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3-30-300 RULE: ADAPTATION TO A PERUVIAN COASTAL DESERT CITY

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Resumo

Regra 3-30-300: Adaptação a uma cidade do deserto costeiro peruano. Avaliar a distribuição das áreas verdes e árvores urbanas é um desafio principalmente nas cidades da América Latina, seja por falta de pessoal técnico ou de recursos econômicos. A “Regra 3-30-300”, é uma abordagem concebida no contexto europeu para avaliar rapidamente a oferta de vegetação urbana. Se consideram o número mínimo de árvores visíveis a partir das residências (3), a porcentagem de cobertura arbórea total (30) e a distância de acessibilidade às áreas verdes (300). O objetivo do presente estudo foi adaptar a Regra 3-30-300 a uma cidade do deserto costeiro peruano para verificar como poderia contribuir para o monitoramento ágil, contínuo e de baixo custo da vegetação urbana. A metodologia foi testada no distrito de Barranco – Lima e envolveu a revisão de cada um dos três indicadores da regra com base nas características físicas do tecido urbano e no contexto climático. Foi proposto um sistema de pontuação para identificar quantitativamente áreas com maior déficit de verde urbano. Os resultados sugerem que a “Regra 3-30-300” poderia ser uma ferramenta útil para a gestão da arborização e das áreas verdes do distrito de Barranco devido à sua flexibilidade para se adaptar a um contexto físico e climático diferente daquele europeu e aos seus baixos requisitos técnicos e financeiros para o ser operado. Por outro lado, o principal desafio continua sendo a disponibilidade de dados de qualidade que permitam a replicação do procedimento ao longo do tempo.

Palavras-chave: Cidades sustentáveis, árvores urbanas, cidades verdes, justiça ambiental, indicadores ambientais.

Abstract

Assessing the distribution of green spaces and urban trees is a challenge mainly in Latin American cities, either due to a lack of technical staff or economic resources. The “3-30-300 Rule” is an approach designed within the European context to quickly assess the supply of urban greenery. It considers the minimum number of trees visible from homes (3), the percentage of canopy cover (30), and the distance to people to access green spaces (300). This study aimed to adapt this Rule to a city in the Peruvian coastal desert, contributing to the agile, continuous, and low-cost monitoring of urban greenery. The methodology was tested in the district of Barranco - Lima and involved adapting each of the three indicators of the rule based on the physical characteristics of the urban fabric and the climatic context. A scoring system was proposed to quantitatively identify the areas with the highest urban green deficit. The results suggest that the “3-30-300 Rule” could be adapted to the Barranco district due to its flexibility to adjust to different spatial and climatic contexts and its low technical and financial requirements for its calculation. However, the main challenge remains the availability of quality data to enable the procedure to be replicated over time.

Keywords: Sustainable cities, urban tree, green cities, environmental justice, environmental indicators.

INTRODUCTION

The process of urbanization has been exerting pressure on the green spaces within cities, leading to a decrease in the provision of ecosystem services. It is projected that by 2050, 68% of the global population will reside in urban areas. This could escalate the competition for the remaining open spaces in cities, further jeopardizing the existence and equitable distribution of urban green spaces. Urban planning will play a crucial role in mitigating this issue, ensuring sustainable development through strategies and actions that enhance the quality of life for all residents, as well as facilitating the adaptation of cities to climate change (FALLMANN; EMEIS, 2020). However, urban plans typically overlook the ecological and environmental significance of green spaces, as well as their importance as part of the infrastructure and public facilities that contribute to societal well-being (WANG, 2009).

Trees, another vital component of urban areas, perform ecological functions that generate various services and benefits for both humans and terrestrial and aquatic ecosystems. However, effective public policies that maximize these benefits are often lacking (GALENIEKS, 2017). The presence of green spaces and urban trees, both in terms of quantity and quality, is usually directly associated with neighborhoods of higher economic income (HEO; BELL, 2022), thereby exacerbating social exclusion and environmental injustice.

Peru is not immune to this issue. In 2017, it was reported that 79.2% of Peru's population lived in urban areas. Lima, the capital city, is a metropolitan region that houses approximately 10 million inhabitants, which is one-third of the country's population. Located in a coastal desert area of the Pacific Ocean, Lima is comprised of 43 autonomous districts. Fragmented municipal management in these districts exacerbates problems such as unequal access to water and public green spaces (MAIZTEGUI, 2021). The absence of an integrated approach, coupled with significant migratory flows, has led to disorganized and expansive growth, often encroaching upon natural areas, agricultural valleys, and regions prone to natural disasters. Despite the city having 29.7 km^2 of green spaces under municipal management, this does not guarantee the presence of trees. There is evidence of inequality in the provision of green spaces among the districts, with the indicator being m² of green spaces per inhabitant (m^2inhab^{-1}) (SINIA, 2022).

