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Tesis

**Measurement and Projection of Public Green Spaces
per Inhabitant in the Central Metropolitan Area of the
City of Huancayo**

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Para optar el Título Profesional de
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Measurement and Projection of Public Green Spaces per Inhabitant in the Central Metropolitan Area of the City of Huancayo

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Abstract Public green spaces contribute to maintaining environmental, social and economic balance in urban areas. However, due to various social and urbanistic factors, the need for more green spaces in urban areas has increased. Currently, the city of Huancayo has green spaces for tourism and public recreation, but with the growth of urban and population, the existing public green spaces are insufficiently supplied. This article addresses the following problem of whether the surface of public green spaces in the Central Metropolitan Area of the City of Huancayo, is proportional to the needs of the current and future population. The objective of this research is to measure and project the amount of public green spaces per inhabitant in the Central Metropolitan Area of the City of Huancayo from 2020 to 2030. This will be achieved through the development of a database of criteria and projections on public spaces, taking as a reference the book "Lima and Public Spaces: Profiles and Integrated Statistics 2010" by Dr. Architect Wiley Ludeña Urquiza. For this, the following methods were used: a bibliographical analysis, in order to compile information from previous research on public green spaces; and a morphological analysis, in which the cadastral maps of the metropolis of Huancayo and its six districts were analyzed: San Agustín de Cajas, Pilcomayo, El Tambo, Huancayo, Chilca, and Huancán. Subsequently, to obtain the data, geographic technological tools were used to help locate public spaces and identify areas, perimeters, and others. The study shows that the

public green spaces in the Central Metropolitan Area of the City of Huancayo are insufficient and are expected to decrease further, which will have a negative impact on the current and future population. This prompts a reflection and discussion on the context of public green spaces in Huancayo in relation to the obtained results. Finally, the article concludes with recommendations that could help address the lack of public green spaces.

Keywords Public Green Space, Green Areas, Measurement, Projection, Database, Endowments, Surface Areas, Urban Diagnosis

1. Introduction

Public green spaces in urban areas serve as recreational areas, promote environmental conservation, and improve the quality of life for current and future communities [1,2]. They have become increasingly important due to pollution, urban growth, respiratory diseases (such as COVID-19), and increasing migration to urban areas [3,4]. According to the United Nations' Sustainable Development Goal 11 for 'Sustainable Cities and Communities,' the urban population is expected to increase by 60% by 2030 [4,5].

The metropolis of Huancayo is one of the most important cities in Peru, is currently undergoing urban development

and is known for its green spaces for tourism and public recreation [6]. The urban and population growth of the city has led to a shortage of green spaces, including public parks, which should be proportionate to the population's needs. Unfortunately, the lack of good municipal approaches has contributed to this issue. The World Health Organization (WHO) and the United Nations (UN) recommend 9 and 16 m² of public green spaces per inhabitant, respectively [7]. The Urban Development Plan of Huancayo from 2015 to 2025 shows a general lack of public green spaces, with only 0.92 m² per inhabitant in the Central Metropolitan Area of the City of Huancayo (CMAH), which is below the recommended indices [6].

The objective of this research is to measure and project the number of public green spaces per inhabitant in the Central Metropolitan Area of the City of Huancayo (CMAH) from 2020 to 2030, since currently there are no detailed studies that examine the relationship between the amount of public green spaces and population growth. These spaces are crucial for generating a variety of activities, including sports, recreation, culture, socializing, and economic development, all of which can improve people's health and promote environmental education [8].

The problem of this research is to determine if the surface of public green spaces in the Central Metropolitan Area of the City of Huancayo (CMAH) is proportional to the needs of the current and future population. This will be accomplished by developing a database of criteria and projections of public spaces, which will consist of obtaining the extent of public spaces according to typologies and projections, as well as the weightings and percentages of public spaces per inhabitant, surface area and typology, in order to obtain the endowment of green spaces per inhabitant of the delimited area [2,3]. Take as a reference the book "Lima and Public Spaces: Profiles and Integrated Statistics 2010" by Dr. Architect Wiley Ludeña Urquiza. This database is necessary to determine future urban projects with public green spaces, allowing sustainable interventions in the abandoned green islands (ecological protection zones) within the Central Metropolitan Area of the City of Huancayo (CMAH), measuring and projecting all public spaces related to green spaces, essential for achieving a sustainable city.

