

# MEASURING THE EFFECT OF COVID-19 ON THE FUNCTIONALITY OF URBAN PUBLIC SPACES: THE CASE OF THESSALONIKI, GREECE

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## Abstract

Motivated by the human need for entertainment in the urban environment and its connection with the concepts of parks and public space in the urban fabric, this paper investigates the adequacy of the network of urban public entertainment spaces in the municipality of Thessaloniki. The research examines the accessibility of citizens to public urban outdoor entertainment spaces, in two distinct scenarios: during periods of full capacity and in the context of the COVID-19 pandemic, which has brought about new challenges to everyday life. The research is carried out by developing a new method for calculating the population serviceability of public entertainment spaces, which is based on the creation of accessibility zones resulting from an estimate of the city's population density, according to floor area ratios and housing coverage. The proposed method offers a spatial model for assessing the adequacy of urban public entertainment spaces to cover specific social conditions, highlighting the gaps and overlaps of population service of these spaces in the urban fabric. The application of this method to the city of Thessaloniki provides promising results for its use as an effective spatial analysis and planning tool.

Keywords: urban parks; pandemic; emergency conditions; capacity; spatial planning.

## 1. INTRODUCTION

In the evolving urban landscape, urban public spaces are vital hubs of social interaction and leisure, satisfying the human need for entertainment within the urban environment (Cho et al., 2015; Abbasi et al., 2016; Polyzos, 2023). Acknowledging the critical role of such spaces, this paper focuses on the municipality of Thessaloniki to examine the adequacy of its urban public spaces network in the context of

an emergency, as the COVID-19 pandemic imposed. In this context, the new requirements of public spaces and urban parks that were brought into the light due to the emergence of the COVID-19 pandemic raise the concern about revisiting the adequacy of these spaces in serving urban needs. In ordinal conditions, the adequacy of urban parks and public spaces can be evaluated by several criteria (Cho et al., 2015; Carmona, 2019; Barlow et al., 2021; Grigoriadou, 2021; Selcuk and Irmak, 2022) and relative to the design criteria, such as (i) the ease of people to access the park or public space, taking into account location, transportation, and physical barriers; (ii) the size and capacity of the park or public space relatively to surrounding area's the population density; (iii) the level of amenities or facilities provided by a park or public space; (iv) the degree of safety and security provided within the park or public space; (v) the environmental quality offered by each park or public space; as well as (vi) the degree to which park or public space meets the needs and desires of the community. The adequacy evaluation of urban parks and public spaces is mainly implemented through primary data collection techniques (Wang et al., 2015; Fan and Luo, 2021), such as surveys and interviews, as well as through the detection of park usage patterns and data analysis based on spatial analysis of demographics (Oh and Jeong, 2007; Deliry and Uygucgil, 2023; Polyzos, 2023). As both these analytical approaches are "emergency sensitive", as they either depend on social distancing or are submitted to availability issues in cases of emergence, such as the case of a pandemic, the requirement to employ analytical tools for assessing the adequacy of urban parks in exceptional cases remains an open academic debate.

Aiming at serving this demand and motivated by the observation of everyday life, during the period of the COVID-19 outbreak in the city of Thessaloniki, Greece, this paper develops a methodological framework evaluating the adequacy of public spaces under special conditions based on secondary and usually easily accessible data. The city of Thessaloniki can be an insightful case for measuring the effect of the COVID-19 pandemic on urban parks and public spaces' city organization (Ruchinskaya et al., 2019; Nikiforiadis et al., 2020; Politis et al., 2021), as it is considered as a megalopolis (the second most populated city) in the context of Greece, it has an adequate area (almost 20 square kilometers), and a considerable coastal forehead competing for the overall city's demand for parks and public spaces. The proposed method examines the accessibility of citizens to public urban outdoor entertainment spaces, based on the city's population density estimates (Griffith, 1981), floor area ratios (Barr and Cohen, 2014), housing coverage (Haapio and Viitaniemi, 2008; Polyzos, 2023) map distances and parks' areas (Oh and Jeong, 2007; Votsis, 2017; Deliry and Uygucgil, 2023; Polyzos, 2023), to evaluate the reach and effectiveness of urban public spaces due to the emergence of the pandemic. By employing the proposed spatial model, urban planners can gain a comprehensive understanding of the strengths and weaknesses of a current urban public spaces network, detect areas requiring improvement, and optimize these spaces to better serve the diverse needs of urban residents. The methodological framework provides a spatial model for urban

planners facilitating effective design and management of urban parks and public spaces, tailored guidance for creating dynamic urban environments, and the necessary tools to revitalize and optimize public entertainment spaces, ultimately shaping cities that are vibrant, socially cohesive, and culturally enriching. The implications of this research can extend beyond the case of Thessaloniki, providing valuable insights and inspiration to urban planners worldwide to unlock the full potential of public spaces, transforming cities into engaging and livable environments fostering a sense of community, enhancing quality of life, and promoting sustainable development.

## 2. LITERATURE REVIEW

Over time, the importance of public spaces has been undervalued due to the way cities have developed (Aravantinos, 2007). Public spaces are a crucial part of urban environments, providing areas for gathering and socializing while also relieving the congestion of city living (Polyzos, 2023). Furthermore, a city's investment in public spaces can be seen as a measure of the social empathy of its residents, as open spaces significantly contribute to maintaining a high standard of living and quality of life (Aravantinos and Kosmaki, 1988). Public spaces offer numerous benefits to a city's citizens, visitors, and businesses (Burgess et al., 1988; Mitchell, 1996; Lloyd and Auld, 2003), such as (i) they provide opportunities for social interaction and community building (Peters et al., 2010); (ii) they offer space for physical activity and exercise, which promotes overall health and well-being (Ward Thompson and Aspinall, 2011); (iii) they attract businesses, visitors, and residents, which can increase urban property values, create jobs, and contribute to economic development (Chang et al., 1996); (iv) they can serve as cultural and artistic venues, hosting concerts, festivals, and art installations (Gibson and Homan, 2004; Van Aalst and Van Melik, 2012); and (v) they contribute to environmental sustainability by providing green spaces, promoting biodiversity, and reducing the urban "heat island" effect (Ramlee et al., 2015).