While there is agreement among Lima's municipalities around the world health organization's (WHO) proposed parameter of 9 m² of green spaces per inhabitant as a minimum requirement to ensure good health conditions for the urban population, there is no standardized methodology for calculating this indicator (SINIA, 2022). Moreover, the indicator (m^2inhab^{-1}) does not provide sufficient information about the accessibility, distribution, and structure of green spaces. As a result, it is impossible to determine the equity of their availability in the urban context (REYES-PAECKE; FIGUEROA, 2010), and consequently, the equity of the provision of ecosystem services and benefits to the city's inhabitants. These variables are crucial for providing universal access to safe and inclusive green and public spaces, thereby achieving objective 11.7 - sustainable cities, of the united nations' sustainable development goals (SDGs).

The Metropolitan Municipality of Lima mandates district municipalities to conduct an inventory of green spaces and urban trees. However, this information is often missing, inconsistent, incorrect, or lacks further analysis. This situation contributes to the disparity in information on natural infrastructure between cities and is limited within both the metropolis and the country (ZUCCHETTI; FREUNDT, 2019). This makes the management of green spaces and urban trees at the district level challenging, compounded by limited technical and financial capacity.

In the international context, even in cities with better socioeconomic indices than Lima, there is still inequity in the accessibility of trees and green spaces. In response, Konijnendijk (2022) proposed Rule 3-30-300 as a practical guideline for developing environmentally equitable and resilient cities. The rule is based on environmental indicators of having at least three well-established trees visible from every home (3), guaranteeing a tree canopy cover (30%) and the accessibility to green spaces (300 m). Current research stems from urban contexts located in European cities, and there is no methodology for a coastal city with a desert climate that presents a heterogeneous urban fabric like Lima.

The rule highlights the need for a quality database that is periodically updated to provide a better description of the current state of urban greenery. Of the 43 autonomous districts that constitute the metropolitan region of Lima, the Barranco district was one of the few that presented updated and high-quality inventories of green spaces and urban trees. This research is based on the hypothesis that Rule 3-30-300 can be adapted to a different urban and climatic context in European cities and can also provide relevant data for the management of urban greenery. The objective is to verify the adaptation of the rule to the context of a city in the coastal desert of Peru, which can contribute to the development of agile, continuous, and low-cost monitoring tools to be used by local municipalities.

MATERIAL AND MEHODS

Study site

The study was carried out in the public spaces of the Barranco, one of the most traditional districts in the metropolis of Lima. Situated on the cliffs of the Pacific coast of Peru, at an altitude of 58 m.a.s.l., the district spans an area of 3.33 km² and is home to approximately 34,378 residents spread across 22 zones (Figure 1) (MUNICIPALIDAD DE BARRANCO; ORGANIZACIÓN PANAMERICANA DE LA SALUD, 2002).

The district is located in a natural coastal desert ecosystem with climatic characteristics of high relative humidity due to cold sea currents (exceeding 80%), and minimal precipitation, which typically totals about 8 mm per year in the form of drizzles. Temperatures remain relatively stable throughout the year, with maximums ranging from 18°C in August to 26.7°C in February, and minimums between 13.5°C in August and 19°C in February (SENAMHI, 2021).

Figure 1. Geographic orientation: a) Map depicting Peru's departments, b) Map illustrating Lima's provinces, c) Map showcasing Lima's districts, d) Map of Barranco district with the delineation of its 22 zones.

Figura 1. Orientação geográfica: a) Mapa representando os departamentos do Peru, b) Mapa ilustrando as províncias de Lima, c) Mapa mostrando os distritos de Lima, d) Mapa do distrito de Barranco com a delimitação de suas 22 zonas.

Research design

The methodological procedure of this study is divided into three parts. The first part involves the collection of digitized information provided by the municipality, which includes: The Inventory of public green spaces, the map of public green spaces, the Inventory of public urban trees, the digital cadastre of the district, and the map of the population census by city blocks from 2017.

The Tree Inventory contains information such as species identification, location (UTM coordinates), and dasometric variables (Diameter at breast height- DBH, Tree height, Log height, and Crown radius). The green spaces inventory includes the name of the green space, location (UTM coordinates), and size. The digital cadastre of the Barranco district provides information on the perimeter of all the plots that constitute it, including the facade of each one. The population census map contains the number of people per block.

Subsequently, the set of environmental indicators that make up Rule 3-30-300 was calculated using microsoft excel (version 2306) and ArcGIS (version 10.5.1). Finally, the interpretation and analysis of the indicators allowed for the diagnosis of the current distribution of urban trees and green spaces. After the results were homogenized, the areas with the best supply and demand for public green spaces and urban trees were identified.