The method used in this study is based on a methodology with a quantitative approach, involving the collection and analysis of data. A bibliographic analysis is carried out to gather information from previous research on public green spaces in relation to the population of the delimited area, which is used to develop a theoretical framework on the importance of public green spaces in urban areas. The research also analyzes the main reference. Morphological analysis is carried out to detail the main aspects of location, surface and population of the Central Metropolitan Area of the City of Huancayo (CMAH), as well as the current importance of its public green spaces. Furthermore, profiles and statistics applicable to our research context are selected to create the database of public spaces in the

metropolitan city.

2. Bibliographic Analysis

2.1. Previous Studies

The analysis of the public green spaces in the Central Metropolitan Area of the City of Huancayo (CMAH) will help us to develop a database to measure and project the surface area (endowment) of public green spaces per inhabitant, taking into account various research and studies related to the subject.

Information about urban public green spaces in Peru is limited. However, objective information on public green spaces can be found in urban development plans, territorial and environmental plans, and in the National Institute of Statistics and Informatics (INEI) systematic database, which provides data on the number of public green spaces per inhabitant [9].

According to the INEI study, the city of Huancayo has 1.1 m² of public green spaces per inhabitant [10], while the Urban Development Plan of Huancayo from 2015 to 2025 diagnosis shows that it has an endowment of 0.92 m² per inhabitant [6]. The city of Huancayo does not meet the recommended indices for public green spaces set by the World Health Organization (WHO) and the United Nations (UN), which are 9 and 16 m² per inhabitant, respectively [7]. This is due to rapid urbanization and the lack of municipal planning, which has led to a reduction or destruction of green spaces [11]. The aforementioned studies present data from a general perspective without developing a database that relates and compares green spaces with other public spaces used for leisure, tourism, commerce, and other activities.

In 2020, the COVID-19 pandemic has highlighted the importance of public spaces being green, healthy, sustainable, adaptable, multifunctional, and equitable. For this reason, public green spaces have become new meeting points where socialization and appreciation of the city are encouraged [12]. Increasing the number of green areas per person can improve the quality of life for individuals [9,13].

Green areas are an essential part of public space, from a general perspective, Aristotle referred to public spaces as vital and humanizing spaces where society gathers to express opinions, discuss proposals and make decisions based on political actions [14]. This definition has evolved in relation to the needs of society, coming to understand public spaces as places of gathering, communication, relationship building and important nodes (focal points) that emerge in urban cities [15]. Understanding what constitutes a public space can be complex, but from an urban perspective the city Huancayo includes pedestrian streets, sidewalks, gardens, small squares, boardwalks, sports slabs, parks, plazas, and other areas that facilitate social interaction.

The population of Huancayo believes that public spaces

in the city are poorly planned and only serve as transportation areas, lacking the necessary elements to encourage cultural activities [16]. The analysis of public green spaces in the metropolitan area reveals that some spaces do reflect the culture of Huancayo, but others fail to do so due to inadequate planning and maintenance.

W. L. Urquizo [2] provides information on public green spaces in the Peruvian context. In his book he notes that urban green in Peru has been identified in two contexts: green as an artistic notation and green as a regenerator of the environment; where the social content of urban green is vindicated. The result is that all green in the city is a manifestation of social green, which can be understood in two dimensions: first, urban green is social green because it satisfies the objective and subjective needs of the population. Second, urban green is social green because of its existence as a fragment of the city as parks, gardens and others, where different social groups and dynamics converge meet. The existence of these spaces contributes to sustainable development, including environmental, social, and economic benefits; additionally, green spaces enhance the artistic and scenic aspects of urban cities.