The spatial distribution of urban parks and public spaces is also critical in creating livable, healthy, and sustainable cities (EuCo, 2023). Urban parks are designed according to various criteria (Cranz, 1982; Cranz and Boland, 2004; Dietrich and Kirchberg, 2017; Yilmaz et al., 2018; Guo and Mell, 2021; Dizdaroglu, 2022), which vary depending on the location, identity, and defining attributes of a city. Common design criteria include accessibility, size, functionality, safety, sustainability, aesthetics, and community engagement. Strategic planning for public spaces (Susanti and Natalia, 2018; Carmona, 2019) is also essential to ensure that the spaces are attractive, functional, and safe for all users. Factors, such as the provision of easy and safe access, the right infrastructure and dimensions, the creation of intimate spaces that foster community engagement, and proper maintenance must be taken into account to ensure that public spaces remain attractive and functional for the city's residents (Carmona, 2019; ECC, 2023). Nowadays, cities and megacities are increasingly in need of new urban open spaces, as well as the

upgrading of existing ones (Polyzos, 2023). Many megacities experience phenomena that increase the need to expand the network of public outdoor urban spaces, such as dense and high floor area ratios that lead to the absence of empty spaces due to the overuse of the urban surface. Moreover, the concentration and density of population distribution result in air and noise pollution from excessive traffic on urban road networks (Breuste et al., 2013; Thorne et al., 2020; Polyzos, 2023).

Urban outdoor public entertainment spaces, such as parks, squares, and pedestrian streets, bring enormous social benefits primarily for humans and their mental health (Gehl, 2013; Polyzos, 2023). They comfort with the fast daily life in cities, the monotony of the urban fabric, stress, and the minimal free time that contribute to isolation and alienation (Knox, 2005). In such spaces, individuals have the opportunity to socialize, communicate, and eliminate stress (Aravantinos, 2007; Peters et al., 2010; Gehl, 2013), as well as an outlet for entertainment, which is especially important for psychological reasons in cities where the pace of life is accelerated (Gehl, 2013). Another critical aspect of the practical value of urban public recreational spaces is related to their original creation, as many of these spaces were established several years ago and yet remain in the same place, despite the changing urban fabric environment (Gospodini and Beriatos, 2006; Tsiotas et al., 2016; Polyzos, 2023). According to this perspective, public urban spaces can be seen as a legacy in a city, bearing a past culture for outdoor entertainment that does not necessarily address contemporary problems of urban living (Aravantinos, 2007). In this context, the redefinition of the network of public entertainment spaces over the years has been subject to revised data, such as population and floor area ratios, to ensure the effective operation of the network (Polyzos, 2023). Overall, a dynamic approach is necessary for a network of urban public entertainment spaces to meet the new needs of a city (Aravantinos, 2007). Therefore, mapping the current situation of a city's outdoor public entertainment spaces and implementing initiatives to further strengthen the network in deficient areas are crucial, particularly during special conditions such as a full capacity situation of these places, and the existence of an integrated network is critical even during a pandemic (Tsiotas et al., 2016).

The emergence of the COVID-19 pandemic has imposed new conditions on social activity and behavior across all aspects of social life (Tsiotas and Tselios, 2022). For instance, to the spread of the virus, measures were taken in the catering and entertainment sector, leading to the suspension of the operation of related shops and a shift in social activity towards alternative outlets. On an urban scale, the given need of residents for entertainment has led to an increased demand for urban public spaces, providing the necessary infrastructure to meet the need for entertainment and socializing (Lloyd and Auld, 2003; Gehl, 2013). The pandemic has had a significant impact on the functionality of urban parks and public spaces worldwide.

The COVID-19 pandemic had a profound impact on the use and perception of urban parks, as highlighted by several studies. For instance, Xie et al. (2020) surveyed Chengdu, China, to explore how the pandemic affected the residents' health and social interaction. They found that visiting urban parks (even weekly visits were beneficial) significantly improved overall health and helped meet individuals' social interaction needs during the pandemic, emphasizing the critical role of urban parks as safe outdoor spaces that facilitate social interaction and promote health and quality of life during a pandemic. Another work by Nikiforiadis et al. (2020) investigated the impact of COVID-19 on travelers' perceptions of bike-sharing systems. Based on a questionnaire survey in Thessaloniki, Greece, although they found that the pandemic did not significantly affect the number of people using bike-sharing for their trips, a proportion of individuals found bike-sharing more attractive during the pandemic, particularly those who were previously commuting by private cars as passengers and registered users of bike-sharing systems. The study suggested that bike-sharing can contribute to the resilience and sustainability of cities by providing a safe and convenient transportation alternative. The study by Geng et al. (2021) analyzed data from Google's Community Mobility Reports and the Oxford Coronavirus Government Response Tracker to examine the impacts of COVID-19 and government response policies on park visitation globally. The results showed that park visits increased since the beginning of the pandemic, indicating the growing demand for parks and outdoor green spaces, and highlighted the important role of parks in contributing to social cohesion during the pandemic.

In the work of Cheng et al. (2021), the authors investigated the happiness of citizens for the use urban parks in Nanjing, China. The results of the analysis showed that access to more vegetated urban parks was associated with higher levels of happiness. The study also detected an increase of this positive correlation during the pandemic, providing valuable information for health-oriented planning and designing of urban parks. In the paper of Jay et al. (2021), a new approach is introduced to monitor park use during the pandemic employing location data extracted from smartphones. This study detected gaps in park visits based on the racial and ethnic composition of park users, demonstrating the requirement to address social inequalities in park accessibility and usage. The work of Larson et al. (2021) examined changes in park usage patterns in North Carolina, USA during the pandemic. The research employed geo-location data and showed a decrease in park visits due to COVID-19, which was greater in socially vulnerable communities. This study raised concerns about equitable accessibility to parks and green spaces, along with their potential impact on health inequalities in communities. The paper of Cook et al. (2021), which examines the impact of the pandemic on park visits and physical activity levels in Los Angeles County, USA, shows that indoor facility closures and stay-at-home orders led to increased park usage and physical activity in neighborhoods with higher proportions of racial and ethnic minorities. These findings highlighted the role of parks as key public resources for physical activity and recreation, particularly in lagged

communities. Further, the work of Addas and Maghrabi (2022) examined the usage patterns, attitudes, and perceptions of urban park visitors in Saudi Arabian cities during the COVID-19 pandemic. The results showed that while the number of park visitors decreased during the pandemic, urban parks remained important for the people's mental and physical well-being. This paper highlighted the importance of urban parks as tools of sustainable urban design to improve the quality and quantity green spaces in Saudi Arabian cities. Finally, Huang et al. (2022) used Twitter data to analyze the public values associated with urban parks before and during the pandemic and observed a shift in these values, with tweets focusing more on the social and health benefits of parks during the pandemic (such as opportunities for socialization, physical activity, and mental well-being), emphasizing the importance of understanding and prioritizing these values for effective park management and planning, as parks play a vital role in supporting the community's social and health needs.

