 20 $m^2/H$[46]. In this regard, the results of the study of cities are the opposite, because since 1990, AIZ has not exceeded 5 $m^2/H$ in general, while AMH has exceeded 20 $m^2/H$ since 1990. In both cases, this average has increased since 1990, but the gap between the two remains (**Figure 6**).

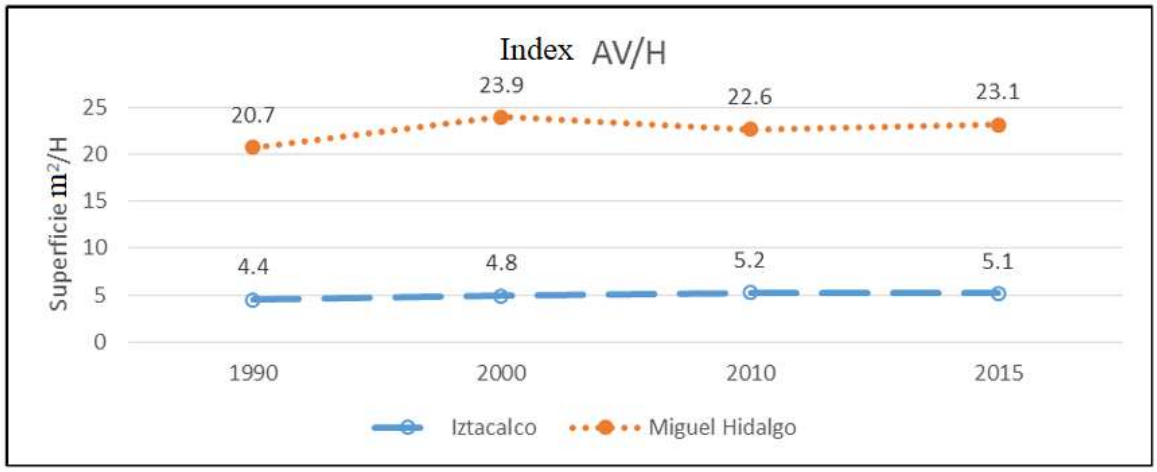


**Figure 6.** Considering the category of green area and furniture, the AV/H ratio.

These results indicate the need for intervention within the territory of the International Development Agency to implement programs to restore public space and create new space. As mentioned above, plans and programs have been developed, but the analysis shows that they are not sufficient to improve the situation of IDA until at least 2015.

The AVUP analysis includes areas without vegetation cover, such as kiosks, parking lots, roads, and other structures required for use, so the calcula-

tion does not reflect the actual vegetation area in these spaces. Therefore, NDVI was used to assess changes in vegetation at the study date. The next section presents the results.

## 2.2. Urban green space vegetation

Considering the total area occupied by AVUP (AMH is 8,440,450 $m^2$ and AIZ is 2,011,247 $m^2$), the vegetation coverage in these areas is calculated through vegetation analysis (NDVI) by QGIS software. Therefore, the changes in vegetation coverage in these areas are calculated.

The following maps (**Figures 7–8**) show 108 spaces classified as AMH "public green space" at the study date. They show green and yellow vegetation zones and non-vegetation zones, respectively.

Like DMH, the maps in **Figures 9–10** show the changes in green space area in 52 spaces calculated in DI.

According to the AVUP vegetation results of AMH, the vegetation coverage continued to improve from 1990 to 2015, reaching 1,288,245 $m^2$. In contrast, the vegetation coverage of AIZ fluctuated in the study year, but the final balance resulted in a loss of 172,361 $m^2$ (**Figure 11**). The change of vegetation in the mayor's office can be attributed to the management and care plan of its green space because the images analyzed are from the same date, so if the impact is caused by climatic conditions, both areas should be affected.

This negative trend indicates that AIZ has lost vegetation cover in AVUP, which reduces the quality of these spaces because vegetation provides services such as retaining contaminated particles, generating oxygen, water seepage, and reducing heat islands[4,5].

