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AN EXPLORATORY STUDY OF THE EVOLUTION OF URBAN GREEN SPACES IN LISBON USING DIACHRONIC ANALYSIS OF ORTHOPHOTO MAPS

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Abstract. Green urbanism, namely in the form of consolidated urban green spaces (UGSs), has gained traction along with the reformist impetus of urban design, based on the ideal of efficient, functional, sustainable cities that promote a better quality of life for their citizens and on the notion of making urban expansion compatible with natural resources. Using a diachronic analysis (1995–2020) of the orthophoto maps of 38 UGSs included in the last version of the main municipality's legislation, framed within the Plano Director Municipal (PDM), whose first version was approved in 1994, we assessed the situation and evolution of the UGSs in the centre of Lisbon, Portugal. We conclude that with fewer or more incidences, depending on the periods analysed, the structure of UGSs in the centre of Lisbon has undergone significant changes, whether in terms of the implementation and requalification of existing UGSs or in terms of the increment and quality of UGSs (space created), thus respecting to a lesser or greater degree the strategic lines defined in various plans, as is the case of the PDM itself, but also of other important documents, such as the *Carta Estratégica* 2010–2024, *Estratégia de Reabilitação Urbana* 2011–2024 and *Estratégia Regional de Lisboa* 2030.

Keywords: Lisbon, green urbanism, Urban Green Spaces (UGSs), orthophoto maps, diachronic analysis.

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1. Introduction

The main work of Beck (1992), entitled "Risk Society", introduces the concept of eco-anxieties potentiated by the rhythms of changes from modernisation, and establishes itself as an excellent starting point to position the debate on new ways of thinking and designing urban spaces.

The way in which healthy lifestyles have begun to be valued and prioritised in city planning, such that they have become more efficient, functional and sustainable and guarantee a better quality of life for citizens, can be positioned as an extension of these same eco-anxieties and new eras of uncertainty (Verheij & Nunes, 2021).

The dedication to urban regeneration projects that took place in the early 2000s, for example, is a clear illustration of a new paradigm whose main objective was to encourage life in urban city centres and where such concepts as liveability (Beatley, 2010) and walkability (Lehmann & Mainguy, 2010), among others, have gained considerable weight in this debate.

With the priority – at least in terms of European public policy – of migrating to an ideal of sustainable, attractive city capable of guaranteeing quality of life for its citizens and commuters, it is almost epistemically imperative to monitor the evolution of urban green spaces (UGSs) in city centres, including how they evolve or are intervened over time (Chen & Jim, 2008; McPherson et al., 2018; Saldiva, 2018).

For this purpose, this article delves into what has been identified as the diachronic path–in terms of UGSs–of the urban centre of Lisbon. Thus, the objective is to map the evolution of these UGSs, namely using the dimensions of interventions and of the way these potential interventions fit the main line contained in the Plano Director Municipal of Lisbon (PDM), which originated in 1994 and which seeks to consolidate green spaces in the city via requalification and incremental strengthening of these UGSs.

Aerophotogrammetry is used as a method in the diachronic analysis of the orthophoto maps of 38 UGSs in the city, specified in the current version of the PDM, with the aim of contributing – based on an exploratory approach – to a theory of the evolution of green urbanism in the city.

2. Background

2.1. Urban green spaces as fundamental structures of green urbanism

The concept of green urbanism, introduced in the 1990s (Lehmann & Mainguy, 2010), establishes itself as the critical rationale for the positioning of the reformist impetus

of urban city centre design. Projected as a conceptual model for the redefinition of urban design, green urbanism – which, for Lehmann and Mainguy (2010), is nothing more than pure common-sense urbanism – is based on transforming and regenerating the ideal of urban spaces, which are capable of conferring social and environmental sustainability to the urban landscape according to different principles that include, for example–and as objectives–guidance in consolidating greener districts and urban biodiversity, landscapes and gardens.

At the genesis of the concept of green urbanism are the contributions resulting from the theory to the limits of growth, which are demonstrated in the negative effects of sprawl, the overconsumption of resources and the activities of urban development and expansion sustained by cities' rapid growth rates (Brundtland, 1987). Accelerated processes of urbanisation are supported by a humankind that is increasingly becoming an urban species and where, according to the United Nations (UN), currently, 55% of the global population lives in cities, a figure that is expected to reach 70% by 2050 (United Nations, 2018).

Rhythms which for decades ignored the functions of urban ecosystems and promoted the replacement of green spaces by other hard mineral surfaces, contribute to microclimatic transformations of cities (increased air temperature, pollution levels) and other morphological changes imposed on urban environments, with a significant impact on inhabitants' lives (Burton, 1997; McPherson, 2001; Lehmann, 2005; Tsoka, 2017).

The concept of green urbanism, according to Farkas et al. (2023), is associated with the expansion of UGSs, and the authors point out that research on UGSs was initially concentrated on the study of urban forests, generally positioned in peripheral areas of cities and ending up gradually changing into green space located in urban city centres. This happened as the discussion also progressed to the urgency of its provision (UGSs) in these central spaces, which are strongly impacted by the urban fabric and the historical subordination of green public spaces to economic interest and expansion.