In summary, these studies reveal that the COVID-19 pandemic considerably affected the role and functionality of urban parks, through the increasing demand for outdoor spaces emphasizing the shifting public values, the potential of parks to promote physical and mental well-being, the need for equitable access, and the role of parks in supporting sustainable and resilient cities during health crises. As the pandemic has altered the typical usage of urban parks and public spaces (in some cases, such spaces facilitated the need to accommodate social distancing requirements in recreation activities, such as the need for restaurants and cafes to expand into public spaces, while in other cases they served more practical issues of public life, such as vaccination sites, temporary hospitals or outdoor classrooms); raised some maintenance challenges (as budget cuts and staff reductions sometimes caused problems for cities to maintain urban parks and public spaces); and highlighted existing inequalities in terms of accessibility to these spaces; more research enhancing a comprehensive understanding of the urban public spaces network can promote the effective design and planning of the urban environment, and serve sustainable and inclusive urban development.

### 3. METHODOLOGY AND DATA

The proposed methodology is based on the estimation of population coverage zones, per public outdoor entertainment area, by calculating the population density of the city of Thessaloniki on the built-up surfaces of the urban plan, using the floor area ratios. For the implementation of the research, a complex methodological framework is developed to assess the adequacy of the municipality's urban public entertainment spaces for the emergency condition of the COVID-19 pandemic compared to their full capacity, to highlight the areas that are not sufficiently served and are in urgent need of creating new such spaces. In this research, the urban public entertainment spaces that were considered in the analysis are shown in Figure 1, including 88 park locations (Figure 2c).

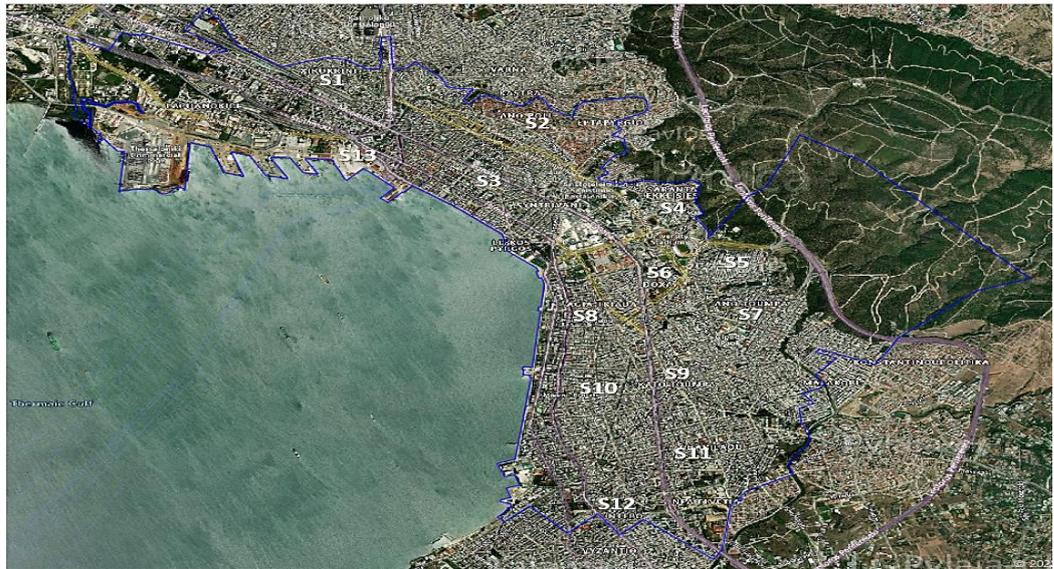
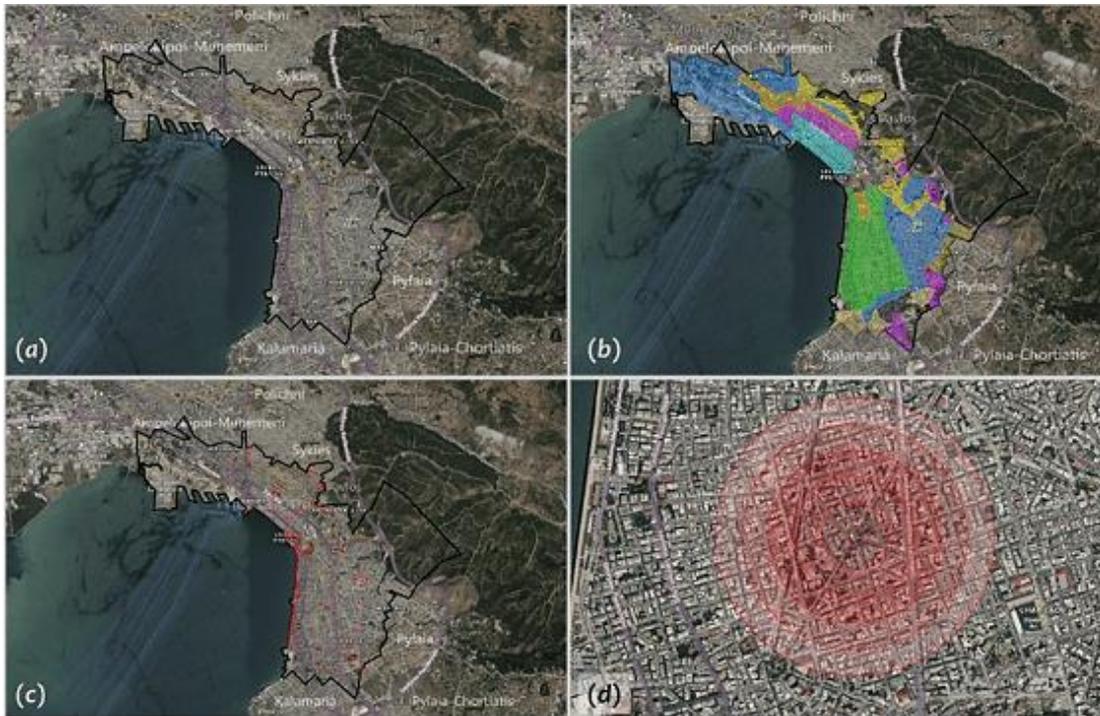


FIGURE 1 - MAP WITH THE AREAS OF THE MUNICIPALITY OF THESSALONIKI THAT ARE CONSIDERED IN THE ANALYSIS.