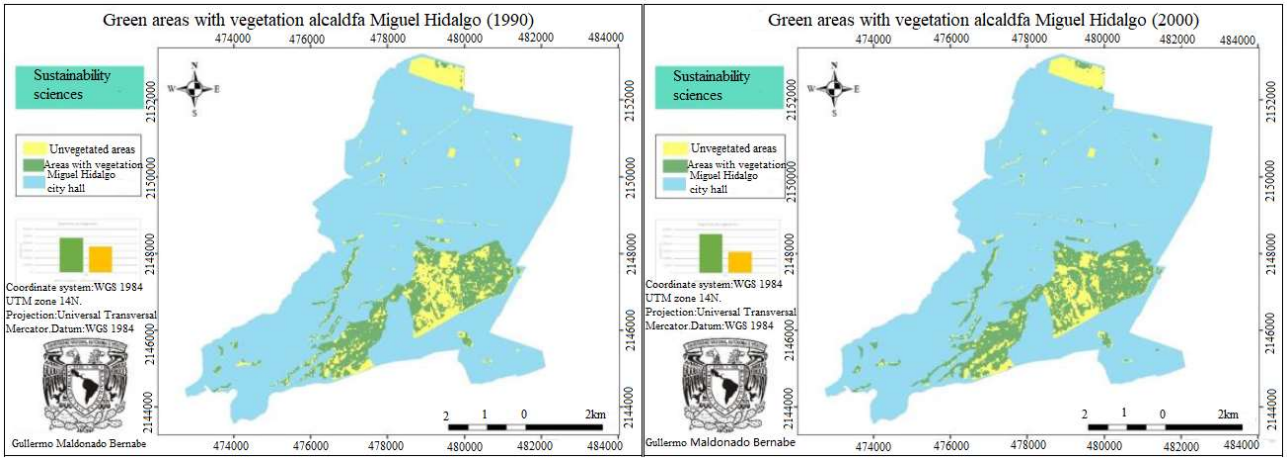


**Figure 7.** Miguel Hidalgo's vegetation coverage in 1990 and 2000.

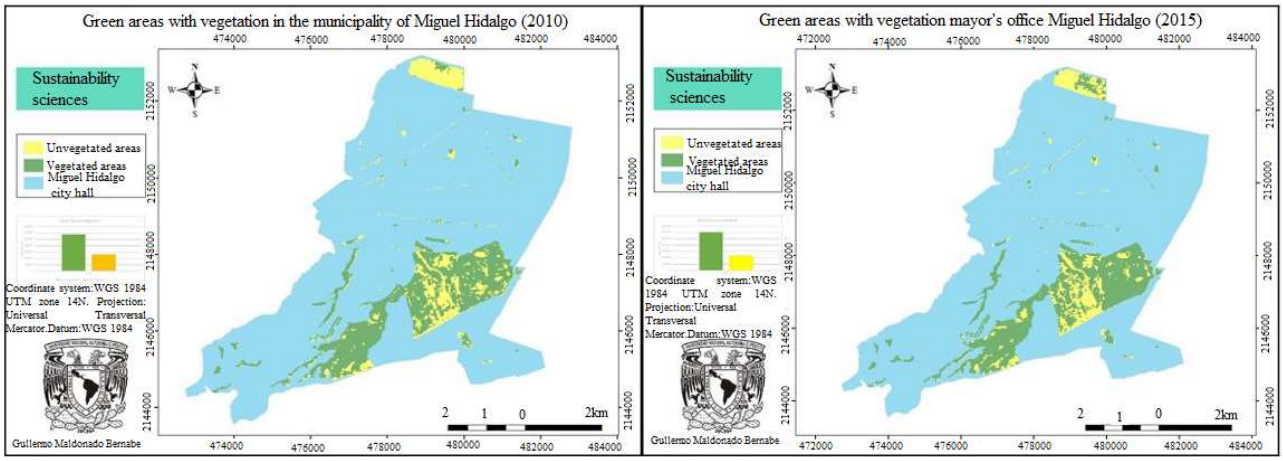


**Figure 8.** Vegetation coverage of Miguel Hidalgo in 2010 and 2015.

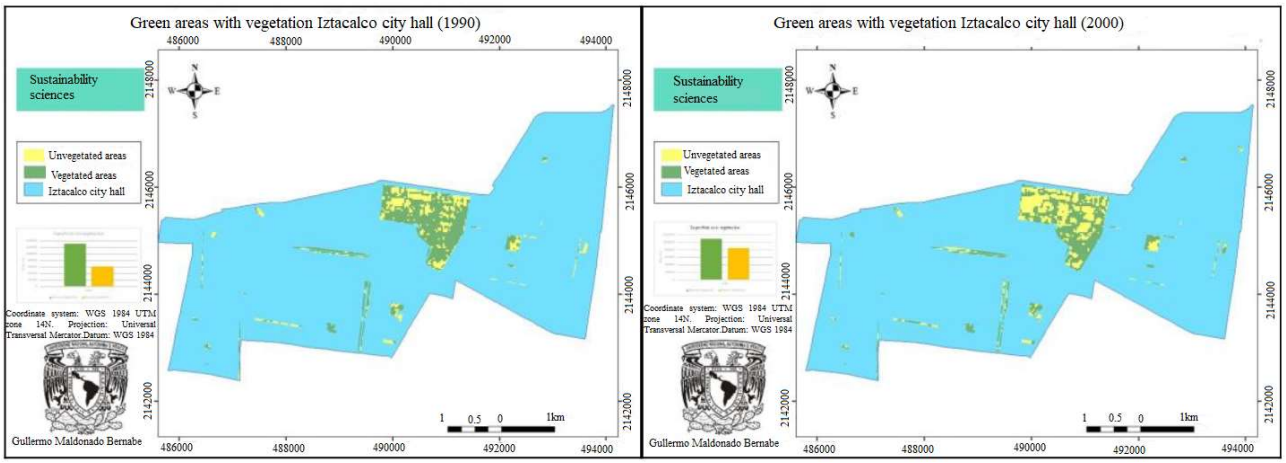


**Figure 9.** Vegetation coverage of Iztacalco in 1990 and 2000.

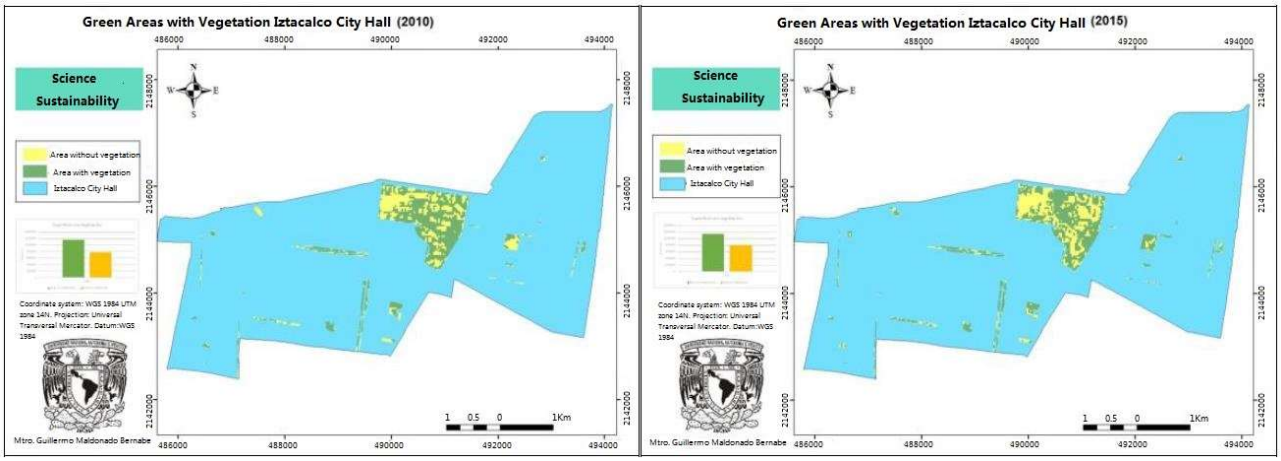


**Figure 10.** Vegetation coverage of iztacalco in 2010 and 2015.

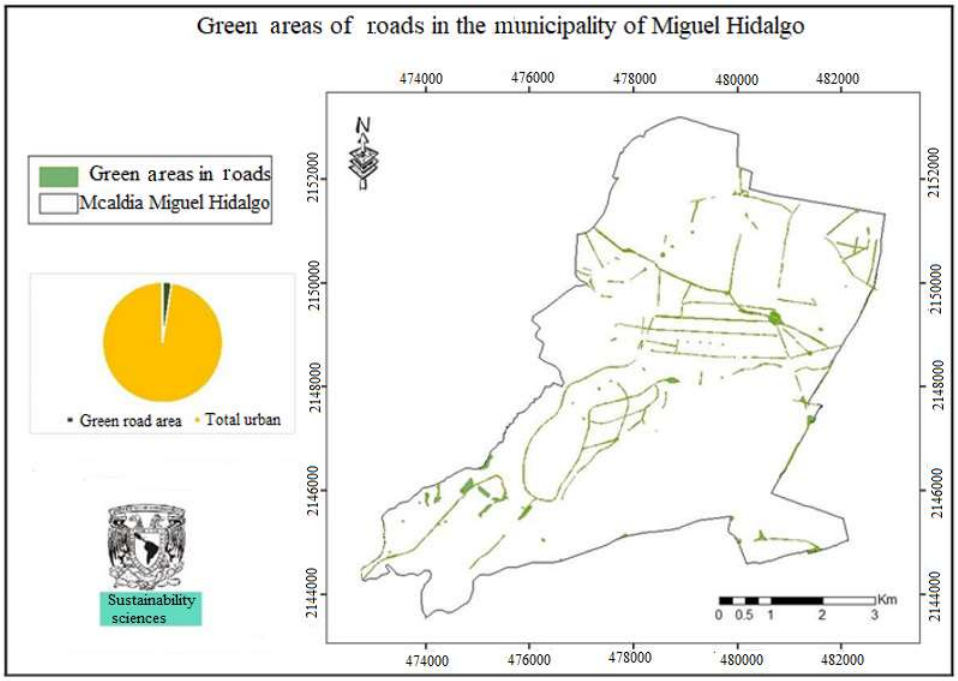


**Figure 11.** Green road area, Miguel Hidalgo.

**Table 11.** Vegetation coverage in the study year

| City hall | 1990 | 2000 | 2010 | 2016 | Difference (1990–2015) |
|---|---|---|---|---|---|
| Miguel Hidalgo | 4,711,204 | 5,398,979 | 5,750,953 | 5,999,449 | 1,288,245 |
| Iztakarko | 1,316,472 | 1,096,950 | 1,156,659 | 1,144,110 | –172,362 |

This shows that if the budgets of the two cities are similar in general, AVUP has not received the same attention. The resources used to maintain AVUP are different. In addition, the lack of AVUP and vegetation degradation in DI may lead to the cost of environmental services not incurred by the mayor's office[1]. The following table shows the estimated costs of some environmental services (**Figure 11**).

This negative trend indicates that AIZ has lost vegetation cover in AVUP, which reduces the quality of these spaces because vegetation provides services such as retaining contaminated particles, generating oxygen, water seepage, and reducing heat island[4,5].

This shows that if the budgets of the two cities are similar in general, AVUP has not received the same attention. The resources used to maintain AVUP are different. In addition, the lack of AVUP and vegetation degradation in DI may lead to the cost of environmental services not incurred by the mayor's office[1]. The following table shows the estimated costs of some environmental services (**Figure 11**).

In this study, the economic value of environmental services is not a goal, but by understanding the cost of environmental services, we can imagine the benefits of healthy and vegetation-rich green space.

Of course, the vegetation of protected areas, sidewalks, wastelands, roads, and other spaces can also serve the whole environment, but the focus of this study is public green space. Then the vegetation in these spaces is analyzed.