UGSs were initially positioned at the centre of the debate on ecological research, but their transversal impact led to the acknowledgement of their relevance to the field of eco-justice issues (Verheij & Nunes, 2021; Gonçalves et al., 2021), based on the recognition that contact with nature in an urban environment can make us happier and healthier, rendering this theme one of the most urgent challenges of contemporary urban architecture (Beatley, 2010). "Cities face growing challenges and urban greenspaces (UGS) play a key role in improving cities liveability" (Gonçalves et al., 2021). They are tools "for cities to develop cleaner, healthier and more attractive living environments" (Verheij & Nunes, 2021, p. 1).

Several authors (Lee & Maheswaran, 2011; Kabisch et al., 2015; Markevych et al., 2017; Verheij & Nunes, 2021; Gonçalves et al., 2021; Kajosaari et al., 2024) point out the importance of UGSs in improving the quality of life of citizens, by enhancing restorative capacities that contribute to the mitigation of harmful effects on health, noise pollution and air pollution, and the mitigation of increased temperatures in urban spaces. And although UGSs are not just dedicated recreational spaces (Hunter et al., 2019) some studies (Arifwidodo & Chandrasiri, 2021) also suggest that the improvement of a green urban space, like an urban park, increase the number of its visitors and users for purposes of regular physical activity.

Many cities are thus focusing on improving their UGSs due to their positive impacts on urban environments and on the quality of life of its inhabitants (Verheij & Nunes, 2021), however, there isn't much research done on the impact of these interventions (Hunter et al., 2019) that can either have negative or positive effects, meaning that a new or improved green area can promote participation in physical or social activities, it can contribute to community cohesion and have environmental benefits as well (Ayala-Azcárraga et al., 2019; Hunter et al., 2019), but in some cases might create negative consequences, such as gentrification or unequal access (Anguelovski & Connolly, 2021; Hunter et al., 2019).

Also, planting trees and vegetation can have a positive impact in the mitigation of urban heat, however, in most cases we cannot know for sure if the selected vegetation type causes any other effect, for example, on the environment or biodiversity. Hence, according to Kajosaari et al. (2024), and although information regarding UGS quality is often not readily accessible, the perceived quality of an UGS is crucial in ensuring its usage.

As Kajosaari et al. (2024, p. 1) state: "The need for metrics capturing UGS quality has been repeatedly addressed in the environmental health literature, which has proposed that alongside quantity, the quality of the UGS is relevant for understanding the reasons for UGS use and its impact on human health and well-being, to better support urban green infrastructure".

This is where this study positions itself as a contribution to responding to this gap as The World Health Organisation (WHO, 2017) itself recognises the importance of assessing the quality of green spaces and other nature-based solutions to improve urban environments and their resilience and metabolism (Meerow & Newell, 2017; Badiu et al., 2019); promote more sustainable lifestyles; stimulate cognitive, emotional and psychosociological benefits; help reduce the sound emitted by road traffic; and provide recreational opportunities for inhabitants (Deming & Swaffield, 2011; WHO, 2017; Olszewska-Guizzo et al., 2020; Sia et al., 2020; Farkas et al., 2023).

2.2. The case of Lisbon

In Lisbon, some studies (Viebrantz & Fernandes-Jesus, 2021, p. 2) show that the quality of life and well-being of the people living in the city have been affected, and notably, a better and greener scenario is desirable, particularly a more attractive central area with accessible green spaces. Indeed, despite the occupation of green spaces being on average 21% in different zip codes, in the vast majority of these zip codes, this coverage is less than 10%, meaning there is a significant disparity in access to green areas among the

various districts of Lisbon, resulting in an estimation that 50% of the Lisbon population does not have access to a single green space near their home (Luz et al., 2019).

In this sense, it is of crucial importance, particularly in terms of societal impact, to analyse diachronically the evolution of these UGSs to understand how the city has evolved, primarily because this measurement is useful to assess the consequences of rapid urbanisation on human well-being and the impacts of European and national funding mechanisms (Fuller & Gaston, 2009; Kabisch & Haase, 2013).

The city of Lisbon is established herein as an important case study because it brings together characteristics that place it within a highly particular dimension. For example, it combines relevance as a European city–where reforms, new policies and goals in favour of green urbanism have been historically discussed, i.e. New Covenant of Mayors for Climate Change and Energy; European Green Capital 2020, etc., (Pedro et al., 2019) but where, simultaneously, and according to Viebrantz and Fernandes-Jesus (2021), Lisbon does not figure among the places/cities where the design of UGSs stands out more – with the lowest-performing areas of Lisbon, identified as the old town, central avenues (avenidas novas) and eastern areas (Pedro et al., 2019). All this despite the already long history of plans and goals that dates back to the end of the last century and that precisely aims to improve the green structure of the city (i.e. Planeamento urbano de Lisboa, PEL 1992; PDM, 1994; Visão Estratégica 2002–2012; Lisbon's master plan, 2012; Carta Estratégica 2010–2024; Estratégia de Reabilitação Urbana; Estratégia Regional de Lisboa 2030).

One of the plans included in the urban planning of Lisbon, and one that serves to situate this article, is the PDM, whose article 49 establishes, as the scope, objectives and regimen, "The design of new green spaces consolidated (…) [with] resilience (…) [led to an] increase of biodiversity" within an integrated ecological structure that aims to "ensure the continuity and complementarity of natural systems in the urban territory [and] the ecological and physical sustainability of the environment through the construction of green spaces of proximity" (Declaration no. 70/2020, of September 4). Green spaces are defined in Article 14 of the same document as:

…spaces that form part of the integrated ecological structure and whose natural, cultural, landscape and urban characteristics must be preserved and valued to ensure a set of functions of ecological balance in the urban environment and to support recreational activities and leisure of the population.