Studies have shown that areas with more green spaces have improved safety, urban order, and accessibility, and promote the predominance of vegetation and nature [17]. Inactive public spaces can become unsafe and lack vitality, as they neither contribute to their surroundings nor generate socioeconomic and environmental activities, therefore, it is important to activate public spaces to promote community engagement and improve the quality of life for residents [9].

The benefits of public spaces for urban residents can be categorized into three groups [8,15]:

- Social and health benefits: Public spaces provide opportunities for recreation, exercise, and socialization, which can improve mental and physical

health, and foster social relationships through various activities.

- Environmental benefits: Green areas in public spaces help reduce environmental pollution and purify the air, contributing to the well-being of the population.
- Economic benefits: Public spaces with adequate regulations can support commercial activities and services, and serve as attractive areas for tourists. This can increase real estate value and generate employment opportunities for the maintenance of these areas, leading to better economic development.

The research is justified by the General Environmental Law - Law No. 28611, which affirms that every person has the right to live in a healthy and balanced environment for the full development of life, additionally, it is the duty of every person to contribute to effective environmental management and protect the environment [18]. The main reference for this research is the book titled “Lima and Public Spaces: Profiles and Integrated Statistics 2010” by Dr. Architect Wiley Ludeña Urquizo, which gives us a guide for developing a database, including guidelines for research and data collection.

2.1.1. Reference to the Database of Public Spaces

To generate a database on public spaces in the Central Metropolitan Area of the City of Huancayo (CMAH), we will follow the procedures outlined by Dr. Wiley Ludeña Urquizo in the book “Lima and Public Spaces: Profiles and Integrated Statistics 2010” [2].

It starts by determining the general aspects of the study area, such as: the total population, the total surface area and the total surface of the urban area. Then a database then will be developed based on the profiles and statistics presented in Table 1. It is important to note that the information in this table is a content analysis of the referent.

Table 1. Profiles and Variable Statistics of Public Spaces in the Metropolis of Lima [2]

PROFILES			STATISTICS
Typologies	Categories	Components	Variables (Indicators)
<ul style="list-style-type: none"> • Public spaces - pavement floor • Public spaces - green floor • Public spaces - liquid surface • Total public spaces (excluding natural parks and liquid surface) • Total public spaces 	<ul style="list-style-type: none"> • Line-flow space • Point-node space • Line-flow / point-node space • Point-node / line-flow space 	<ul style="list-style-type: none"> • Streets-pedestrian streets • Stairs • Sidewalks • Berms • Plazas • Small plazas • Sports slabs • Seawalls-parks • Alamedas-walks • Parks-road landscaping • Zonal parks • Residential parks • Metropolitan thematic or de Jure parks • District parks • Natural parks- Vacant urban land • Liquid surface 	<ul style="list-style-type: none"> • Surface area per component (hectares) • Surface of components (m²) by the number of inhabitants (m²/inhab.) • Percentage of component area with respect to total surface (%) • Percentage of component area with respect to the surface of “urban area” (%) • Percentage of area per component with respect to the total surface area of public spaces (%)

Finally, the data is organized into two parts. The first part determines the extensions of public spaces according to typologies and projections. The second part calculates the weightings and percentages of public spaces per inhabitant, surface area, and typology of the study area. This analysis of the data results in the endowment of green spaces per inhabitant in the studied city.

Taking into account the aforementioned characteristics, it is possible to generate and implement a database of criteria and projections for public spaces in the Central Metropolitan Area of the City of Huancayo (CMAH), with the aim of determining whether the surface area of public green spaces is proportional to the population in 2020 and projected for 2030.

3. Methods

The research methods were divided into two parts: a bibliographic analysis and a morphological analysis. The bibliographic analysis examined previous research on the surface of public green spaces per inhabitant within the study area and applied guidelines to develop a database on public spaces. Subsequently, morphological analysis is performed to specify the urban and population context of the city of Huancayo in relation to its public spaces. The main sources used for this analysis are the Urban Development Plan (PDU) of Huancayo from 2015 to 2025 and the Concerted Development Plans of each district.