## 2.3. Road greening area

The space identified as road green space (AVV) in DMH accounts for 669,175 $m^2$, accounting for 1.44% of the total area (**Figure 11**). Admittedly, these spaces are not regarded as leisure areas, but they are part of the urban green infrastructure. In addition to beautifying the urban landscape, they also have environmental functions, namely multi-functional spaces[52–55]. In general, the trend of AVV in DMH is the same as that of AVUP, that is,

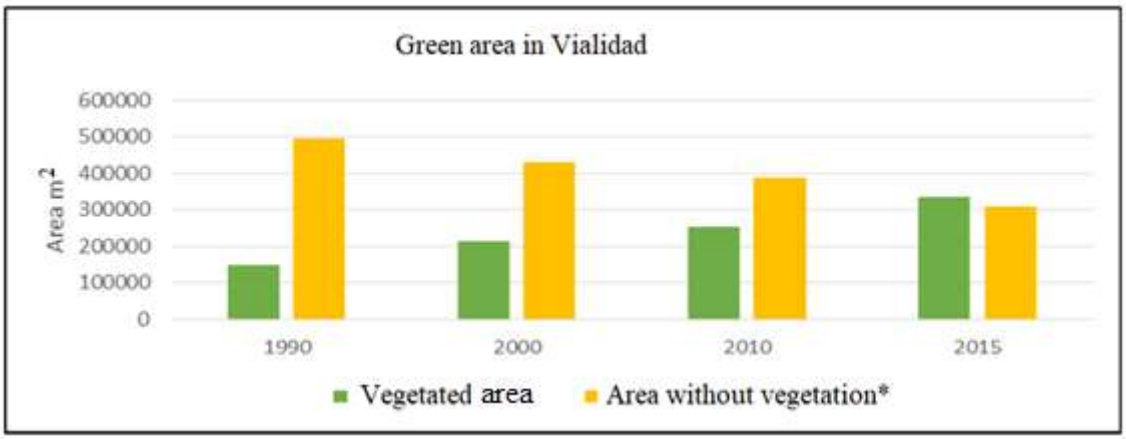


**Figure 12.** Miguel Hidalgo's green road area has been changed. *Space without plant cover.

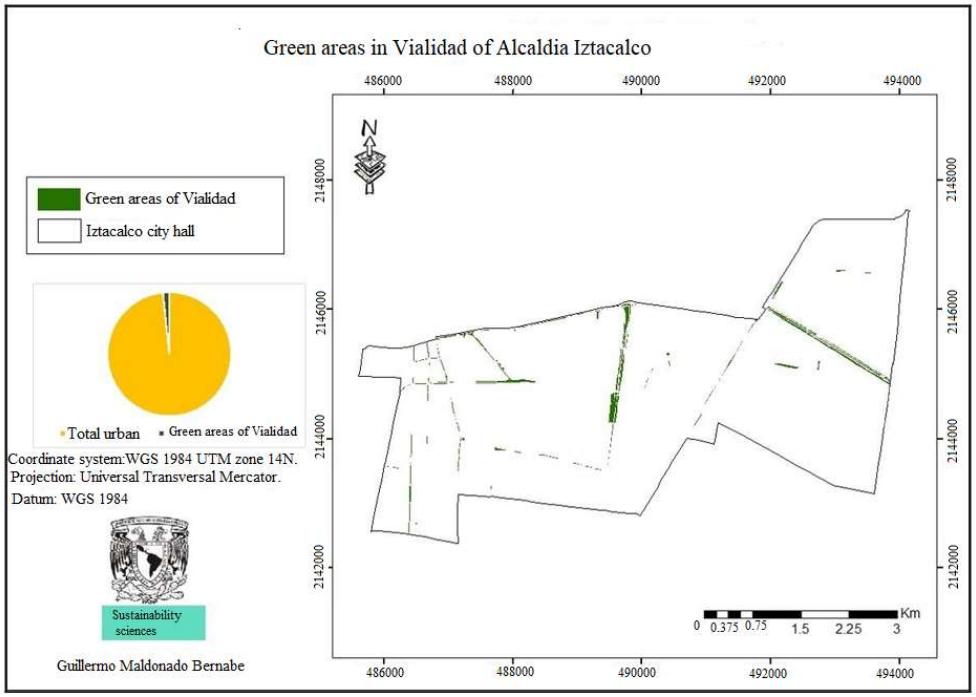


**Figure 13.** Green Road area of Iztakarko.

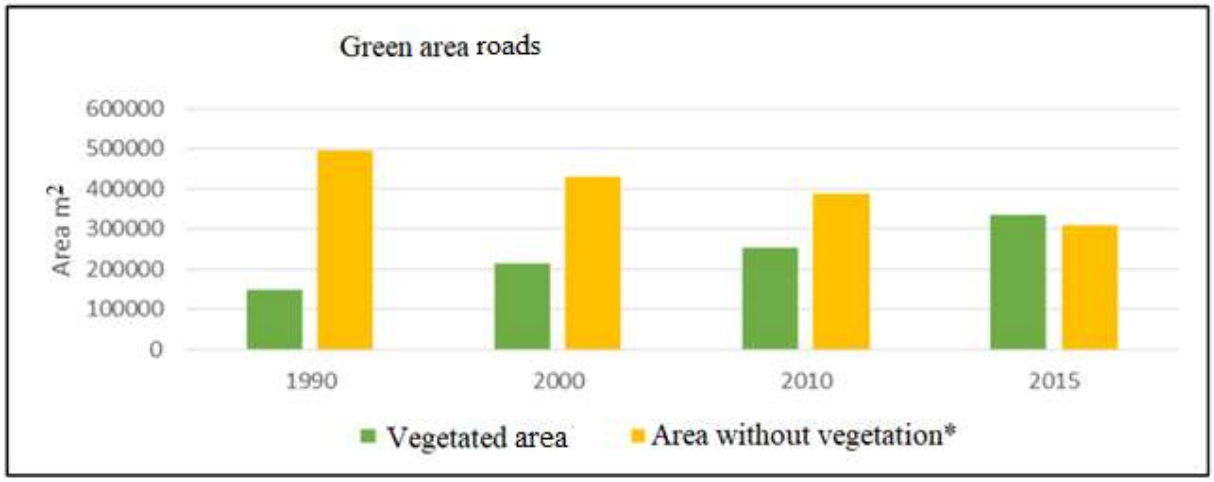


**Figure 14.** The road green area of Miguel Hidalgo has been changed.

**Table 12.** The average life span of each tree is 50 years

| Service | Cost (USD) | Mexican Peso (May 2017) |
|---|---|---|
| Oxygen production | 31,250 | 562,500 |
| Air purification | 62,000 | 1,116,000 |
| Water infiltration | 37,500 | 675,000 |
| Soil erosion control | 31,250 | 562,500 |

their vegetation coverage has more than doubled. As shown in the figure below, the total increase in vegetation is 186,003 $m^2$ (**Figure 12**).