Tree from every home (3 units)

According to Konijnendijk (2022), this indicator only considers well-established trees, defined by the author as those with a canopy area of at least 25 m². For this study, a panel of local experts and the "Manual de Silvicultura Urbana y Periurbana de la Municipalidad de Lima" were consulted to establish the criteria for "well-established trees" within the context of a coastal desert city. As a result, a well-established tree was defined as an individual exceeding 2.5 m in height and having a DBH greater than 5 cm. This represents the initial adaptation of the criterion.

Konijnendijk (2022) also proposes using buffers, (areas of influence), starting from the centroid of each plot (home) with radii ranging from 25 to 30 m. However, given the non-uniform urban fabric of Barranco, the recommended radius sizes were not universally applicable. In some cases, the buffers included trees located behind homes that were not visually accessible. After experimenting with various buffer dimensions, a 15-m radius was determined to be the most suitable (the second adaptation of the Rule). It is worth noting that Nieuwenhuijsen *et al.* (2022) found also a 15 m distance feasible for calculating this indicator in Barcelona. A third adaptation was introduced to refine the precision of terrain dimensions, specifically defining the center of each buffer as the facade of each home.

The indicator calculation was carried out using the Generate Near Table software tool within ArcGIS (version 10.5.1). This tool generated a table indicating the number of public trees visible from the facade of each home throughout the entire district. This data was exported to a spreadsheet and organized into a dynamic table based on four categories representing the number of observable trees (0, 1, 2, and 3 trees). Finally, this table was correlated with the using of the unique code assigned to each home, resulting in the facade map displaying the number of trees visible from each home.

Canopy cover (30 per cent)

This indicator is being adopted by numerous countries as a strategy to effectively increase canopy cover. Methodologies for analyzing this indicator through remote sensing (for instance, for calculating the NDVI index) are commonly applied, where the accuracy of the data is tied to the resolution of the images used (KLOBUCAR *et al*., 2021). However, analysis and calculation using this method may require greater technical and financial capacity. For this study, the calculation and classification of relative canopy cover, as proposed by Kenney *et al.* (2011), was chosen. The method suggests working with the value of canopy cover relative to the potential canopy cover of the evaluation area, defining potential canopy cover as the space where canopy cover exists and could exist. The indicator was calculated using the following formula:

$$Relative\ canopy\ cover = \frac{Canopy\ cover}{Potencial\ canopy\ cover} \times 100\%$$

This decision is made with the understanding that when considering only the value of canopy cover, there may be instances where two areas have the same value, but one area may have a higher potential canopy cover, while the other may have reached its maximum value due to the available space. Additionally, the relative canopy cover indicator was chosen because Barranco, like various district municipalities of the metropolis, only has jurisdiction over public spaces, which are considered the potential canopy cover.

The calculation of canopy cover was performed using ArcGIS software (version 10.5.1). Initially, each tree’s location was georeferenced, and the crown radius of each individual was projected using the buffer tool. Subsequently, the crowns of intersecting trees were merged, and the resulting area was calculated. The map of canopy cover was then intersected with the map of zones of the Barranco district, yielding specific values of the existing tree canopy cover in each of the 22 zones. The calculation of the potential canopy cover was made by dividing the difference between the map of the blocks of the district and the map of the evaluation area. The map of potential canopy cover of the district was then intersected with the Map of zones, thus obtaining the value of the potential canopy cover by zone. Finally, the value of the relative canopy cover per zone was calculated.

Accessibility to green spaces (300 meters)

Konijnendijk (2022), drawing on WHO recommendations, asserts that all city residents, irrespective of their socioeconomic status, should have access to a green space of at least 0.5 to 1 ha within no more than 300 m from their homes (WHO, 2016). The Barranco district, historically lacking an urban planning proposal, is characterized by a large number of small green spaces (less than 0.5 or 1 ha). Many of these are a result of urban fabric fragmentation due to the construction of public roads for motorized vehicle transit. Consequently, accessibility to green spaces was evaluated according to Nucci (2008) and WHO (2016), where green spaces are categorized into different size ranges and influence radii. The influence radius is 100 m for green spaces from 150 to 449 m²; 200 m for green spaces from 450 to 4999 m²; and 300 m for green spaces greater than 0.5 ha and less than or equal to 5 ha. Using this information, the area of influence (buffer) of each green space was defined, and then the intersection of all buffer areas was segmented to determine the number of green spaces accessible from each segment. This was then intersected with the population census map, which had previously calculated the population density per block, thereby determining the number of people who have access to a certain amount of green space throughout the district.

Homogenization of the 3-30-300 indicators

To quantitative identification, each indicator was homogenized as they have different units (Indicator 3: Number of homes; Indicator 30: Percentage of canopy cover; and Indicator 300: Number of persons). Various calculations were made to express the results of each indicator of the rule as a percentage, which were then considered in a final score that allowed for the ranking of zones according to their demand.