[Legend] **S**<sub>1</sub>: Xirokrini, **S**<sub>2</sub>:Ano Poli, **S**<sub>3</sub>:Historical Center, **S**<sub>4</sub>:Saranda Ekklisies, **S**<sub>5</sub>:Triandria, **S**<sub>6</sub>:Doxa, **S**<sub>7</sub>:Ano Toumpa, **S**<sub>8</sub>:Agia Triada, **S**<sub>9</sub>:Kato Toumpa, **S**<sub>10</sub>:Analipsi, **S**<sub>11</sub>:Harilaou, Depo, **S**<sub>12</sub>:Port area (Source: Own elaboration).

To evaluate the reach and effectiveness of public urban outdoor entertainment spaces, the proposed methodological framework builds on a set of variables selected from the relevant literature, including (i) the city's population density estimates (Griffith, 1981), (ii) floor area ratios (Barr and Cohen, 2014), (iii) housing coverage (Haapio and Viitaniemi, 2008; Polyzos, 2023), (iv) map distances and (v) park surface areas (Oh and Jeong, 2007; Deliry and Uygucgil, 2023; Polyzos, 2023). In particular, population density is positively related to and affects urban park capacity, as when it increases, the demand for green spaces and recreational areas also increases. For instance, in cases where the urban park is not designed to accommodate the increased demand based on population density, it can lead to overcrowding, reduced accessibility, and increased wear and tear on the park, while when is designed to do so, it can provide a valuable resource for the local community and improve quality of life (Guo et al., 2019; Leon-Moreta, 2020; Polyzos, 2023). Next, the floor area ratio (FAR) is the ratio expressing the built area per land area (Nemeth, 2009; Barr and Cohen, 2014; Polyzos, 2023), namely the buildable area corresponding to a certain building site, where cases higher than one ( $FAR > 1$ ) indicate the potential of vertical (floor) construction. The FAR can be considered as both directly and indirectly related to an urban park capacity, as on the one hand, it is competitive to public urban spaces (a higher floor area ratio may result in less available land for urban parks and public spaces), whereas, on the other hand, it is useful for providing information for the amount of population distributed vertically in a city map. Auxiliary to the FAR, we consider the housing coverage (Haapio and Viitaniemi, 2008; Polyzos, 2023), which expresses the share

of built area projection compared to the total city land area. Finally, the geometric characteristics, such as the map distances and park surface areas (Oh and Jeong, 2007; Deliry and Uygucgil, 2023; Polyzos, 2023), are taken into account in the analysis for map processing.



**FIGURE 2 -** (A) THE BOUNDARIES OF THE MUNICIPALITY OF THESSALONIKI WITH A BLACK LINE SHOWN IN A GEO-REFERENCED MAP, (B) THE POLYGONS OF THE DIFFERENT FLOOR AREA RATIOS IN THE MUNICIPALITY OF THESSALONIKI, (C) A SNAPSHOT OF ALL DIGITIZED URBAN PUBLIC ENTERTAINMENT SPACES IN THE STUDY AREA, (D) BUFFER ZONES OF AN URBAN PUBLIC ENTERTAINMENT AREA IN THE STUDY AREA (SOURCE: OWN ELABORATION).

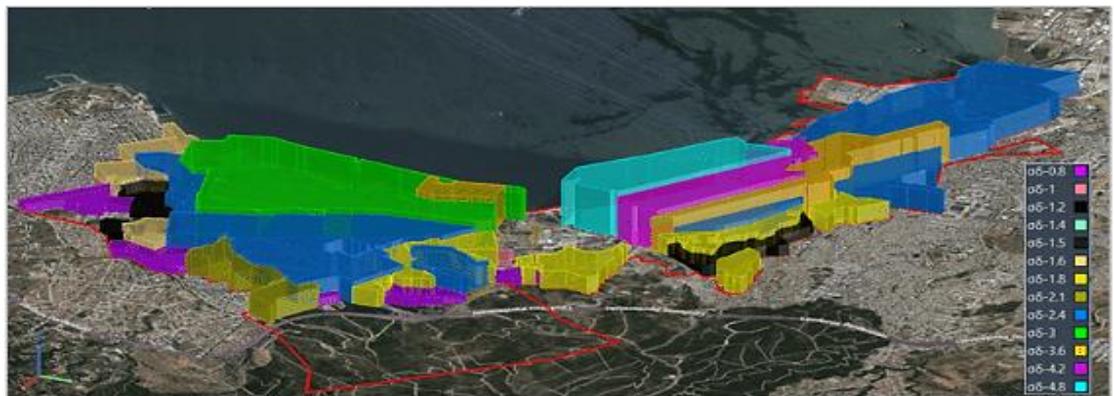
Within this context, the proposed methodological framework consists of eight algorithmic steps, which are briefly described as follows:

**Algorithmic steps of the proposed methodological framework**

- Step#1:** Computation of the building volumes = FAR · housing coverage,
- Step#2:** Estimation of the population densities = population mass / building volume,
- Step#3:** Computation of the available urban parks' areas,
- Step#4:** Estimation of the urban parks' population capacity,
- Step#5:** Estimation of buffer zones of the urban parks' geographical coverage,
- Step#6:** Mapping of the urban parks' geographical coverage zones,
- Step#7:** Evaluation, statistical, and empirical analysis,
- Step#8:** Conclusion making.