The research develops a quantitative methodology by collecting numerical data on public spaces in the Central Metropolitan Area of the City of Huancayo (CMAH). The

objective is to obtain the endowment of green spaces per inhabitant by creating a database on public spaces in Huancayo. The data collected from public spaces in the research area were measured using geographic tools such as Google Earth Pro and Argis. This included the location and identification of areas, perimeters, distances, and other relevant information. The accuracy of this information was verified using the Cadastral Map of the Metropolitan Area of Huancayo [19].

The database is created using various techniques, such as measuring public spaces based on their typology and component, and directly observing green areas within these spaces. The research instruments enable the collection and processing of all the information obtained.

3.1. Morphological Analysis

3.1.1. Analysis of the Urban Context of the Research Area and its Public Spaces

This research focuses on the Central Metropolitan Area of the City of Huancayo (AMCAH), which includes six districts: San Agustín de Cajías, Pilcomayo, El Tambo, Huancayo, Chilca, and Huancán. These districts are situated in the province of Huancayo, department of Junín, Peru, and have a total area of 87.52 km², with a net urban area of 46.74 km² [6,19].

Figure 1 displays the study area's location and boundaries, while Table 2 presents the surface area of each district. The data was obtained from the Urban Development Plan (PDU) of Huancayo 2015 - 2025 [6].

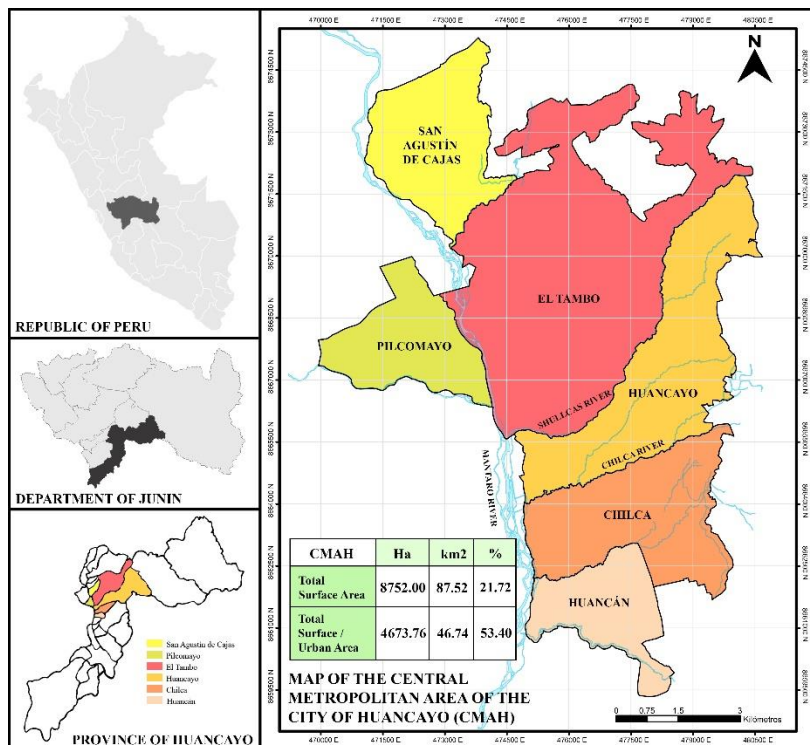


Figure 1. Map of the location and localization of the CMAH

Table 2. Total surface - Urban area of the districts of the CMAH [2]

N°	Districts	Total surface area of the District	Total surface area of the District within the CMAH	Total surface / Urban area of the Districts within the CMAH	
		km ²	km ²	Ha	km ²
1	San Agustín de Cajas	23.09	10.29	549.51	5.50
2	Pilcomayo	20.50	7.97	425.61	4.26
3	El Tambo	73.56	33.43	1785.24	17.85
4	Huancayo	237.55	16.39	875.26	8.75
5	Chilca	28.04	12.71	678.74	6.79
6	Huancán	12	6.73	359.40	3.59
TOTAL		394.74	87.52	4673.76	46.74