Another important document is the 2010–2014 Carta Estratégica (Câmara Municipal de Lisboa, 2009), which aims to achieve sustained attractiveness, for example, in the consolidation of green areas. Meanwhile, the Estratégia de Reabilitação Urbana (Câmara Municipal de Lisboa, 2011) includes, in Article 2 of the Legal Regime for Urban Rehabilitation, guidance for the rehabilitation of green spaces, although here the requalification of these green spaces boils down to just 5.25% of the total investment allocated to total intervention in the city.

Finally, the Estratégia Regional de Lisboa 2030 (Área Metropolitana de Lisboa & Comissão de Coordenação de Desenvolvimento Regional de Lisboa e Vale do Tejo, 2020) recovers the idea of a tendency towards urban expansion that is not always compatible with natural resources, and it discusses the need to offer better lifestyles through the creation of green structures capable of guaranteeing ecological connectivity in articulation with the urban space via: priority 1, the promotion, regeneration and urban qualification of urban spaces; and priority 2, aimed at improving air quality in urban areas with the implementation of new green infrastructure.

Ultimately, the key words that allow these documents to be condensed and that will let the results obtained to be situated include, on the one hand, the intervention in and requalification of existing green spaces for their resilience and consolidation, and, on the other hand, the increment of this structure according to a review of urban indexes and the spaces made available by the city to green areas.

3. Materials and method

Aerophotogrammetry is used as a method based on the diachronic analysis of the orthophoto maps of the 38 UGSs (Figure 1) that are part of Lisbon's integrated ecological structure – green spaces included in the last version of the PDM –, whose first version was approved in 1994 and which, as we saw earlier, also aims to consolidate the city's green space and render the city of Lisbon more attractive in light of the green urbanism discussed above.

A notable strength of this procedure lies in the comprehensive utilization of orthophoto maps spanning a significant timeframe, offering valuable insights into the evolution of UGSs over the years. By integrating these maps with local urban planning documents (PDMs) and legislative frameworks, the study provides a holistic view of UGS development against policy objectives. Additionally, the study's focus on central Lisbon ensures a concentrated analysis of a vital urban area, shedding light on the dynamics of green space management in a dense urban context as is the case of the Portuguese capital deemed 2020 European Green Capital.

We focus on selecting the green spaces that are in the central zone of the city (Area I) according to the current version of the PDM (Figures 1 and 2), which overlaps with the central zone of the 1992 Strategic Plan (PEL) (Figure 3) in a reconfiguration, over time, of the very definition of the city centre.

We examine the evolution of these spaces by using orthophoto maps from 1995 (Registo Nacional de Dados geográficos); 2001, 2003, 2006, 2011, 2016 (LXI website), as well as the current satellite images from Google Maps from 2020 onwards.

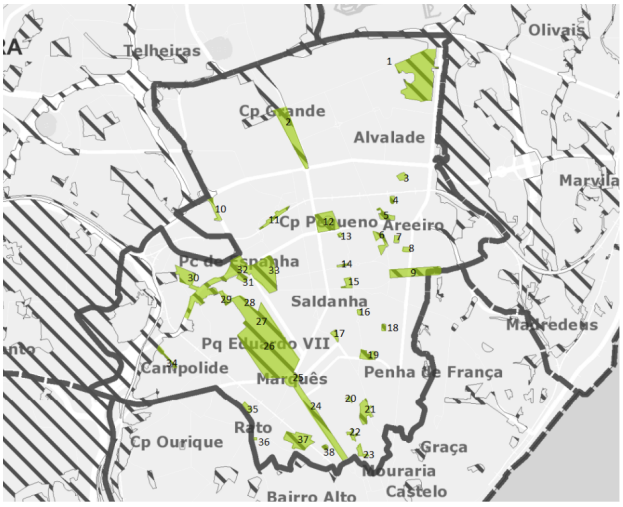
Because the central area from 1992 does not correspond exactly with the area of the central zone from the current PDM, not all green areas were included in this research. The remaining green areas are mostly isolated parks, and this information was confirmed also using the Open Street Map website[1].

[1] https://www.openstreetmap.org/#map=16/38.7271/-9.1452

The area that is part of the Green Corridor[2] was divided into 11 subzones, most of which are parks or roadside greenery with a specific name and clear borders, such as Avenida da Liberdade, Marquês de Pombal, Parque Eduardo VII, Parque Amália Rodrigues, Jardim do Palácio Mendonça, Jardim Amnistia Internacional, Embaixada de Espanha and Jardins Gulbenkian. The remainder of the area was divided among Green Corridor Park–Jardim José Medeiros Ferreira, Praça de Espanha and the area next to Aqueduto das Águas Livres, shown in the Annex.

3.1. Analysed UGSs

In our selected study area, we focused on the green spaces that are part of the integrated ecological network of Lisbon. These areas were carefully divided into 38 distinct zones for analysis. The majority of these zones are isolated parks, gardens, or squares, while a fragment remains unnamed green patches.