The tree-from-every-home indicator is a function of the number of homes that can observe a certain number of trees (0, 1, 2, and 3 trees). It was grouped into four categories: C0 (homes that do not see any trees), C1 (homes that see 1 tree), C2 (homes that see 2 trees), and C3 (homes that see 3 trees). The number of homes in each category was calculated, and the results were converted into percentages relative to the total number of homes per zone. A weighting was then performed, multiplying the values "4," "3," "2," and "1" to categories C0, C1, C2, and C3, respectively, with the highest value given to category C0 to prioritize the zones that do not have trees in public spaces near their homes. Finally, the results of each category per zone were summed to obtain the value of the final score (THS) (Equation 1), where the zone with the highest score is the one that needs the highest number of trees in public spaces near their homes.

The tree canopy cover score (TCS) was based on the percentage of relative canopy cover existing within each zone of the district. The percentage difference of the relative canopy cover (RCC) by zones (avenues, streets, among others) was calculated, which was the value used for the final analysis (Equation 2).

The accessibility score (SGS) was calculated by determining the percentage of individuals who do not have access to any green space by zone throughout the district. This value was used for the final analysis (Equation 3).

The final analysis was conducted by summing the scores of each indicator, thereby obtaining a final score (FS) per zone (Equation 4). The areas with the highest scores were identified as having the greatest demand for green spaces and urban trees.

Where:

$K_{1\text{-}22}$: Barranco zones
THS: Tree from every home score

$$\boldsymbol{THS_K} = \boldsymbol{C0_K}\% \times \mathbf{4} + \boldsymbol{C1_K}\% \times \mathbf{3} + \boldsymbol{C2_K}\% \times \mathbf{2} + \boldsymbol{C3_K}\% \times \mathbf{1}$$

$$\boldsymbol{TCS_K} = \mathbf{1} - \boldsymbol{RCC}\%_{\boldsymbol{K}}$$

$$\boldsymbol{SGS_K} = \%\,\boldsymbol{PNSG}$$

$$\boldsymbol{FS_K} = \boldsymbol{THS_K} + \boldsymbol{TCS_K} + \mathbf{SGS}_{\boldsymbol{K}}$$

C1-4: Categories of the indicator tree from every home
RCC: Relative canopy cover
PNSG: Persons who do not have access any green space
TCS: Tree canopy cover score
SGS: Accessibility score
FS: Final score

RESULTS

At the district level, 21.5% of homes in the district lack nearby trees. Moreover, over half of the homes (51.5%) can view three trees, thus ensuring a greater number of trees near their residences. Homes in zones 8, 15, and most parts of 21 do not have any well-established trees in view (Table 1). Conversely, zones 16 and 17 have the highest tree endowment, as these zones contain large public green spaces that can accommodate a higher density of trees, allowing more homes to view more trees (Figure 2a).

The RCC of the Barranco district is only 14.7%. According to the parameters proposed by Kenney *et al*. (2011), this result falls into the low category, indicating that the potential canopy cover ranges between 0 and 25%. This result is observed in 20 zones of the district (Table 1), which is concerning as it suggests that the district is not prepared to accommodate trees with large-diameter crowns due to the limited space available. Only two zones (14 and 22) have a RCC between 25 and 50% (medium category), but these two zones have values very close to the low category (27.1% and 25.9%, respectively). Zone 8 has the lowest RCC in the district, as priority has been given to establishing sidewalks and roads. Zone 16 has the highest canopy cover throughout the district, but it still falls into the low category due to the fact that while this zone contains trees with a large canopy tree cover, it has a higher potential canopy cover (Figure 2b).

Table 1. Indicators summary: A table presenting the results of indicators 3-30-300 calculated by zone.
Tabela 1. Resumo dos indicadores: Uma tabela apresentando os resultados dos indicadores 3-30-300 calculados por zona.