In this case, the program directly related to road vegetation is the urban reforestation program, which aims to clean up and reforest the main roads and camels in the city, so it can be said to be effective at least in this regard. In terms of their share in local councils, the AVV of local councils' accounts for 1.68% of their territory, which means that they account for 389,496 $m^2$ of the general mayor's office. In AVV, the vegetation area increases, although to a lesser extent than in DMH, which is directly related to the low number of DI camels and roundabouts. By understanding the cost of environmental services, we can imagine the benefits of healthy and vegetation-rich green space. The following maps

and figures show the area occupied by the road and the annual vegetation calculation, respectively (**Figure 13**).

At least under this criterion, the reforestation program also played a role because it increased the vegetation coverage to 15,574 $m^2$ (**Figure 14**).

# 3. Conclusions

According to the censuses and information of INEGI and CONAPO, the gap in living conditions of residents in Mexico City has narrowed, as economic income, housing conditions, and service coverage have improved, so it can be said that the social program has been successful so far[56–59].

Mexico City is one of the entities with the lowest proportion of poverty and social backwardness among the population, but the origin and mode of urbanization affect the development of the territory and thus the opportunity to improve space[60–63].

Specifically, there are great differences in the quantity, quality, and distribution of green space in the study city, because as shown in the figure, DMH has more green space, partly due to Chapultepec Forest[64–67]. However, even without this space, the number of parks is much larger than di.

Therefore, the results show that urban AVU is concentrated in some areas, in this case, DMH. Therefore, the residents of the study towns have different access to and enjoyment of these spaces, which can be confirmed by looking at the AV/H index of each town. Therefore, even if the per capita total green space rate of the city is acceptable, it does not mean that the distribution of these spaces is fair.

Environmental and social services are also unequal in different regions, which may lead to social deterioration in specific regions (DI in this case). These results are consistent with what Fernández Alvarez[68] said. He said that the distribution and accessibility of AVU are seriously biased towards the marginalized population because the socio-economic characteristics of the population are directly related to the square meter of green space per resident[69,70].

As far as the research mayor's office is concerned, it has been mentioned that these social gaps have been narrowed at present, but the different urbanization modes of the two regions are the factors that limit (AIZ) or promote (AMH) the improvement of their AVU capacity.

In addition, the deterioration of AVU is a serious problem for the whole city, because the benefits brought by vegetation help to reduce the ecological footprint and improve the quality of urban life. In this regard, Mexico City's efforts should focus on achieving welfare and social equity in its territory, taking into account factors such as quality of life, mobility, income, services, environmental quality, and access to green areas.

The results show that considering the study city, the urban green space is unevenly distributed, and the area and vegetation coverage conditions are different, so the management and improvement program does not play a role (in the whole territory). This means that government, academic, and social efforts must be strengthened to eliminate this inequality[71]. Therefore, for CDMX, the goal of becoming a green, inclusive, and fair city is still far away.

Finally, it must be noted that this work can lay the foundation for the development of a system to monitor the progress of AVU protection and improvement, because the established method allows time comparison, so as to promote the planning and management of AVU. Finally, if higher-resolution satellite images are used, the vegetation status in these spaces can be estimated more accurately, and the results may be clearer.

# Conflict of interest

The authors declare no conflict of interest.