1 – Parque José Gomes Ferreira/Mata de Alvalade e Quinta do Narigão); 2 – Jardim Mário Soares – Campo Grande; 3 – Senhorio dos Lagares d'El-Rei; 4 – Jardim Igrejas Caeiro; 5 – Jardim Fernando Pessa; 6 – Jardim Irmã Lúcia – Praça de Londres; 7 – Jardim da Praça Pasteur; 8 – Jardim da Praça João do Rio; 9 – Jardim da Alameda Dom Afonso Henriques; 10 – *Area next to Av. dos Combatentes; 11 – *Area next to Residências Montepio Serviços De Saúde S.A.; 12 – Jardim do Marquês de Marialva – Campo Pequeno; 13 – Jardim Maria José Moura; 14 – Jardim Gomes de Amorim; 15 – Jardim do Arco do Cego; 16 – Jardim Cesário Verde; 17 – Praça José Fontana; 18 – Jardim Constantino; 19 – *Area of the Dona Estefania Hospital; 20 – Jardim da Paz/Jardim Maria de Lourdes Pintasilgo; 21 – Campo dos Mártires da Pátria; 22 – Jardim do Torel; 23 – *Area next to Coliseu dos Recreios; 24 – Avenida da Liberdade; 25 – Praça Marquês de Pombal; 26 – Parque Eduardo VII; 27 – Jardim Amália Rodrigues; 28 – Jardins do Palácio Mendonça; 29 – Jardim José Medeiros Ferreira – Green Corridor Park; 30 – Jardim da Amnistia Internacional; 31 – Embaixada De Espanha; 32 – Parque Gonçalo Ribeiro Telles – Praça de Espanha; 33 – Jardins Gulbenkian; 34 – *Area next to the Alcântara valley aqueduct (Aqueduto das Águas Livres); 35 – Jardim Marcelino de Mesquita; 36 – *Area next to Largo Hintze Ribeiro; 37 – Botanical Garden of Lisbon; 38 – Praça da Alegria.

*UGS's without official name.

Figure 1. 38 selected UGSs in Lisbon's central area for analysis (source: map adapted from the PDM, 2012)

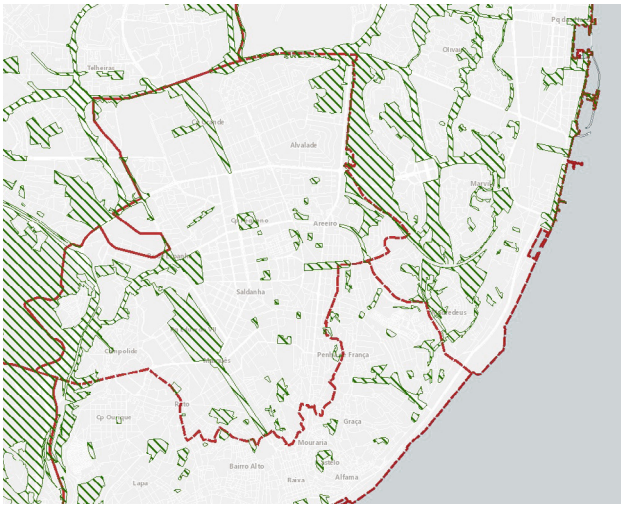


Figure 2. Central zone with green areas of the integrated ecological structure in the current PDM (source: Lisboa Interativa, 2020)

Figure 3. Central area according to the PEL 1992 (source: Câmara Municipal de Lisboa, 2002)

3.2. Limitations and how these limitations could have influenced the findings

The study aimed to analyse the evolution of UGSs based on planning documents and orthophoto maps, but limitations arose concerning the availability of numerical data from municipal sources. Despite efforts to gather information from the interactive website of the municipality, limitations persisted in accurately quantifying the scale of changes or financial resources allocated to green space shaping, due to the absence of these indicators. This is

[2] https://nextcity.nl/lisbon-green-corridor/

something that Verheij and Nunes (2021, p. 8) also noticed in their study of Lisbon's urban greening strategies. When analysing the data collected from the wide strategic documents of Lisbon, it became clear that these do not address local particularities of different green spaces. And within this frame of reference, other international studies (Hunter et al., 2019) also had to employ quasi-experiment methods to produce pre and post improvement design analyses due to the lack of official indicators for measuring interventions in different UGSs.

However, the study was able to produce visual representations illustrating the creation of new green areas within the selected zone (as we will see below). Therefore, while the study's data may appear general, they will provide valuable insights into the spatial distribution of UGSs and the extent to which they meet quality guidelines within the analysed zone.

In addition, the project encountered limitations that warrant consideration. Firstly, the vague nature of legislative frameworks regarding UGSs in Lisbon poses challenges in assessing policy compliance and evaluating the extent to which proposed objectives were achieved. The absence of specific data and commitments impedes a thorough analysis of policy effectiveness. Secondly, the lack of orthophoto maps predating 1995 constrain a comprehensive understanding of historical UGSs dynamics, limiting insights into long-term trends and developments. Furthermore, variations in orthophoto quality and seasonal changes in imagery introduce potential inaccuracies in feature analysis, particularly regarding vegetation and landscape features.

That said, the 1995 orthophoto maps[3] have a rather poor quality. The low resolution and lack of detail in the 1995 map obscure key features and nuances, hindering a comprehensive portrayal of baseline conditions and the extent of alterations over time. As a result, the analysis may have underestimated the cumulative effects of historical maintenance, redesigns, and developments, leading to potential inaccuracies in interpretations of overall trends in UGS evolution in the first phase (from 1995 to 2001).

Furthermore, the orthophoto maps from 2001–2016 from the LXI website presumably are from different seasons, so there might be limitations due to vegetation cycles or due to drought. Manual comparison of orthophoto images introduces the possibility of subjective interpretation and tiny mistakes in identifying changes, particularly in features like tree crown pruning, pavement updates, or new plantings. For instance, changes in vegetation appearance due to seasonal fluctuations or drought conditions could have led to misinterpretations of vegetation cover or health.