Zones	**Tree from every home**				**Tree canopy cover**	**Accessibility**			**Final analysis**	
	Percentage of homes				Relative Canopy Cover	Percentage of persons			**Zones**	**Final score**
	Number of trees seen per terrain					Number of green spaces accessed				
	0	**1**	**2**	**3**		**0**	**1**	**more than 1**		
1	35.9%	16.5%	13.5%	34.1%	8.8%	68.3%	31.7%	0.0%	**8**	4.39
2	12.0%	8.6%	17.2%	62.2%	11.9%	52.2%	14.1%	33.8%	**3**	4.17
3	32.7%	17.3%	9.6%	40.4%	6.1%	80.9%	16.7%	2.3%	**1**	4.14
4	29.8%	19.0%	16.7%	34.5%	9.5%	22.9%	46.7%	30.5%	**21**	4.05
5	16.0%	12.1%	17.5%	54.4%	13.5%	11.8%	40.2%	48.0%	**15**	3.60
6	6.1%	27.3%	23.5%	43.2%	10.6%	3.7%	55.7%	40.7%	**4**	3.57
7	3.2%	9.6%	24.5%	62.8%	24.5%	42.4%	35.2%	22.3%	**20**	3.24
8	44.5%	18.2%	9.1%	28.2%	5.0%	65.1%	32.6%	2.4%	**2**	3.11
9	15.5%	28.4%	17.4%	38.7%	12.6%	0.0%	6.9%	93.1%	**9**	3.08
10	7.0%	18.3%	14.5%	60.2%	12.8%	0.0%	25.4%	74.6%	**18**	3.02
11	26.4%	8.5%	12.8%	52.3%	13.0%	5.7%	24.1%	70.2%	**19**	3.01
12	16.1%	11.5%	11.5%	60.9%	16.6%	0.0%	6.8%	93.2%	**11**	2.95
13	11.3%	16.0%	13.9%	58.8%	10.9%	10.5%	49.9%	39.6%	**22**	2.95
14	18.6%	8.8%	8.0%	64.6%	27.1%	0.0%	31.0%	69.0%	**6**	2.89
15	43.5%	13.0%	9.8%	33.7%	6.5%	0.0%	0.0%	100%	**5**	2.88
16	3.8%	7.6%	7.6%	81.0%	19.1%	0.0%	0.0%	100%	**13**	2.79
17	6.3%	6.3%	5.3%	82.1%	17.4%	0.0%	0.0%	100%	**7**	2.71
18	25.8%	11.7%	10.4%	52.1%	9.8%	0.0%	0.0%	100%	**12**	2.66
19	31.4%	8.6%	3.8%	56.2%	19.8%	0.0%	1.4%	98.6%	**10**	2.59
20	28.6%	4.8%	6.8%	59.9%	11.6%	33.5%	22.6%	43.9%	**14**	2.54
21	42.0%	14.5%	12.2%	31.3%	13.4%	51.4%	19.0%	29.6%	**17**	2.19
22	**25.6%**	14.9%	14.0%	45.5%	25.9%	0.0%	0.7%	99.3%	**16**	2.15
DISTRICT AVERAGE										
	21.5%	**13.8%**	**13.2%**	**51.5%**	**14.7%**	**21.1%**	**24.7%**	**54.2%**		

In terms of accessibility (Table 1), the findings reveal that 21.1% of the population lacks access to any green space, whereas approximately 78.9% of the district's population can reach at least one green space. However, it is important to note that this percentage alone does not guarantee sufficient canopy cover. Among the 22 zones assessed, zones 1, 2, 3, 8, 21, and 7 (Figure 2c) have the highest concentration of individuals without access to any green space. In contrast, zones 16, 17, 18, 19 and 22, exhibit nearly universal access to multiple green spaces, primarily due to their larger size, including areas like the Malecon zone, Parque Federico Villareal, Parque Municipal, Parque de los Héroes, and Parque de la Familia.

When considering the overall indicators, the collective score allows pinpoint the less privileged zones within the district. Zones 1 and 3 have few spaces tree coverage, and a significant portion of their population lacks access to green spaces. In zone 2, although a significant portion of the population does not have access to green spaces, there is a relatively higher canopy cover and more trees (Table 1).