# References


1. ONUHabitat. Índice básico de las ciudades prosperas: Miguel Hidalgo (Spanish) [Prosperous cities core index: Miguel Hidalgo]. Ciudad de México: ONUHabitat; 2016.
2. Secretaría del Medio Ambiente. Inventario de áreas verdes del Distrito Federal (SEDEMA) (Spanish) [Inventory of green areas in the Federal District (SEDEMA)]. Ciudad de México: Secretaría del Medio Ambiente; 2003.
3. Sierra Rodríguez I, Ramírez-Silva JP. Los parques como elementos de sustentabilidad de las ciudades (Spanish) [Parks as elements of sustainability in cities]. Revista Fuente 2010; 2(5): 6–14.
4. Gómez Gutiérrez C. El desarrollo sostenible: Conceptos básicos, alcances y criterios para su evaluación (Spanish) [Sustainable development: Basic concepts, achievements and criteria for assessment]. In: Cambio Climático y Desarrollo Sostenible: Bases conceptuales para la educación en Cuba (Educación). La Habana: Editorial Educación Cubana; 2014.
5. López E. Beneficios en la implementación de áreas verdes urbanas para el desarrollo de ciudades turísticas (Spanish) [Benefits in the implementation of urban green areas for the development of tourist cities]. Topofilia: Revista de Arquitectura, Urbanismo y Ciencias Sociales 2013; 4(1): 16.
6. Salvador Palomo PJ. La planificación verde en las Ciudades (Spanish) [Green planning in cities]. Madrid: Gustavo Gili; 2003.
7. Kendal D, Lee K, Ramalho C, *et al*. Benefits of urban green space in the Australian context. Melbourn: Clean Air and Urban Landscape NESP Hub; 2016.
8. Observatorio de Medio Ambiente Urbano. Agenda 21 Málaga 2015: Agenda urbana en la estrategia de sostenibilidad integrada 2020–2050 (Spanish) [Agenda 21 Malaga 2015: Urban Agenda in the integrated sustainability strategy 2020–2050]. Malaga: Málaga City Council; 2015
9. Sherer PM. The benefits of parks: Why America needs more city parks and open space. San Francisco, California: The Trust for Public Land 2003; 32.
10. Flores-Xolocotzi R. Incorporando desarrollo sustentable y gobernanza a la gestión y planificación de áreas verdes (Spanish) [Incorporating sustainable development and governance to the management and planning of urban green areas]. Frontera Norte 2012; 24(48): 165–190.
11. Reyes Päcke S, Figueroa Aldunce IM. Distribution, surface area and accessibility of green areas in Santiago de Chile. EURE 2010; 36(109): 89–110.
12. Procuraduria Ambiental y de Ordenamiento Territorial. Presente y Futuro de las Áreas Verdes y del Arbolado de la Ciudad de México (Ekilibria) (Spanish) [The present and future of Mexico City's green areas and the Arbo-side of Mexico City (Ekilibria)]. Ciudad de México: Estudios y Publicaciones; 2010.
13. Hinojosa Robles E. Urban green infrastructure management in Mexico City and Beijing: The search for sustainable cities. Investigación Ambiental 2014; 6(1): 69–77
14. Galindo-Bianconi AS, Victoria-Uribe R. La vegetación como parte de la sustentabilidad urbana: beneficios, problemáticas y soluciones para el Valle de Toluca (Spanish) [Vegetation as part of urban sustainability: Benefits, problems and solutions for the Toluca Valley]. Quivera 2012; 14(1): 98–108.
15. Pérez-Medina S, López-Falfán I. Green spaces and urban trees in Merida, Yucatan. Toward urban sustainability. Economía, Sociedad y Territorio 2015; 15(47): 1–33.
16. Bolin B, Matranga E, Hackett EJ, *et al*. Environmental equity in a sunbelt city: The spatial distribution of toxic hazards in Phoenix, Arizana. Global Environmental Change Part B: Environmental Hazards 2000; 2(1): 11–24.
17. Benítez G, Chacalo A, Barois I. Aportes A La Ecologia Urbana De La Ciudad De Mexico (Spanish) [Contributions to the urban ecology of Mexico City]. In: Rapoport EH, López-Moreno IR (editors), Aportes a la Ecología Urbana de la Ciudad de México. Ciudad de México: Limusa; 1987. p. 193–201.
18. Flores-Xolocotzi R, Gonzáles-Guillen MJ. Green areas and public park planning. Revista Mexicana de Ciencias Forestales 2010; 1(1): 17–24.
19. Instituto Nacional de Estadística Geografía e Informática. Anuario estadístico y geográfico del Distrito Federal 2015 (INEGI). Ciudad de México: INEGI; 2015.
20. Bolivar Espinoza GA, Caloca Osorio OR. Distribución espacial de la pobreza (Spanish) [Spatial distribution of poverty]. Distrito Federal de México 1990–2040. Polis: Revista Latinoamericana 2011; (29): 1–29
21. Instituto Nacional de Estadística Geografía e Informática. Producto interno bruto por entidad federativa 1997–2002 (INEGI) (Spanish) [Gross domestic product by state 1997–2002 (INEGI)]. Ciudad de México: INEGI; 2020.
22. Instituto Nacional de Estadística Geografía e Informática. Banco de Información Eonómica (Spanish) [Eonomic Information Bank] [Internet]. 2017 [updated 2017 Apr 26]. Available from: https://www.inegi.org.mx/sistemas/bie/?idserPadre=10200070#D10200070
23. National Social Development Policy Evaluation Committee. Poverty reporting and assessment. Mexico City: NSDPEC; 2013.
24. Secretaría del Medio Ambiente. Agenda ambiental de la ciudad de México programa de Medio Ambiente 2007–2012 (Spanish) [Mexico urban