Table 3. Formula for population growth rate and estimated population [21]

Formula for calculating growth rate	Formula for estimating population
$TC = \left(\left(\sqrt[n]{\frac{P2}{P1}} \right) - 1 \right) \times 100$	$Pe = Pi \times (1 + TC)^n$
TC = Population growth rate P1 = Initial population P2 = Final population n = Number of years between final population and initial population	Pe = Estimated population Pi = Initial population of the last Census TC = Population growth rate n = Number of years to be projected from initial population

Table 4. Estimated population of the urban districts of the CMAH

N°	Districts	Growth rate	Population of the CMAH		Estimated population of the CMAH	
		2007 - 2017	2007	2017	2020	2030
1	San Agustín de Cajas	4.06%	9957	14820	16700	22065
2	Pilcomayo	4.20%	13295	20055	22690	30263
3	El Tambo	1.26%	146375	165825	172173	187945
4	Huancayo	0.69%	110842	118696	121170	127146
5	Chilca	1.73%	77313	91758	96604	108927
6	Huancán	5.15%	14903	24631	28636	40699
TOTAL		1.58%	372685	435785	457973	517045

According to INEI [20], the population of the province of Huancayo in the last national census of 2017 was 438369 inhabitants, and it is estimated that the Central Metropolitan Area of the City of Huancayo has 435785 inhabitants; reaching 457973 inhabitants in 2020.

To project the estimated population for 2030, it is necessary to calculate the TC (population growth rate) based on the initial population and the final population of the last census. The formulas for this calculation are provided in Table 3 [6,21].

Having found the growth rate of 1.58%, it is projected that in 2030 the estimated population in San Agustín de Cajas will be 22065 inhabitants; in Pilcomayo, 30263 inhabitants; in El Tambo, 187945 inhabitants; in Huancayo, 127146 inhabitants; in Chilca, 108927 inhabitants; and in Huancán, 40699 inhabitants; therefore, there will be a total

of 517045 inhabitants in the Central Metropolitan Area of the City of Huancayo, as shown in Table 4.

3.1.2. Profiles and Statistics of Public Spaces in the Central Metropolitan Area of the City of Huancayo (CMAH)

This research analyzes the profiles (typologies and components) of public spaces in the Central Metropolitan Area of the City of Huancayo (CMAH) based on the information presented in Table 1. The analysis is then related to the variables (statistics) to develop a database of criteria and projections on public spaces in the CMAH, in order to determine whether the public green spaces reach the adequate endowment per inhabitant in the year 2020 with a projection until 2030.

Table 5. Profiles and Statistics of Public Spaces in the CMAH 2020

Public space domain	N °	Profiles	Variables (Statistics)
Public Spaces in the Central Metropolitan Area of the City of Huancayo		Public spaces - pavement floor	<ul style="list-style-type: none"> • Surface area per component (hectares) • Surface of components (m²) by the number of inhabitants (m²/inhab.) • Percentage of component area with respect to total surface (%) • Percentage of component area with respect to the surface of "urban area" (%) • Percentage of area per component with respect to the total surface area of public spaces (%)
	1	Plazas	
	2	Small plazas	
	3	Sports complexes - Sports slabs	
	4	Seawalls (planned)	
	5	Alamedas-walks	
		Public spaces - green floor	
	1	Local Parks	
	2	Theme Parks	
	3	Natural parks- Vacant urban land (unplanned)	
		Public spaces - liquid surface	
	1	Liquid surface	

Based on the "Urban Diagnosis of the Huancayo Urban Development Plan 2015 -2025" [6,22,23], we can define the components of public spaces, in relation to the study area (CMAH) as:

Public Spaces - Pavement Floor

- **Plazas:** They are public urban spaces, where various social, commercial, and cultural activities take place. They are typically located in the central part of cities and are surrounded by representative buildings, such as political and religious structures. The minimum area for these spaces is 1 hectare, but this may vary depending on the territorial scale of the districts in the study area (CMAH).
- **Small plazas:** They are open spaces of small and medium dimensions, of irregular shapes, formed by the meeting of passages and accesses that fulfill different social functions.
- **Sports complexes - Sports slabs:** These spaces are designated for sports practice and serve to provide recreational activities for the population. The study will consider all sports facilities within the study area (CMAH), excluding stadiums and sports fields, as they could distort the development of the database.
- **Seawalls:** In the context of the study area (CMAH), these spaces are located on the edges of the city and consist of routes or walks that run along the rivers.
- **Alamedas:** These pedestrian walkways are located in residential areas, running linearly next to streets or avenues within the study area (CMAH).

Public Spaces - Green Floor

- **Local Parks:** These are open and extensive spaces with green areas for passive recreation within the study area (CMAH).
- **Theme Parks:** In the study area (CMAH), there are zoological and cultural parks that offer unique attractions and entertainment for the population. These parks are distinguished from other public spaces due to their specialized uses and larger size, exceeding the minimum area of 2 hectares.
- **Natural parks- Vacant urban land (unplanned):** The study area (CMAH) contains unplanned and undeveloped spaces that are used for public passive and active recreation. These spaces are characterized by the presence of people engaging in various activities despite the lack of intervention.

Public Spaces - Liquid Surface

- **Liquid surface:** These spaces promote socialization through swimming activities. This study considers spaces dedicated to aquatic recreation and sports, excluding rivers to prevent distortion of the database.

Figure 2 displays photographs of significant public spaces in the Central Metropolitan Area of the City of Huancayo (CMAH).