The orthophoto maps made available until 2016 resulted from the same official source (LXI). However, the information provided by this source ends in 2016, so we had to resort to Google satellite images to continue the diachronic analysis of green spaces, which entails extra limitations, as follows: the current satellite images (gathered on march 2023) from Google Maps, albeit identified as being from 2023, are in fact from 2020, because some areas of the city were rehabilitated and the changes are not visible (i.e. Jardim Gomes de Amorim was inaugurated in 2022[4]); in addition, the interventions in the Praça de Espanha area on the time of the analysis were in a more advanced phase than shown on the satellite images, which only show progress from the beginning of the works, which started in 2020, as the traffic was delimited on the images[5].

4. Results

The results of our analysis are presented in two tables. Table 1 provides insights into the interventions palpable across the 38 case studies spanning from 1995 to 2020. The predominant interventions observed are the establishment of new green spaces and the redesigning of existing ones. Additionally, smaller-scale interventions and maintenance activities such as the creation of new pathways or paved areas, upgrades to pavements, reduction in vegetation or tree cover, expansions of park areas and green spaces, installation or enhancement of playgrounds, and the addition of bike lanes are documented.

Table 1. Type of intervention in the UGSs

UGS	New green space	New design	New pathway/ pavement area	Pavement upgrade	Reduction in vegetation or tree coverage	Increase in the park area	Increase in the green area	Playground added/ upgraded	Bike line added
1			yes						
2		yes			yes				
3									
4				yes	yes				
5		yes			yes				
6		yes			yes	yes			

[3] https://snig.dgterritorio.gov.pt/rndg/srv/search?dataFormat=-GeoTIFF

[4] https://www.jf-avenidasnovas.pt/inauguracao-da-requalificacao-do-jardim-gomes-amorim/

[5] https://www.lisboa.pt/praca-de-espanha

End of Table 1

UGS	New green space	New design	New pathway/ pavement area	Pavement upgrade	Reduction in vegetation or tree coverage	Increase in the park area	Increase in the green area	Playground added/ upgraded	Bike line added
7				yes					
8			yes		yes		yes		
9								yes	
10	yes								
11									
12		yes				yes		yes	
13				yes	yes				
14		yes						yes	
15	yes								
16				yes	yes				
17				yes	yes				
18					yes				
19			yes						
20								yes	
21			yes		yes	yes		yes	
22					yes			yes	
23									
24									
25			yes			yes			yes
26									
27	yes								
28					yes				
29			yes			yes	yes		yes
30	yes		yes						yes
31									
32									yes
33									
34									
35					yes				
36					yes				
37					yes				
38				yes	yes			yes	

Table 2. Intervention fluxes through time

UGS	1995–2001	2001–2003	2003–2006	2006–2011	2011–2016	2016–2020
1					X	
2					X	X
3						
4		X				
5	X					
6		X	X	X	X	
7		X				
8	X	X				
9	X					
10			X	X		
11						
12		X	X	X		

End of Table 2

UGS	1995–2001	2001–2003	2003–2006	2006–2011	2011–2016	2016–2020
13					X	X
14		X				
15			X			
16				X	X	
17				X	X	X
18					X	
19					X	
20					X	
21	X	X			X	
22	X	X				X
23						
24						
25					X	
26						
27	X	X				
28						X
29				X	X	
30	X	X		X		
31						
32				X		X
33						
34						
35					X	
36					X	
37					X	
38				X	X	X