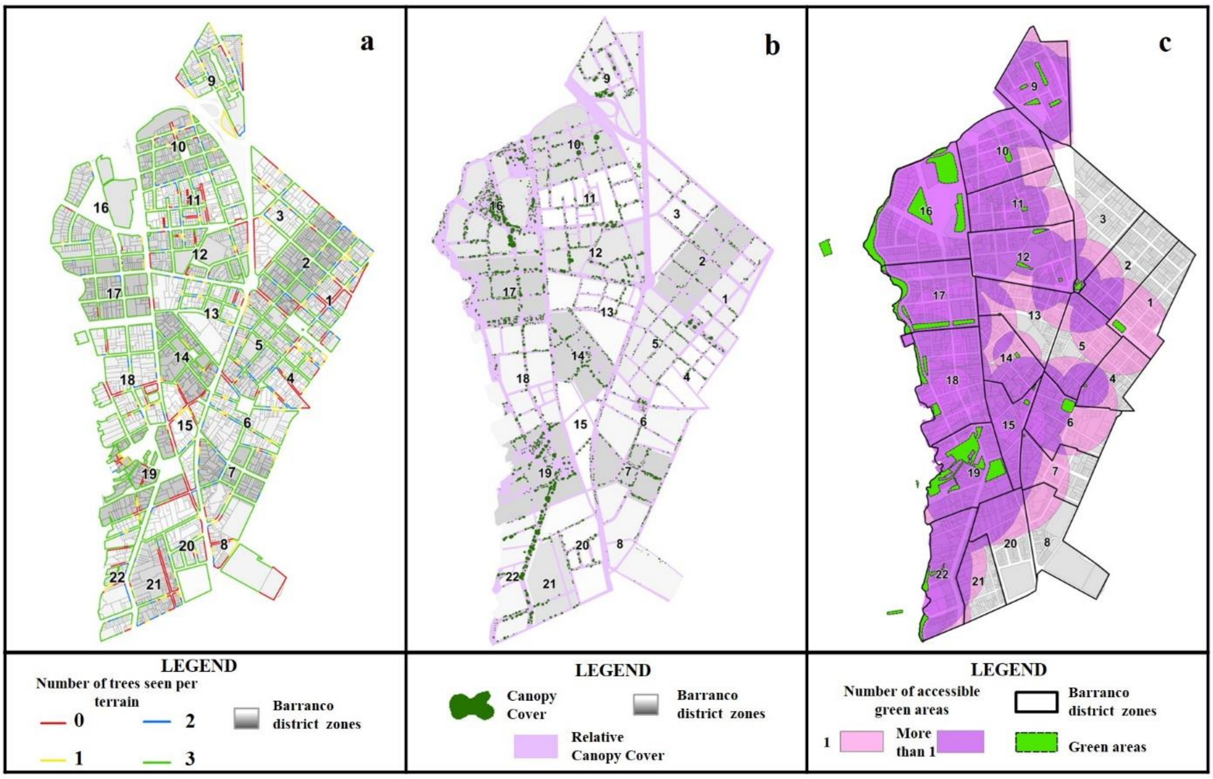

Figure 2. Demand metrics under Rule 3-30-300: a) Map displaying indicator 3: Tree demand by zone, b) Map portraying indicator 30: Tree cover demand by zone, c) Map highlighting indicator 300: Green area demand by zone.

Figura 2. Métricas de demanda de acordo com a Regra 3-30-300: a) Mapa exibindo o indicador 3: Demanda de árvores por zona, b) Mapa retratando o indicador 30: Demanda de cobertura arbórea por zona, c) Mapa destacando o indicador 300: Demanda de áreas verdes por zona.

The study identified that the most peripheral zones of the district have the greatest demand for urban trees and green spaces, while zones near the sea have the greatest supply. Upon analyzing the FS, it can be asserted that zones 8, 3, 1, and 21 have the highest demand for urban greenery. This is because most individuals in these zones do not have access to a nearby green space, the percentage of relative tree cover is low, and they have a lower tree supply. In the case of zone 15, although individuals have access to more than one green space, it does not have a sufficient number of trees in its public spaces. This is why it is among the five zones that require more green spaces, indicating a higher priority in urban tree management. Conversely, in Barranco, only two zones (16 and 17) are the best areas in terms of accessibility, tree endowment, and RCC in the entire district.

DISCUSSION

In the district of Barranco, a notable disparity exists in the distribution of trees within public spaces. In zones like 16 and 17, approximately 80% of households can enjoy the sight of three trees. In contrast, zones 21, 15, and 8 witness a situation where 40% of homes lack a view of trees from their premises. This imbalance is closely linked to the presence of exceedingly narrow streets that offer limited space for tree planting and the development of canopy cover. As highlighted by Lin *et al.* (2021), such conditions can affect tree diversity, structural variety, and the long-term survival of tree individuals, given the limited scope for replacing aging trees over time.

The shortage of trees and canopy cover in specific areas of the Barranco district can be attributed to a combination of factors. These include a lack of awareness regarding the benefits of trees, the constrained technical and financial capabilities of various municipal administrations, and an underdeveloped tree management system. Socioeconomic disparities among the population in different zones also play a role in restricting tree planting, especially in the district’s periphery. This is attributed to factors such as building density and less robust management structures, as identified by Escobedo *et al.* (2015). Additionally, as noted by Nelson *et al.* (2021), cultural aspects, implementation costs, and ongoing tree maintenance can significantly influence the distribution of trees.

When considering accessibility, it becomes evident that residents in areas farther from the coastline experience a reduced expanse of green spaces, whereas those in coastal regions enjoy greater access to green areas within the district. This situation can be traced back to Barranco's historical evolution in the late 19th and early 20th centuries when affluent families from Lima established the district as a seaside retreat, featuring large houses on medium to large plots of land. In contrast, the innermost areas of the district were occupied by fishermen and artisans, residing in modest homes with small squares connected by narrow alleys (MUNICIPALIDAD DE BARRANCO; ORGANIZACIÓN PANAMERICANA DE LA SALUD, 2002).