Figure 2. Public spaces of the CMAH

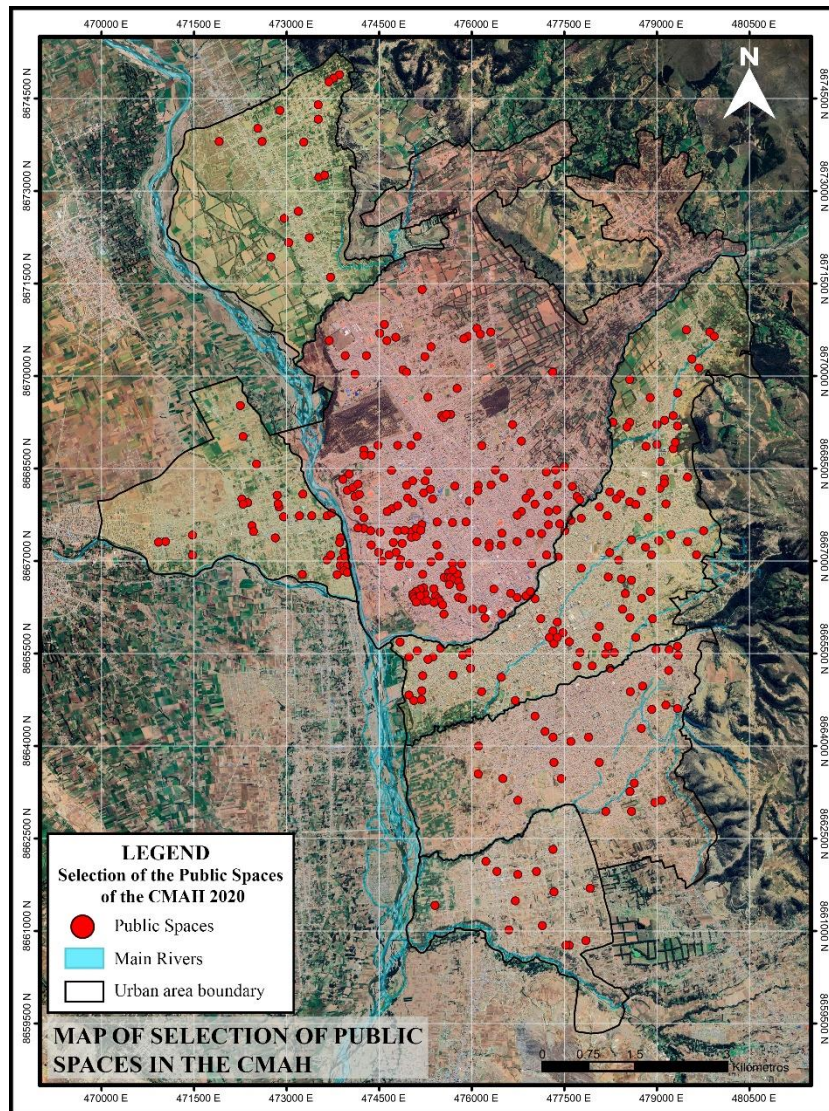


Figure 3. Map of selection of public spaces in the CMAH

The public spaces in the Metropolitan Central Area of the City of Huancayo (AMCH) have been selected based on specific parameters. Geographic technological tools such as Google Earth Pro and Argis were used to create the selection map shown in Figure 3. The map was based on the diagnosis of the PDU of Huancayo [6,19]. The main objective of public spaces in the metropolitan city of Huancayo is to express its culture and customs. However, due to the lack of better urban projects at present, public green spaces have lost their value. This is supported by the research mentioned in the bibliographic analysis.

4. Results

The database was generated by collecting information on

public spaces in the Central Metropolitan Area of the City of Huancayo (CMAH) from 2021 to 2023. The information collected includes profiles and statistics, which are presented in Table 5. The surface area of each public space within the mentioned typologies was obtained using the geographic technological tool Google Earth with the guidance of the Cadastral Map of the Metropolitan Area of Huancayo [19]. The process began with creating a data table that describes the extension of public spaces based on typologies and projections from 2020 to 2030. Next, a data table was generated to display the weightings and percentages of public spaces per inhabitant, surface area, and typology. Finally, data was collected on the endowments of public green spaces per inhabitant from 2020 to 2030.

Table 6. PUBLIC SPACE. Central Metropolitan Area of the City of Huancayo (2020 - 2030). *Extension according to typologies and projections*

	VARIABLES / COMPONENTS	CENTRAL METROPOLITAN AREA OF THE CITY OF HUANCAYO			
		2007	2017	2020	2030
	Total population	372685	435785	457973	517045
	Total surface area (km ²)	87.52	87.52	87.52	87.52
N°	PUBLIC SPACES - PAVEMENT FLOOR	Ha	Ha	Ha	Ha
	POINT-NODE SPACE				
1	Plazas (1)	4.79	5.64	5.94	6.77
2	Small plazas (2)	1.06	1.19	1.23	1.34
3	Sports complexes - Sports slabs (3)	17.58	20.90	22.1	25.36
	LINE-FLOW / POINT-NODE SPACE				
4	Seawalls (planned) (4)	0.89	1.01	1.05	1.15
5	Alamedas-walks (5)	0.38	0.41	0.42	0.44
	TOTAL PARTIAL	24.71	29.15	30.74	35.05
N°	PUBLIC SPACES - GREEN FLOOR	Ha	Ha	Ha	Ha
	POINT-NODE / LINE-FLOW SPACE				
1	Local Parks (6)	18.02	21.00	22.05	24.84
2	Theme Parks (7)	5.91	6.39	6.55	6.94
3	Natural parks-Vacant urban land (unplanned) (8)	33.02	38.28	40.12	45.00
	TOTAL PARTIAL	56.94	65.67	68.72	76.79
N°	PUBLIC SPACES - LIQUID SURFACE	Ha	Ha	Ha	Ha
	POINT-NODE / LINE-FLOW SPACE				
1	Liquid surface (9)	1.05	1.35	1.46	1.77
	TOTAL PARTIAL	1.05	1.35	1.46	1.77
	PUBLIC SPACES TOTAL excluding (8) and (9)	48.64	56.54	59.34	66.83
	PUBLIC SPACES TOTAL	82.70	96.17	100.92	113.60