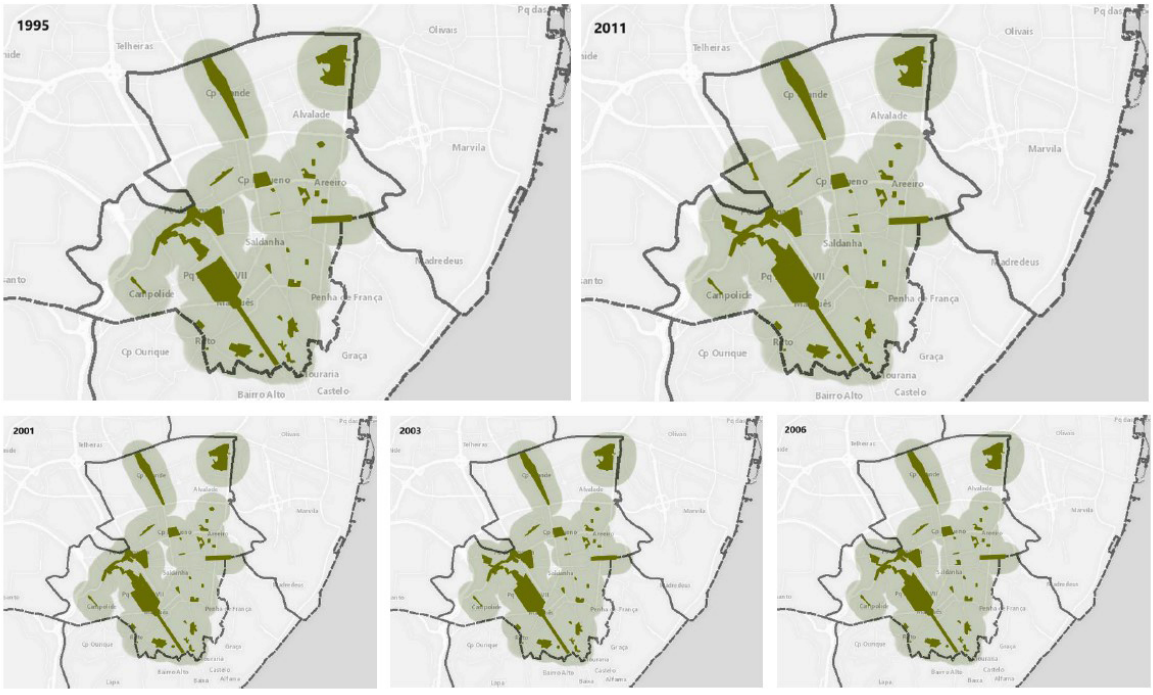


Figure 4. UGSs and their impact zone (source: own elaboration according to the LXI website (Espacos verdes – Carta da Área de Influência dos Espaços Verdes), Lisboa Interativa, 2020)

Table 2 provides information of the occurrence of these interventions across the years within six distinct time periods. Furthermore, alongside these tables, the results are visually depicted in Figure 4, illustrating the green areas and their 300 m impact zone according to WHO, demonstrating changes over the years. For further detail, Figures 5 to 10 in the appendix showcase the specific type of interventions, its location, and the corresponding time period in which they occurred.

5. Future paths

Some studies (Farkas et al., 2023) show that urbanised areas, especially in developed countries, lack an adequate quality and quantity of UGSs; indeed, their quality dimension has been strongly revisited in the literature (Swaffield, 2002; Nowak, 2018; Xue, 2019; Burtan et al., 2021; Zhong et al., 2022), where the explored idea is that not even the UGSs designed in cities can in their entirety respond to the benefits that are intended to be extracted from them. In other words, there is a kind of mismatch among the plan, its implementation and its result, which leads to a discussion that places ornamental and decorative projects among the most complex challenges of urban planning.

In this sense, by continuing the work discussed in this article, we will return to the 38 analysed UGSs (especially those that underwent a redesign), with the objective of exploring the quality dimension of these spaces, employing a morphological approach to compare conditions before and after the redesign, with orthophoto maps serving as foundational data.

The second phase would extend our analysis to encompass the entire city, where representative case studies will be selected of areas that were created within the analyzed timeframe. This comprehensive examination will evaluate the design of these spaces, integrating the principles of biophilic urbanism (Kellert, 2008; Beatley, 2010, 2017; Beatley & Newman, 2013), which is based on the idea of harmony between the city and the projected green space, alongside other metrics to assess green space quality. Biophilic urbanism is capable (or not) of effectively making cities more intelligent and sustainable according to the empirical evidence of its social, psychological, and other benefits, resulting from direct (and indirect) exposure to natural elements that are effectively able to combine with the context and that are resilient in the face of anthropic and climatic effects, which implies choosing the best vegetation with better growth conditions adapted to different locations and contexts.

Finally, the third phase would entail conducting stakeholder interviews and surveys to gain insights into perceptions and usage patterns of Urban Green Spaces (UGSs).

Such a multi-dimensional evaluation strategy promises to offer deeper insights into how these spaces contribute to urban well-being and environmental sustainability. Integrating this aspect into future research endeavors promises to enrich our understanding of UGS quality dynamics and inform more targeted strategies for urban green space management in Lisbon.

6. Conclusions and discussions

This article focused on evaluating changes in Lisbon's green areas through the lens of orthophoto maps. The emphasis was on understanding how these spaces were transformed since the implementation of the official masterplans. While the analysis primarily delved into historical shifts over the past 20–25 years, a deeper exploration into the quality dimension of these spaces was secured. It is widely acknowledged that maintenance plays a pivotal role in enhancing the quality of green areas, and any upgrades or alterations made to these spaces are typically aimed at improving them.

Thus, this article not only provided insights into the chronological sequence of interventions but also offered glimpses into how these interventions have potentially influenced the quality of these spaces over time, following those studies (Arifwidodo & Chandrasiri, 2021) that indicate that improving UGSs can benefit urban residents.

By deciphering the types of interventions, their frequency, and their temporal proximity, valuable information was collated about the evolving quality of these UGSs in Lisbon.

In the period of 2011–2016, 16 UGSs had interventions, most of which in this period included park maintenance, such as reducing vegetation or tree crown coverage. However, there were also such interventions as increasing the park, green and pedestrian areas by demolishing a parking lot (29) or removing traffic areas (25). In some of the UGSs, new pathways or bike lines were added (1, 19, 25), and in other areas, playgrounds (20) were created. The biggest intervention of this period was done to the north part of Campo Grande, where the whole area was redesigned.

In the other periods, the number of parks that experienced interventions is between 4 and 10, with an average of 7.4.

In the examined period, four new UGSs in total were created:

- the roadside greenery next to Av. dos Combatentes, finished between 2006–2011;
- the Jardim do Arco do Cego, finished between 2003–2006;
- the Jardim Amália Rodrigues, finished between 2001–2003;
- and the Jardim da Amnistia Internacional, finished between 2001–2003.

In conclusion, since 1995 (baseline data), most of the new parks in the central Lisbon area were created in the period 2001–2003, mostly under the prospects of PDM.