It can be argued that significant size green spaces provide access to a majority of the district's inhabitants, supporting the findings of Suárez *et al.* (2020), who contend that substantial green areas offer the most benefits to the largest number of individuals. Furthermore, as per Reyes-Paecke *et al.* (2010), large green spaces tend to be the preference of citizens, though specific studies to corroborate this assertion within the context of Barranco would be valuable. Supplementary studies should also assess the quality of green spaces, taking into account factors such as sanitation, infrastructure, maintenance, cleanliness, and other elements influencing the enjoyment and well-being of residents. Additionally, environmental, social, and health indicators could offer valuable insights for municipal decision-making, contributing to the establishment of more sustainable urban models in the coastal desert region.

Effective district planning, with a strong emphasis on sustainable development, will play a pivotal role in narrowing the accessibility gaps to green spaces and urban trees, ultimately leading to the gradual enhancement of the three indicators measured. Additionally, according to Rayan *et al.* (2022), green urban planning can serve as a vital strategy for bolstering resilience against the impacts of climate change. Factors such as spatial constraints (e.g., narrow streets) and the shift in paradigms related to transportation modes should be taken into account. This is crucial given that vehicular traffic infrastructure occupies significant portions of the district's public open spaces.

To address the issue of limited tree planting (rule indicator 3) in the district and to counteract the effects of climate change on urban environments, there is a pressing need to formulate urban tree planting plans. These plans should consider the selection of xerophytic species and the use of treated or gray water for irrigation to reduce competition for drinking water, a critical concern in arid urban areas. Hosek (2019) stresses the importance of integrating urban design, including the width of streets and sidewalks, into these plans. Managing the factors that influence the development of tree species, enabling them to reach maturity and maximize their benefits, is equally essential.

Arborizing the district will bring forth a range of ecosystem services, as elucidated by Tovar (2017). These services encompass climate regulation through leaf evapotranspiration creation of shaded areas on urban surfaces and walls, and the sequestration of greenhouse gases, among others. The insights from Nowak *et al.* (1997) emphasize the necessity of defining costs and maintenance while considering the needs of the local populace and the potential for their integration into the management of these urban assets.

Despite the emphasized benefits of urban trees and green spaces, it is vital to acknowledge the research conducted by Fernández-Juricic (2000), which discovered that areas with the highest biodiversity of urban vegetation host the most diverse bird species. Faunal biodiversity plays a fundamental role in enhancing and ensuring the continuity of a variety of ecosystem services, not solely confined to urban environments.

The adaptation of the 3-30-300 Rule has demonstrated its versatility and agility as a tool, with the potential for immediate application due to its low technical and financial requirements for calculating the indicators. Nevertheless, the primary challenge lies in maintaining a consistent supply of high-quality data, allowing for the procedure's replication over time, and establishing a robust monitoring system capable of guiding municipal investments and actions.

CONCLUSION

- The adaptation of the three indicators of the 3-30-300 rule enabled the characterization of the demand for urban trees and green spaces in public spaces in the Barranco district. According to the findings, 21.5% of homes do not have nearby trees, the RCC of the district is low, particularly in 20 zones, and 21.1% of the population does not have access to any green space. Consequently, in the Barranco district, there are disparities in the enjoyment and benefits derived from urban trees and green spaces.
- The proposed adaptation of the 3-30-300 Rule can be applied in urban contexts of cities located in desert climates and characterized by a socioeconomic reality different from that found in European cities.
- Due to the differences between the units of the indicators and the territorial cutout used by the databases, a scoring system was devised for the results of each indicator of the rule. This system facilitated the identification of areas with greater or lesser demand for green spaces and urban trees.

- For comprehensive management of urban greenery, the results obtained by applying the 3-30-300 rule could be complemented with specific indicators capable of providing insights related to the characteristics and quality of green spaces and urban trees.
- The verification of the three indicators serves as an initial step for future studies to add new insights on topics such as resilience to climate change and the potential improvement of urban biodiversity.

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REFERENCES

ESCOBEDO, F. J.; CLERICI, N.; STAUDHAMMER, C. L. Socio-ecological dynamics and inequality in Bogotá, Colombia' s public urban forests and their ecosystem services. **Urban Forestry & Urban Greening**, v. 14, n. 4, p. 1040–1053, 2015.

FALLMANN, J.; EMEIS, S. How to bring urban and global climate studies together with urban planning and architecture? **Developments in the Built Environment**, v. 4, n. July, p. 100023, 2020.

FERNÁNDEZ-JURICIC, E. Avifaunal Use of Wooded Streets in an Urban Landscape. **Conservation Biology**, v. 14, n. 2, p. 513–521, 24 abr. 2000.

GALENIEKS, A. Importance of urban street tree policies: A Comparison of neighbouring Southern California cities. **Urban Forestry & Urban Greening**, 2017.

HEO, S.; BELL, M. L. Investigation on urban greenspace in relation to sociodemographic factors and health inequity based on different greenspace metrics in 3 US urban communities. **Journal of Exposure Science & Environmental Epidemiology**, v. 33, n. 2, p. 218–228, 22 mar. 2023.