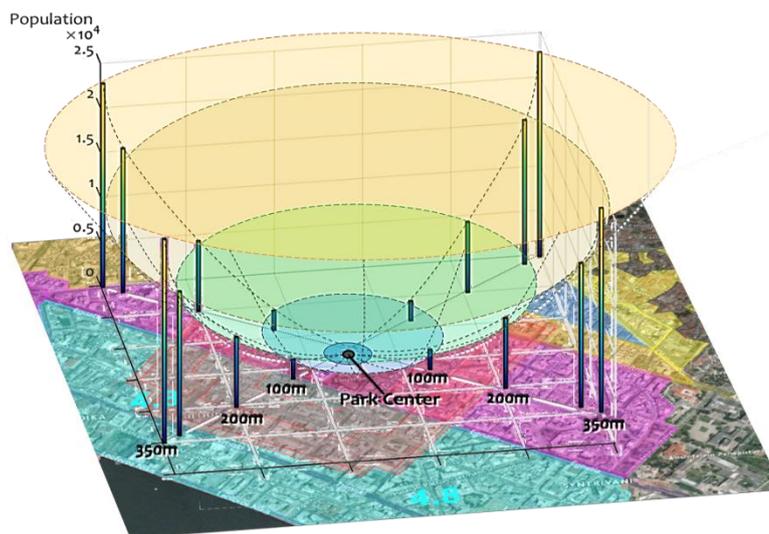
In particular, in the *first step* (step#1), we compute the building volumes of the city of Thessaloniki (excluding streets and vacant and similar surfaces), defined by the products of FAR and the housing coverage per city zone (Figure 2b, Figure3). Data of floor area ratios and building coverage were extracted from an open data portal of the Greek Government (geodata.gov.gr, 2021) and an open data portal of the

municipality of Thessaloniki (MOT, 2021). In the *second step* (step#2), we compute the population densities, distributed throughout the building volumes (population/m<sup>3</sup>) of the city instead of the housing coverage (population/m<sup>2</sup>). For these estimations, we assume homogeneity in the population distribution within the building volumes, thus defining the population density as a function of the building volumes. Population data of the municipality of Thessaloniki were extracted from the national census of 2011 (ELSTAT, 2011). In the *third step* (step#3), we compute the areas (m<sup>2</sup>) of the 88 available urban parks and public spaces in the municipality of Thessaloniki, using cad methods.



**FIGURE 3** - THE BUILDING VOLUMES OF THE CITY OF THESSALONIKI, COMPUTED BY THE PRODUCTS OF FAR AND THE HOUSING COVERAGE (SOURCE: OWN ELABORATION).

In the *fourth step* (step#4), we estimate the parks' population capacity, by assigning (distributing) the neighborhood population to each park's area. To do so, we consider two scenarios: (i) a total density one, where we assume that a park can serve one person per square meter (1 person/m<sup>2</sup>). According to this scenario, the nominal area of a park numerically converts to the number of citizens that it can serve (area  $\equiv$  citizens). For the sake of standardization, we name this scenario as the total park capacity; (ii) the second scenario regards the case of COVID-19, where, according to the restrictions of social distancing, people should be at least distant 1.5-2m. The highest space-consuming interpretation of this restriction translates into assigning one person per four-square meter (4m<sup>2</sup>) park surface (1 person/4m<sup>2</sup> = 0.25 people/m<sup>2</sup>). In the *fifth step* (step#5), we estimate the buffer zones of the urban parks' geographical coverage (Figure 2d, Figure 4), by offsetting a park's perimeter up to a radius encompassing population mass equal to the park's population capacity (as defined in step#4). In the *sixth step* (step#6), we make the necessary adjustments to map the urban parks' geographical coverage in the city map (namely into the discrete space of the city's building blocks). To do so, we construct the geographical coverage zone of each park, by counting the building blocks included in the buffer zones that were previously created. Here, building blocks that were intersected by the buffer zones were also included in the zones of geographical coverage, thus accepting cases where building blocks are included in the geographical coverage of different parks.



**FIGURE 4** - EXAMPLE OF A PSEUDO-3D ILLUSTRATION OF POPULATION COVERAGE ZONES FROM A PARK (CONSIDERED AS CIRCULAR) AS A FUNCTION OF GEOGRAPHICAL DISTANCE (SOURCE: OWN ELABORATION).

After defining the zones of geographical coverage for each park in Thessaloniki, we evaluate the geographical coverage compared to the city's map and we apply statistical and empirical analysis to detect patterns of population density per geographical coverage, along with differences between the COVID-19 requirements for urban public space and their total capacity. Provided that a coastal foreland or coastal front of a city is vital for public space needs (Marshall, 2004; Lee, et al., 2008), as it provides a natural public space offering opportunities for various recreational (such as walking, jogging, cycling, etc.) and cultural activities (also serving as gathering places for social events and festivals), we also selectively include the coastal front of the Thessaloniki in our analysis, to evaluate its importance in the service of public spaces in the city. Finally, in the *eighth step* (step#8), we discuss the results in the context of urban and sustainable planning, towards promoting a comprehensive understanding of the strengths and weaknesses of an urban public spaces network, unlocking the full potential of public spaces, transforming cities into engaging and livable environments fostering a sense of community, enhancing the quality of life, and promoting sustainable development.

#### 4. RESULTS AND DISCUSSIONS

The application of the proposed methodology to the municipality of Thessaloniki provides insights into the adequacy of the city's urban public entertainment spaces and sheds light on the distribution and accessibility across different neighborhoods within the municipality, under the diverse social conditions taken into account. The evaluation of the population serviceability of public entertainment spaces reveals significant variations. In terms of numbers, by excluding the coastal front, urban entertainment spaces merely possess 1% of the urban area, highlighting that the existing urban entertainment spaces in the municipality of Thessaloniki are very limited compared to the total area. It also highlights the major