In the examined period, five total areas were redesigned:

- Jardim Mário Soares – Campo Grande between (north) 2011–2016, and (south) 2016–2020;

- Jardim Irmã Lúcia – Praça de Londres between (south) 2003–2006 and (roundabout) 2006–2011;
- Praça do Campo Pequeno – Jardim do Marquês de Marialva between 2003–2011;
- Jardim Gomes de Amorim between 2001–2003;
- Jardim Fernando Pessa between 1995–2001.

In each time period, at least a part of an area was redesigned.

In the period 2001–2003, two UGSs had an increase in the amount of green area or park area (other than the creation of the new parks).

In the period 2003–2006, two UGSs saw an increase in green or park areas.

In the period 2006–2011, one UGS had an increase in its total park area.

In the period 2011–2016, two UGSs increased space.

Post-2016, nothing significant happened (once again, such interventions as Praça de Espanha are not considered here because they cannot be analysed in terms of the chosen method; see limitations).

In summary, we argue that the strong guidelines for a new strategy aimed at green urbanism in Lisbon, based on the principles of intervention, requalification and increasing UGSs in the centre of Lisbon, as defined by the most significant plans (PDM, Carta Estratégica; Estratégia de Reabilitação Urbana, Estratégia Regional de Lisboa, etc.), have been fulfilled, with greater or lesser prominence in different periods, even if some studies suggest that the quantity and quality of UGSs in the centre of Lisbon are still insufficient (Viebrantz & Fernandes-Jesus, 2021), following strategies that are based on discourses which prioritise the ecological function of urban green areas while overlooking its social function (Verheij & Nunes, 2021).

Additionally, considering the 300-meter impact area guideline suggested by the WHO (2017), it was observed that while some new green areas had a minor impact, others significantly addressed areas previously lacking coverage.

By analyzing the urban green spaces of central Lisbon since 1995 and compiling a report on the interventions undertaken, we move one step closer to obtaining information on their current quality.

Regardless of all limitations, the article provides valuable insights into the evolution of UGSs in central Lisbon, offering a foundation for further research and policy refinement.

Notwithstanding the potential from cross-sectional evidence, we still know little about how to design new, or improve or promote existing UGSs for health, wellbeing, social and environmental benefits (Hunter et al., 2019), and this article allows us to deepen a clear example of the practicality and implementation of public policies for urbanism and of the instruments that aim to respond to the challenges of urban sustainability in cities over a span of time.

Through a detailed examination of the changes in selected green areas in Lisbon over the past two decades, the study aimed at unraveling nuanced insights into the dynamics of UGS evolution and quality enhancement strategies, making significant contributions both to the scientific understanding of UGSs and to society at large.

From a scientific standpoint, the detailed analysis of green area evolution using orthophoto maps contributes to the growing body of knowledge concerning UGSs dynamics in Lisbon and by unraveling historical trends and patterns, the research provides valuable insights into the factors influencing the evolution of green areas within Lisbon's urban environments. On a societal level, the findings of this project offer practical implications for urban planners, policymakers, and landscape architects involved in the management and development of green spaces and by identifying trends in green area evolution, the research informs evidence-based decision-making aimed at enhancing the livability and sustainability of urban environments.

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Author contributions

KR and TMM conceived the study and were responsible for the design and development of the data analysis. KR and TMM were responsible for data collection and analysis. KR and TMM were responsible for data interpretation. KR wrote the first draft of the article.

Disclosure statement

In the production of this article, we were not involved in any interests involving other parties. We assume that this article was conducted in an ethical and responsible manner and tries to present its results clearly, honestly, without fabrication, falsification and inappropriate data manipulation.

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Appendix

Figures 5 to 10. Analysed UGSs – Modifications by time period, their locations, types of intervention and development throughout/over the years (source: own elaboration with image developed in miro software)