environmental agenda, environmental programme 2007–2012]. Ciudad de México: Sedema; 2012.
25. AlMomento.mx. Presentan denuncia popular por impacto ambiental en obra de Mixcoac (Spanish) [Popular complaint filed for environmental impact of Mexico construction project] [Internet]. 2017 [updated 2017 Jul 9]. Available from: https://almomento.mx/presentan-denuncia-popular-por-impacto-ambiental-en-obra-de-mixcoac/.
26. Ancira-sánchez L, Trevinho Garza EJ. Using satellite images for forest management in northeast Mexico. Madera y Bosques 2015; 21(1): 77–91.
27. Vera R. Mexico Tren México-Toluca: Ecocidio, descontento social y los mismos socios del poder (Spanish) [Toluca train: Ecological killing, social discontent and the same power partners from the process] [Internet]. 2017 [updated 2017 Jul 13]. Available from: https://www.proceso.com.mx/391895/tren-mexico-toluca-ecocidio-descontento-social-y-los-mismos-socios-del-poder-2.
28. Aguilar N, Galindo G, Fortanelli J, *et al*. Índice normalizado de vegetación en caña de azúcar en la Huasteca Potosina (Spanish) [Normalized index of sugarcane vegetation in the Huasteca Potosina]. Avances En Investigación Agropecuaria 2010; 14(2): 49–65.
29. Gonzalez-Elizodo S, Gonzalez-Elizodo M, Cortes-Ortiz A. Vegetación de la Reserva de la Biosfera "La Michila", Durango, México (Spanish) [Vegetation in the "La Michila" biosphere reserve in Durango, Mexico]. Acta Botánica Mexicana 1993; 22: 1–104.
30. Guzman A, López-García J, Manzo Delgado LL. Spectral and visual analysis of vegetation and land use with Landsat ETM+ images assested by digital aerial photography, of the Chichinautzin Biological Corridor, Morelos, Mexico. Investigaciones Geográficas, Boletin Del Instituo de Geografía, UNAM 2008; 1(67): 59–75.
31. Trucíos-Caciano R, Estrada-Ávalos J, Cerano-Paredes J, *et al*. Interpretation of change in land and soil use. Terra Latinoamericana 2011; 29(4): 359–367.
32. Aguilar Arias H, Mora Zamora R, Vargas Bolanos C. Metodología para la corrección atmosférica de imágenes Aster, RapidEye, Spot 2 y Landsat 8 con el módulo Flaash del Software ENVI (Spanish) [The method of atmospheric correction for aster, Rapideye, spot 2 and Landsat 8 images by using ENVI software Flaash module]. Revista Geográfica de América Central, Julio-dici 2014; (53): 39–59.
33. Sánchez M. El df pierde en 15 Años 56 mil árboles por obras (Spanish) [Mexico City loses 56,000 trees in 15 years due to construction work] [Internet]. 2017 [updated 2017 Jun 13]. Available from: http://www.sinembargo.mx/24-05-2015/1353514.
34. Peña Araya MA. Correcciones de una imagen satelital ASTER para estimar parámetros vegetacionales en la cuenca del río Mirta, Aisén (Spanish) [Corrections of an ASTER satellite image to estimate vegetational parameters in the Mirta river basin, Aisén]. Bosque 2007; 28(2): 162–172.
35. Meneses-Tovar CL. El índice normalizado diferencial de la vegetación como indicador de la degradación del bosque (Spanish) [The normalized differential vegetation index as an indicator of forest degradation]. Revista Internacional de Silvicultura e Industrias Forestañes 2011; 62(238): 72.
36. Soria Ruiz J, Granados Ramirez R. Obtenidos de los sensores AVHRR del satélite NOAA y TM del Landsat (Spanish) [Relationship between vegetation indices obtained from NOAA satellite AVHRR and Landsat TM sensors]. Ciencia Ergo Sum 2005; 12(2): 167–174.
37. Aldana D, Anges T, Bosques Sendra J. Cartography of the land cover/land use of the National Park Sierrade La Culata, Mérida State-Venezuela. Revista Geográfica Venezolana 2008; 49(2): 173–200.
38. Hernández F, Maríadela L, Palacios Romero A, *et al*. Influencia de la urbanización en el cambio de la vegetación colindante del corredor Pachuca-Tizayuca (2000–2014) (Spanish) [Impact of urbanization on vegetation change near Pachuca tizayuca corridor (2000–2014)]. Revista Mexicana de Ciencias Forestales 2016; 7(33): 20–39.
39. Ramos-Reyes R, Palma-López D, Ortiz Solorio CA, *et al*. Change of land use by means of geographical information systems in a Cacao region. Terra Latinoamericana 2004; 22(3): 267–278.
40. Secretaría de Desarrollo Urbano y Vivienda. Programa Delegacional de Desarrollo Urbano de Miguel Hidalgo (Spanish) [Miguel Hidalgo delegation urban development program]. Mexico: Gaceta Oficial Del Distrito Federal; 2008. p. 169.
41. Rivera N. En la casa de la Sal: Monografia, cronicas y leyendas de Iztacalco (Gobierno d) (Spanish) [Salt house: Monographs, chronicles and legends of Iztakarko]. Mexico: Gobierno del Distrito Federal; 2002.
42. Secretaría de Desarrollo Urbano y Vivienda. Programa delegacional de desarrollo urbano para la delegación iztacalco (Spanish) [Iztakalko delegation urban development mission program]. Mexico: Gobierno del Distrito Federal; 2008. p. 136.
43. Instituto Nacional de Estadística Geografía e Informática. Principales resultados de la encuesta intercensal 2015 (Primera) (Spanish) [Main results of the 2015 intercountry survey]. Aguascalientes: INEGI; 2015.
44. Sorensen M, Barzetti V, Williams J. Manejo de las áreas verdes urbanas (Spanish) [Urban green space management]. Washington D.C.: Banco Interamericano de Desarrollo; 1998.
45. Handley J. Accessible natural green space. Standards in towns and cities: A review and toolkit for their impementation. Peterborough: Natural England; 2003.
46. Atiqul HSM. Urban green spaces and an integrative