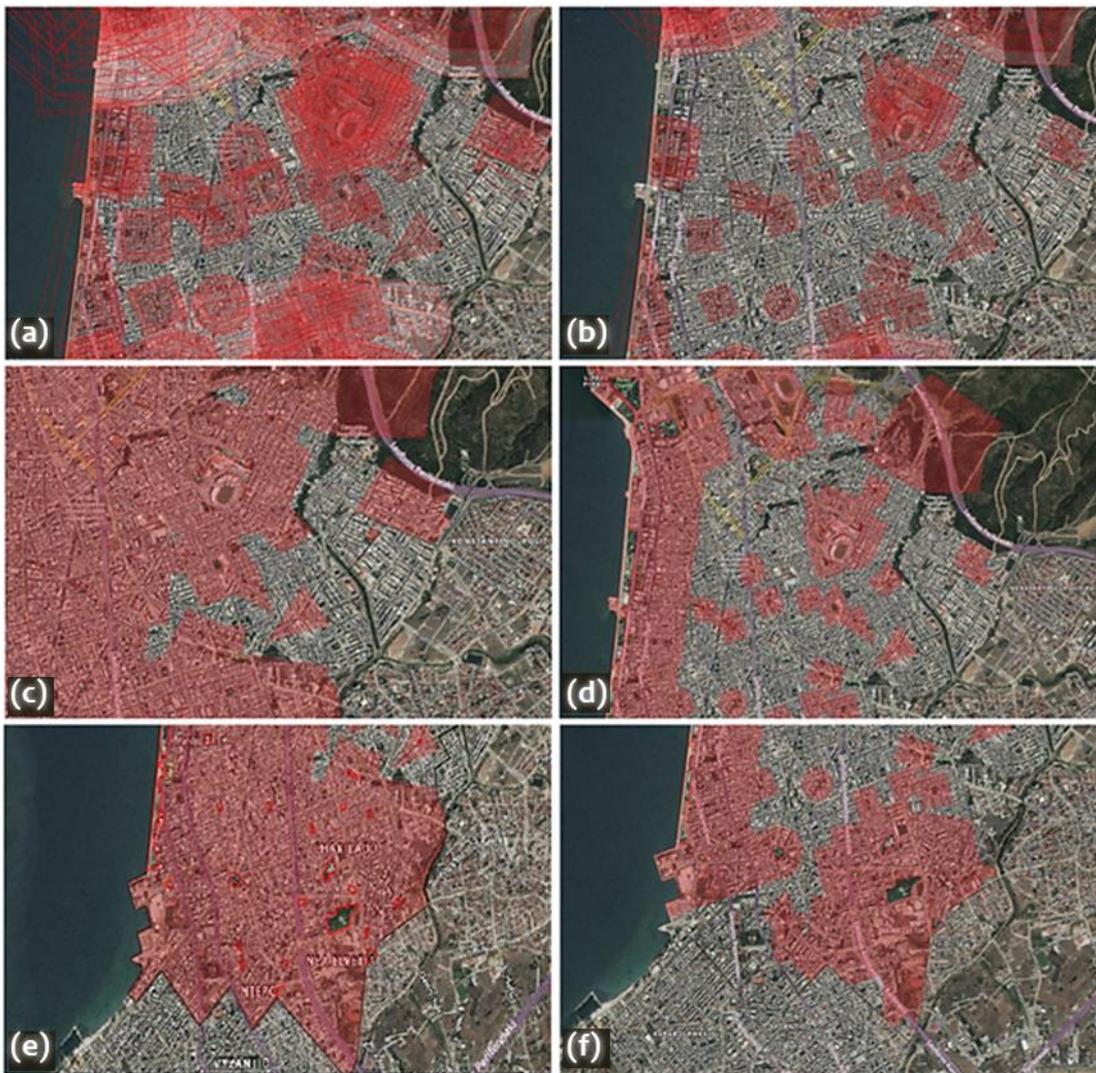
importance of effective urban planning of these, few, green and public spaces in the city. The maps of Figure 5 depict the service gaps emerging for the nominal case of the total capacity due to the COVID-19 requirements, including the major public space of the city's coastal front. As it can be observed, in the nominal case of the total capacity (Figure 5a), the zones of geographical coverage of the 88 available parks merge into a continuous area covering the total city's layout. However, for the COVID-19 case (Figure 5b), the analysis highlights considerable gaps within the urban fabric (that cover over about 50% of the total city's area), indicating a need for additional or improved entertainment spaces when emergency conditions as a pandemic apply. A comparison between the nominal capacity and COVID-19 cases interprets that the coastal front serves as a pivotal and highly influential space for the need for public space in the municipality of Thessaloniki, given its central location and extensive size. The coastal front area plays a significant role in providing urban public entertainment spaces and adequately serving a disproportionately large number of people. Further, by taking into account that the space per citizen requirements between the nominal capacity and the COVID-19 cases are described by the odds 1:4 (due to definition, see section 2), we can interpret that the analogy of these gaps in the total area does not follow a linear (proportional) rule. This deviation of linearity highlights the need to further evaluate the adequacy of public spaces in the city, using quantitative analysis.



**FIGURE 5 -** GEOGRAPHICAL COVERAGE ZONES OF THE MUNICIPALITY OF THESSALONIKI: (A) FOR THE NOMINAL CASE OF TOTAL CAPACITY; AND (B) FOR THE COVID-19 CASE (INCLUDING THE COASTAL FRONT).

Moreover, the maps of Figure 6 illustrate the service zones emerging for the nominal case of the total capacity and due to the COVID-19 requirements, excluding this time the major public space of the city's coastal front. On the one hand, this figure identifies areas with gaps (similar to the previous discussion) in the population service of urban parks and public spaces in Thessaloniki, which particularly regard the center and east regions of the city. This observation interprets that several areas exhibit a deficit in the number and size of available entertainment spaces, leading to limited accessibility and lower population serviceability. This scarcity becomes more evident by considering the spatial restrictions imposed by the COVID-19 pandemic (in the second column of Figure 6), implying that many entertainment spaces within the municipality are unable to accommodate the required physical distancing measures effectively,

leading to reduced capacity and potential overcrowding during peak periods. This outcome highlights the need for adaptive measures and guidelines to ensure the safe utilization of public spaces during pandemics or other similar situations and serve emergency conditions, enabling urban planners and policymakers to make informed decisions and address the evolving needs of the urban population. On the other hand, Figure 6 also illustrates areas in the city with overlapping service zones, which can be seen as a “waste” of public urban space in the city of Thessaloniki, whether taking into account that at the same time non-serviceable zones (denoted by the gaps) exist in the city.



**FIGURE 6 -** GEOGRAPHICAL COVERAGE ZONES OF THE MUNICIPALITY OF THESSALONIKI FOR THE NOMINAL (LEFT COLUMN) AND THE COVID-19 CASES (RIGHT COLUMN) AND FOR DIFFERENT CITY REGIONS: (A,B) S<sub>8</sub>, S<sub>9</sub>, AND S<sub>10</sub>; (C,D) S<sub>5</sub>, S<sub>6</sub>, AND S<sub>7</sub>; (E,F) S<sub>10</sub>, S<sub>11</sub>, AND S<sub>12</sub>.