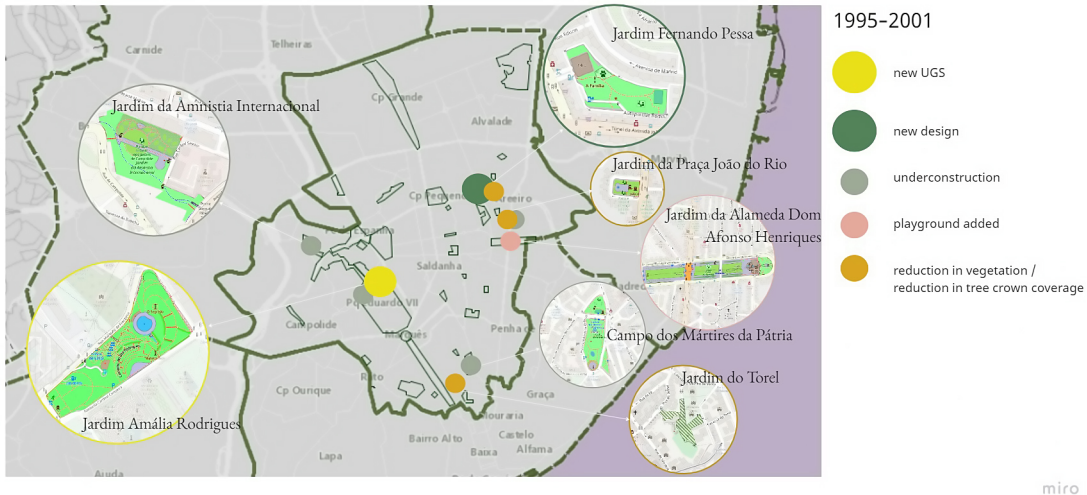

Figure 5. 1995–2001

Figure 6. 2001–2003

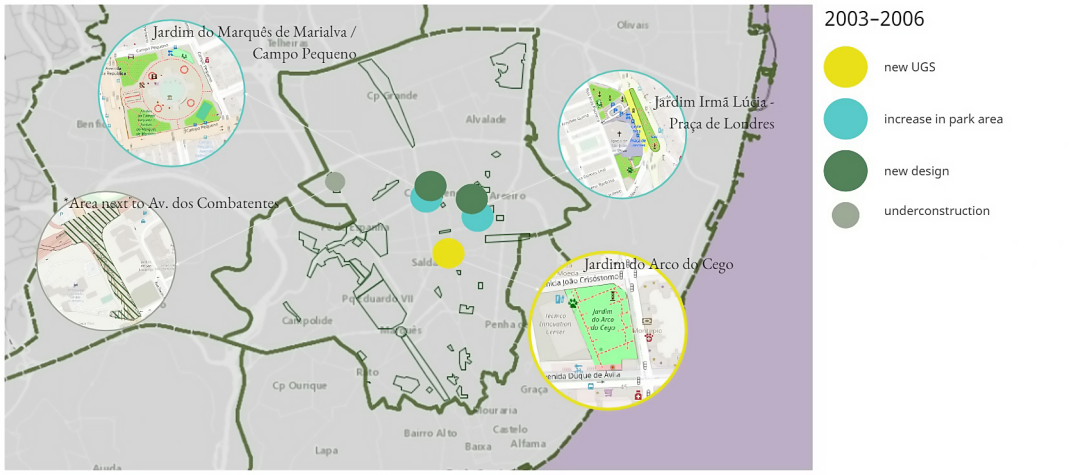

Figure 7. 2003–2006

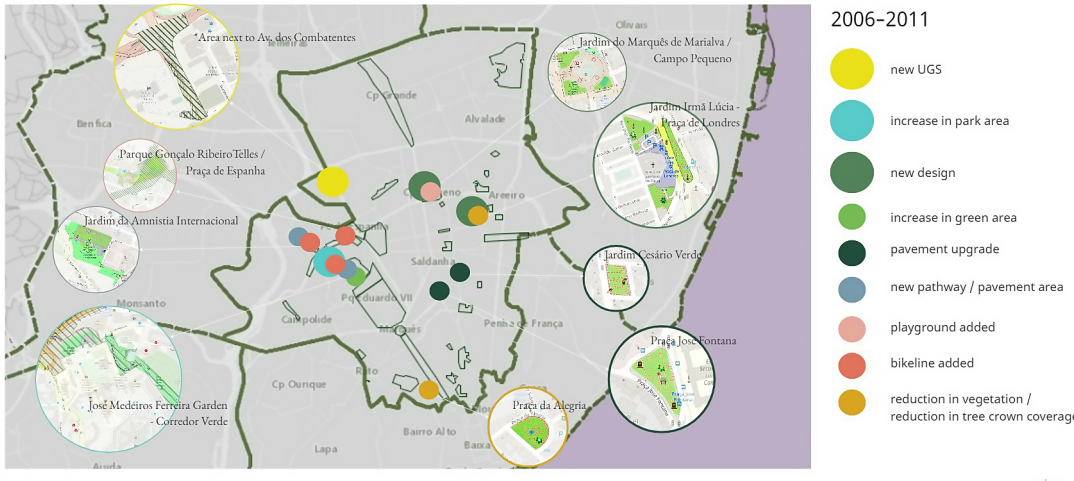

Figure 8. 2006–2011

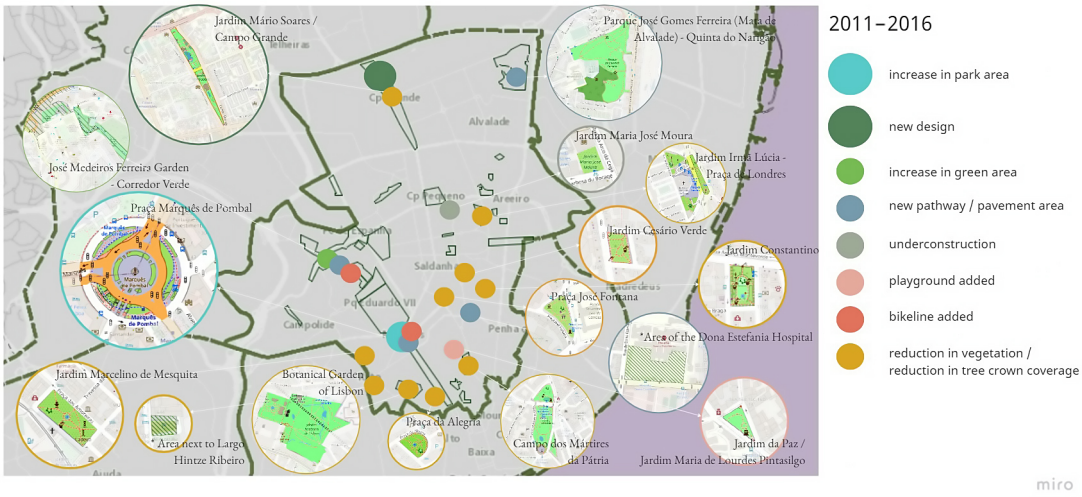

Figure 9. 2011–2016

Figure 10. 2016–2020