HOSEK, L. Tree Cover of Accra's Neighbourhoods—a Green Divide. **Urban Forum**, v. 30, n. 3, p. 341–355, 11 sep. 2019.

KENNEY, W. A.; WASSENAER, P. J. E. VAN; SATEL, A. L. Criteria and Indicators for Strategic **Urban Forest Planning and Management**. v. 37, n. 3, p. 108–117, 2011.

KLOBUCAR, B.; SANG, N.; RANDRUP, T. B. Trees, Forests and People Comparing ground and remotely sensed measurements of urban tree canopy in private residential property. **Trees, Forests and People**, v. 5, p. 100114, 2021.

KONIJNENDIJK, C. C. Evidence-based guidelines for greener, healthier, more resilient neighbourhoods: Introducing the 3–30–300 rule. **Journal of Forestry Research**, 26 ago. 2022.

LIN, J.; WANG, Q.; LI, X. Landscape and Urban Planning Socioeconomic and spatial inequalities of street tree abundance, species diversity, and size structure in New York City. **Landscape and Urban Planning**, v. 206, n. November 2020, p. 103992, 2021.

MAIZTEGUI, B. Cartografía de la desigualdad: Investigación geográfica sobre el acceso a los espacios públicos y áreas verdes de Perú. **ArchDaily Perú**, 2021.

MUNICIPALIDAD DE BARRANCO; ORGANIZACIÓN PANAMERICANA DE LA SALUD. **Plan De Desarrollo Integral De Barranco**. [s.l: s.n.].

NELSON, J. R.; GRUBESIC, T.H.; MILLER, J.A.; CHAMBERLAIN, A.W. The equity of tree distribution in the most ruthlessly hot city in the United States: Phoenix, Arizona. **Urban Forestry & Urban Greening**, v. 59, n. January, p. 127016, 2021.

NIEUWENHUIJSEN, M. J.; DADVAND, P.; MÁRQUEZ, S.; BARTOLL, X.; BARBOZA, E. P.; CIRACH, M.; BORRELL, C.; ZIJLEMA, W. L. The evaluation of the 3-30-300 green space rule and mental health. **Environmental Research**, v. 215, n. September, p. 114387, 2022.

NOWAK, D.; DWYER, J.; CHILDS, G. Los beneficios y costos del enverdecimiento urbano. En: **Áreas Verdes Urbanas en Latinoamérica y el Caribe**. [s.l: s.n.], 1997.

NUCCI, J.C. Qualidade Ambiental e Adensamento Urbano: um estudo de ecologia e planejamento da paisagem aplicado ao distrito de Santa Cecília (MSP). Curitiba: O Autor, 2 ed, 2008, 150p.

RAYAN, M.; GRUEHN, D.; KHAYYAM, U. Frameworks for Urban Green Infrastructure (UGI) Indicators: Expert and Community Outlook toward Green Climate-Resilient Cities in Pakistan. **Sustainability**, v. 14, n. 13, p. 7966, 29 jun. 2022

REYES-PAECKE, S.; FIGUEROA, I. Distribución, superficie y accesibilidad de las áreas verdes en Santiago de Chile. n. May 2014, 2010.

SERVICIO NACIONAL DE METEOROLOGÍA E HIDROLOGÍA DEL PERÚ (SENAMHI). **CLIMAS DEL PERÚ – Mapa de Clasificación Climática Nacional Ministerio del Ambiente**. [s.l: s.n.].

SISTEMA NACIONAL DE INFORMACION AMBIENTAL - SINIA. **Indicador: Superficie de área verde urbana por habitante**. Disponível em: <https://sinia.minam.gob.pe/indicador/1617> Acesso em: 08 ago 2022.

SUÁREZ, M.; BARTON, D. N.; CIMBUROVA, Z.; RUSCH, G. M.; GÓMEZ-BAGGETHUN, E.; ONAINDIA, M. Environmental justice and outdoor recreation opportunities: A spatially explicit assessment in Oslo metropolitan area, Norway. **Environmental Science and Policy**, v. 108, n. April, p. 133–143, 2020

TOVAR, G. Manejo del arbolado urbano en Bogotá. **Territorios**, v. 16–17, p. 149–174, 2017.

WANG, X.-J. Analysis of problems in urban green space system planning in China. **Journal of Forestry Research**, v. 20, n. 1, p. 79–82, 19 feb. 2009.

WORLD HEALTH ORGANIZATION. Urban Green Spaces and Health, a review of evidence. Copenhagen: WHO Regional Office for Europe, 2016.

ZUCCHETTI, A.; FREUNDT, D. **Ciudades Del Perú. Primer Reporte Nacional de Indicadores Urbanos 2018**, p. 148, 2019.