This observation interprets that certain neighborhoods have a higher concentration of entertainment spaces relative to the population, resulting in the redundancy of services and resources, a surplus capacity, and potential underutilization. Also, it suggests opportunities for optimization and improvement

of the urban public space in the city of Thessaloniki and a prioritization map of conspicuous gaps that in conjunction with the higher population densities highlight areas for future urban public space creation. Jointly, the maps of Figure 5 and Figure 6 can provide valuable guidance for urban planners and policymakers in enhancing the urban fabric and addressing the evolving needs of the population.

To go deeper into the analysis, we examine the adequacy of urban public spaces as a function of population distribution. To do so, we first construct the scatter plots (P,d) shown in Figure 7, expressing the correlation between population coverage (P) and distance from a park (d). The analysis reveals that the best fittings describing this relationship (for both the nominal capacity and COVID-19 cases) follow a logarithmic rule, although, for the COVID-19 case, the fitting is not of a high determination. The logarithmic pattern describing this relationship interprets that as a park's size increases the population coverage increases with diminishing returns, indicating the development of small and medium sizes (with an area less than 0.2ha and a geographical coverage of less than 250m, for the case of Thessaloniki)<sup>1</sup> public spaces in a city as a good practice for efficient urban planning and design, implying that economies of scale in urban public planning and design do not suggest an effective developmental strategy compared to a locality. Provided that a distance of 200-250m can be considered within the range of a neighborhood<sup>2</sup> (Polyzos, 2023), this finding highlights the importance of the neighborhood scale in the design and development of urban public spaces, complying with the theoretical and empirical knowledge regarding the vital role of the neighborhood (Patricios, 2002; Polyzos, 2023) as a core component of the urban structure and functionality. Within this context, the results of Figure 7 highlight the need of incorporating the concept of urban parks as a conditional variable in a city's neighborhood design. Further, by taking into account the odds of urban public space requirements between the nominal capacity and the COVID-19 cases 1:4, we can (similarly to a previous comment) observe that difference in scale between the respective logarithmic patterns  $y_1=158.81\ln(x_1)-980.87$  /  $y_2=69.95\ln(x_2)-308.48$  is about 1:(2.3-2.5), also implying that this relationship is described by a higher order of complexity.

To obtain further insights into this relationship, we construct the diagram with the error bars shown in Figure 8, which examine the relationship between the population coverage of a park and the diversification (as conceived by the average number of different FAR zones crossed by a park's geographical coverage) of the urban built environment, both for the nominal capacity and the COVID-19 case. As it can be observed, this relationship also adheres to a logarithmic pattern, expressing that as a park's population coverage increases, the urban built environment becomes more perplexed in a city. We can further

<sup>1</sup> Whether measuring the logarithmic slopes for the curve of the nominal capacity, we can observe that over 1800 population capacity (which corresponds to 1800m<sup>2</sup> park area and 210m distance from a park of the geographical coverage) the diminishing returns become less than 5%.

<sup>2</sup> Within the context of Perry's and Stein's models of urban neighborhoods (Polyzos, 2023), the time distance of a neighborhood radius is 10min walking (· ~4km/h average walking speed = 650m).

observe that the confidence intervals of the error bars expand with a higher number of floor area ratios, while below a level of 2000 population capacity are considerably narrower than the succeeding ones. This observation complies with a previous finding about the neighborhood's importance in the design and development of urban public spaces, interpreting this time that the planning and management of urban public spaces at the neighborhood scale may provide an engine contributing to urban consolidation and consistency.

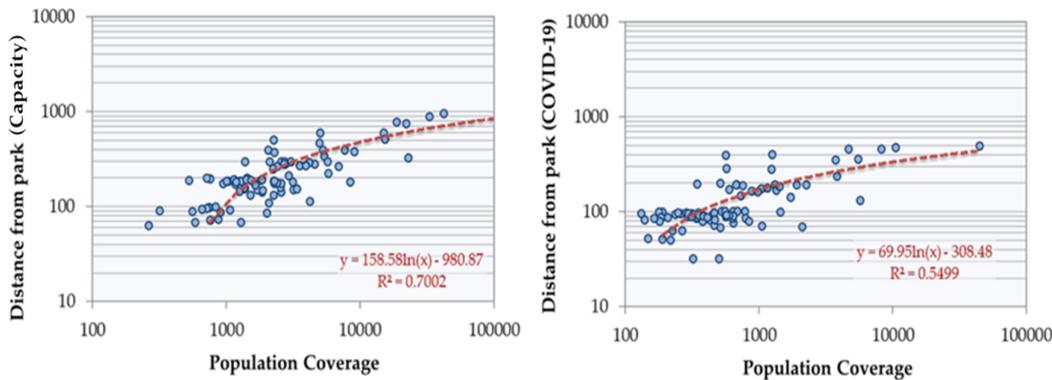


FIGURE 7 - SCATTER PLOTS SHOWING THE CORRELATION BETWEEN THE DISTANCE FROM THE PARK AND POPULATION COVERAGE (LINEARLY RELATED TO THE PARK'S AREA), FOR THE NOMINAL CAPACITY (LEFT) AND COVID-19 (RIGHT) CASES, IN THE CITY OF THESSALONIKI. LOGARITHMIC AXES AND FITS ARE SHOWN.