approach to sustainable environment. Journal of Environmental Protection 2011; 7(2): 601–608.
47. Jennings V, Larsen L, Yun J. Advancing sustainability through urban green space: Cultural ecosystem services, equity, and social determinants of health. International Journal of Environmental Research and Public Health 2016; 13(196): 15.
48. Maas J, Van Dillen S, Vertheij R, *et al*. Social contact as a possible mechanism behind the relationship between green space and health. Health and Place 2009; 15(2): 586–595.
49. World Health Organization. Urban green space and health: A review of evidence [Internet]. Copenhagen: WHO; 2016. Available from: https://www.euro.who.int/__data/assets/pdf_file/0005/321971/Urban-green-spaces-and-health-review-evidence.pdf.
50. Fan Y, Das K, Chen Q. Neighborhood green, social support, physical activity, and stress: Assessing the cumulative impact. Health and Place 2011; 17(6): 571–582.
51. Grant L. Multifunctional urban green infrastructure. London, UK: CIWEM; 2010.
52. Secretaría de Desarrollo Social. Pobreza, Desigualdad y Marginación en la Ciudad de México (Dirección) (Spanish) [Poverty, inequality and marginalization in Mexico City (direction)] [Internet]. Ciudad de México; 2004. Available from: http://www.sideso.cdmx.gob.mx/documentos/2003_seminario_pobreza_y_desigualdad.pdf.
53. Asamblea Legislativa del Distrito Federal VI Legislatura. Ley de salvaguarda del patrimonio urbanístico arquitectónico del distrito federal (Spanish) [Law for the safeguarding of the urban architectural heritage of the federal district]; 2014 Nov 28 (Mexico). Available from: http://aldf.gob.mx/archivo-3b5d31bc1dbb20329e76ef5fa2ec73f6.pdf.
54. Urban Green Space Website [Internet]. Berlin: Senate Department for the Environment, Transport and Climate Protection. 2019. Available from: https://www.berlin.de/senuvk/natur_gruen/index_en.shtml.
55. Cvejić R, Eler K, Pintar M, *et al*. A typology of urban green spaces, ecosystem services provisioning services and demands [Internet]. 2015 May 13. Available from: https://assets.centralparknyc.org/pdfs/institute/p2p-upelp/1.004_Greensurge_A+Typology+of+Urban+Green+Spaces.pdf/.
56. Departamento de Ordenación del Territorio y Medio Ambiente. Criterios de sostenibilidad aplicables al planeamiento urbano (Spanish) [Sustainability criteria applicable to urban planning]. 2003 May 22. Available from: https://tysmagazine.com/criterios-sostenibilidad-aplicables-al-planeamiento-urbano/.
57. Administración Pública Del Distrito Federal. Decreto de presupuesto de egresos del distrito federal para el ejercicio fiscal 2000 (Spanish) [Federal district expenditure budget decree for fiscal year 2000]. Ciudad de México: Gaceta Oficial del Distrito Federal; 1999. p. 75–79.
58. Administración Pública Del Distrito Federal. Decreto de presupuesto de egresos del distrito federal para el ejercicio fiscal 2010 (Spanish) [Decree of expenditure budget of the federal district for fiscal year 2010]. Ciudad de México: Gaceta Oficial del Distrito Federal; 2009. p. 3–31.
59. Administración Pública Del Distrito Federal. Decreto de presupuesto de egresos del distrito federal para el ejercicio fiscal 2015 (Spanish) [Decree of expenditure budget of the federal district for fiscal year 2015]. Ciudad de Méxio: Gaceta Oficial del Distrito Federal; 2014. p. 19–23.
60. Instituto Nacional de Estadística Geografía e Informática. Los Hogares en México (Primera) (Spanish) [Mexican families (first)] [Internet]. Aguascalientes: INEGI; 1997. Available from: https://en.www.inegi.org.mx/contenidos/productos/prod_serv/contenidos/espanol/bvinegi/productos/historicos/21 04/702825491697/7028254916971.pdf.
61. Instituto Nacional de Estadística Geografía e Informática. XII Censo General de población y Vivienda 2000 (INEGI) (Spanish) [XII general census of population and housing 2000 (INEGI)]. Aguascalientes: INEGI; 2000.
62. Instituto Nacional de Estadística Geografía e Informática. Principales resultados del censo del censo de población y vivienda 2010 (INEGI) (Spanish) [Main census results of the 2010 population and housing census (INEGI)]. Aguascalientes: INEGI; 2011.
63. Jiménez Pérez J, Cuéllar G, Treviño E. Áreas verdes del municipio de monterrey (Spanish) [Green areas in the city of Monterrey]. Monterrey: Universidad Autónoma de Nuevo León; 2013.
64. Municipio de Durango. Plan director de forestación urbana del municipio de Durango (Spanish) [Urban afforestation master plan for the municipality of Durango]. Durango: Gaceta Municipal; 2006. p. 41.
65. Secretaría del Medio Ambiente. Plan verde de la Ciudad de México: 5 años de avances (Spanish) [Mexico City green plan: 5 years of progress]. Ciudad de México: Sedema; 2012.
66. Secretaría del Medio Ambiente. Sustainable CDMX: Green, mobile, educational, recreative. Ciudad de México: Sedema; 2015.
67. Secretaría del Medio Ambiente. NADF-001-RNAT-2015 [Internet]. 2015. Available from: http://www.paot.org.mx/centro/normas_a/2016r/NADF-001-RNAT-2015_PODA_DERRIBO_TRASPLANTE_01_04_2016.pdf.
68. Secretaría del Medio Ambiente. Ciudad verde, Ciudad viva (Spanish) [Green city, living city] [Internet]. 2016. Available from: http://data.sedema.cdmx.gob.mx/sedema/index.php/ciudad-verde.
69. Secretaría del Medio Ambiente. Programa de Reforestación Urbana (Spanish) [Urban Reforestation Program] [Internet]. 2017. Available from http://data.

sedema.cdmx.gob.mx/reforestacion-urbana/index.html.

70. UN-Habitat III. Urbanization and development. Nairobi: UN-Habitat; 2016.
71. Fernández-álvarez R. Inequitable distribution of green public space in the Mexico City: An environmental injustice case. Economía, Sociedad y Territorio 2017; 42(54): 399–428.