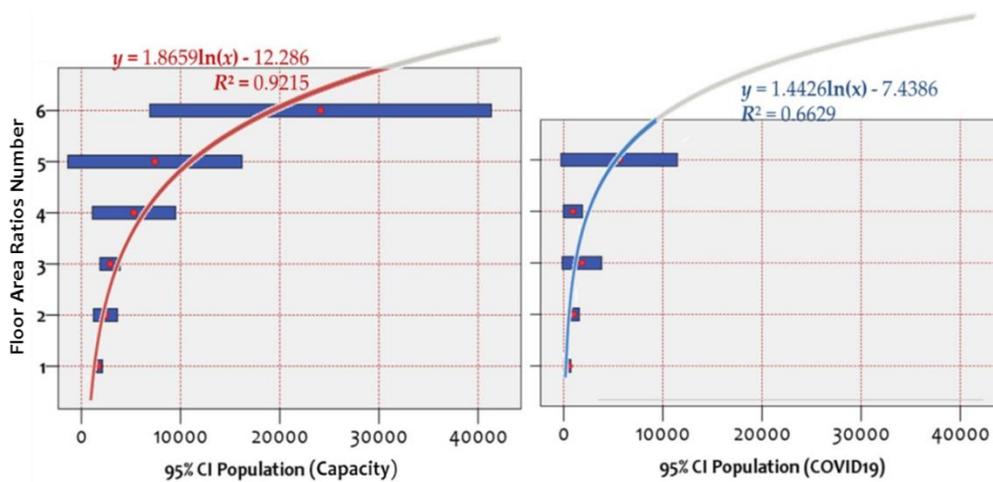
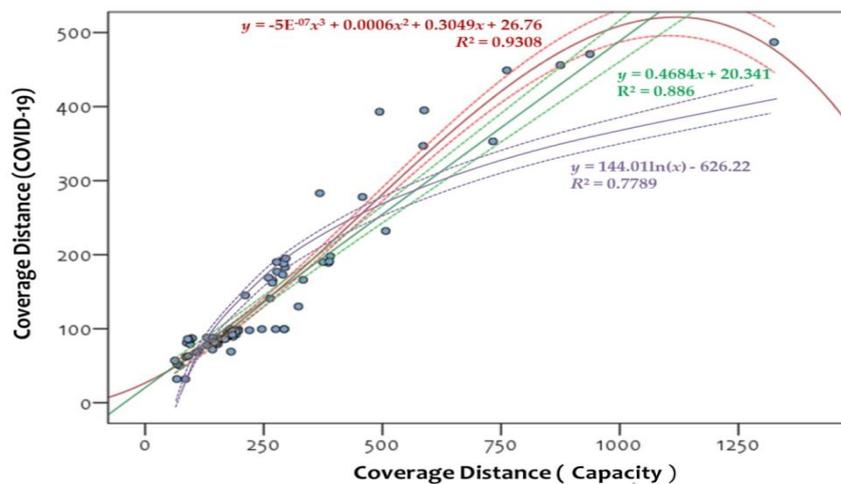


FIGURE 8 - ERROR BARS OF 95% CONFIDENCE INTERVALS FOR THE MEAN POPULATION PER NUMBER OF FLOOR AREA RATIOS THAT INCLUDED PER PARK COVERAGE IN THESSALONIKI, FOR THE NOMINAL CAPACITY (LEFT) AND THE COVID-19 (RIGHT) CASES (THE COASTAL FRONT PUBLIC SPACE IS INCLUDED IN THE ERROR BAR COMPUTATIONS).

Finally, to further examine the transformation of the coverage distance due to the emergence of the COVID-19 pandemic in the city of Thessaloniki, we construct the scatter plot shown in Figure 9, illustrating the correlation between the coverage distances of these two examined cases. The analysis shows that the best-fitting curve describing this relationship is a cubic one, with a negative higher-order coefficient and a bell-shaped pattern across the available empirical data. Without focusing on the numerical values of the thresholds (which are empirically defined in this scatter plot), this curve illustrates that the

relationship between a park's nominal capacity and COVID-19 coverage distances is described by a pattern composed of three stages: (i) a stage of an almost linear increase (describing the first third of the nominal distance's range); (ii) a stage of diminishing returns (describing the second third of the nominal distance's range); and (iii) a final stage of decline (describing the final third of the nominal distance's range). As in previous findings, this curve also highlights the importance of the neighborhood scale in the effectiveness of urban public space planning, as at higher nominal distances the serviceability of the emergency conditions (such as in COVID-19, where there is a greater demand for urban public entertainment spaces) is disproportional, showing diminishing returns to scale. This outcome indicates that there is a saturation point where the creation of larger public entertainment spaces may not yield desired results for the COVID-19 condition, suggesting the importance of considering optimal sizes for such spaces.



**FIGURE 9** - SCATTER PLOT SHOWING THE CORRELATION BETWEEN THE COVERAGE DISTANCES FOR THE NOMINAL CAPACITY (X-AXIS) AND COVID-19 (Y-AXIS) CASES IN THE CITY OF THESSALONIKI. LINEAR (GREEN), CUBIC (RED), AND LOGARITHMIC (PURPLE) FITS ARE SHOWN.

## 5. CONCLUSIONS

Recognizing their importance in fostering social interactions and enhancing the quality of urban life, this paper examined the adequacy of the urban public entertainment space network in the municipality of Thessaloniki, by assessing the accessibility of citizens to 88 outdoor urban recreational areas, paying specific attention to two scenarios: the nominal (full) capacity of the parks and the adjusted requirements due to the COVID-19 pandemic. To evaluate the challenges posed by the COVID-19 pandemic on the nominal conditions of the public urban space's design, the research built on a novel method of evaluating the population serviceability of public spaces, based on the creation of accessibility zones generated by population density estimations, floor area ratios, housing coverage, and the parks' geometric features. By identifying gaps and overlaps in the population service provided by these spaces, the proposed methodology may offer valuable insights for urban planners and policymakers to enhance the distribution

and accessibility of public entertainment spaces. In particular, the analysis highlighted first that the urban entertainment spaces are limited compared to the total urban area and that the coastal front area plays a significant role in providing urban public entertainment spaces. By excluding the serviceability of the coastal front, the analysis revealed some urban areas with gaps in the population service, indicating a need for additional or improved entertainment spaces. The scarcity became more evident by considering the spatial restrictions imposed by the COVID-19 pandemic, highlighting the need for adaptive measures and guidelines in urban planning to ensure the safe utilization of public spaces during pandemics or other similar situations. Moreover, the proposed approach detected areas with overlapping services, expressing a redundancy of services and resources, a surplus capacity, and potential underutilization and suggesting opportunities for optimizing the distribution and utilization of existing spaces. Empirical analysis of the available park data provided insights into the development of small and medium-sized public spaces in a city as a good practice for efficient urban planning and design. The analysis revealed that the neighborhood scale can contribute to both more efficient access and consolidated and consistent serviceability of urban public spaces in the city of Thessaloniki. Overall, the findings underscored the potential of the proposed spatial model in providing a comprehensive evaluation tool for incorporating the challenges posed by the COVID-19 pandemic and other emergency conditions to the nominal capacity of public entertainment spaces, providing a valuable tool for policymakers and planners to enhance the distribution and accessibility of public entertainment spaces, ultimately improving the urban environment and quality of life for residents.

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