Table 7. PUBLIC SPACE. Central Metropolitan Area of the City of Huancayo (2020). *Weightings and percentages per inhabitant, surface area and typology*

VARIABLES / COMPONENTS		CENTRAL METROPOLITAN AREA OF THE CITY OF HUANCAYO								
		2020	(m ² /hab) TOTAL	(m ² /hab) WITHOUT T (16)	% Surface area/ TOTAL TERRITOR Y	% Surface/ Urban Area	% Surface area/ TOTAL PUBLIC SPACE	% Surface area/ Type of Public Space	% Surface area/ green without (16)	% Surface area/ Public Space Without (16) (17)
	Total population by district	457973								
	Total surface area by district (km²)	87.52								
	Total surface area by district (ha)	8752.00								
	Total surface area by district (ha) / urban area	4673.76								
N°	PUBLIC SPACES - PAVEMENT FLOOR	Ha								
	POINT-NODE SPACE									
1	Plazas (1)	5.94	0.13		0.07	0.01	5.89	19.32		10.01
2	Small plazas (2)	1.23	0.03		0.02	0.01	1.22	4.00		2.07
3	Sports complexes - Sports slabs (3)	22.10	0.48		0.26	0.01	21.90	71.89		37.24
	LINE-FLOW / POINT-NODE SPACE									
4	Seawalls (planned) (4)	1.05	0.02		0.02	0.01	1.04	3.42		1.77
5	Alamedas-walks (5)	0.42	0.01		0.01	0.01	0.42	1.37		0.71
	TOTAL PARTIAL	30.74	0.67		0.38	0.05	30.47	100.00		51.80
N°	PUBLIC SPACES - GREEN FLOOR	Ha								
	POINT-NODE / LINE-FLOW SPACE									
1	Local Parks (6)	22.05	0.48	0.48	0.26	0.01	21.85	32.09	77.10	37.16
2	Theme Parks (7)	6.55	0.14	0.14	0.08	0.01	6.49	9.53	22.90	11.04
3	Natural parks- Vacant urban land (unplanned) (8)	40.12	0.88		0.46	0.01	39.75	58.38		
	TOTAL PARTIAL	68.72	1.50	0.62	0.80	0.03	68.09	100.00	100.00	48.20
N°	PUBLIC SPACES - LIQUID SURFACE	Ha								
	POINT-NODE / LINE-FLOW SPACE									
1	Liquid surface (9)	1.46	0.03		0.02	0.01	1.45	100.00		
	TOTAL PARTIAL	1.46	0.03		0.02	0.01	1.45	100.00		
	PUBLIC SPACES TOTAL excluding (8) and (9)	59.34	1.30		0.72	0.07	58.81			
	PUBLIC SPACES TOTAL	100.92	2.20		1.20	0.09	100.00			

Table 8. PUBLIC GREEN SPACES: Central Metropolitan Area of the City of Huancayo (2020 - 2030). Green area - Indexes $m^2/inhab.$ and required surface.

References	Years	Population	Existing green area		Deficit of green area	Optimal area 8 $m^2/inhab.$
			Ha	$m^2/inhab.$	Ha	
OWN STUDY	2007	372685	23.93	0.64	274.22	298.15
OWN STUDY (2)	2017	435785	27.39	0.63	321.23	348.63
OWN STUDY (3)	2020	457973	28.60	0.62	337.78	366.38
OWN STUDY (4)	2030	517045	31.78	0.61	381.86	413.64

The database consists of the Tables 6, 7 and 8, which correspond to the public spaces of the Central Metropolitan Area of the City of Huancayo in the year 2020, with projections until 2030. The tables were created to determine and calculate the surface area of each type of public space and to identify the surface area of public green spaces in relation to the area's inhabitants. The following thematic maps and graphs will comprehensively analyze the data obtained.

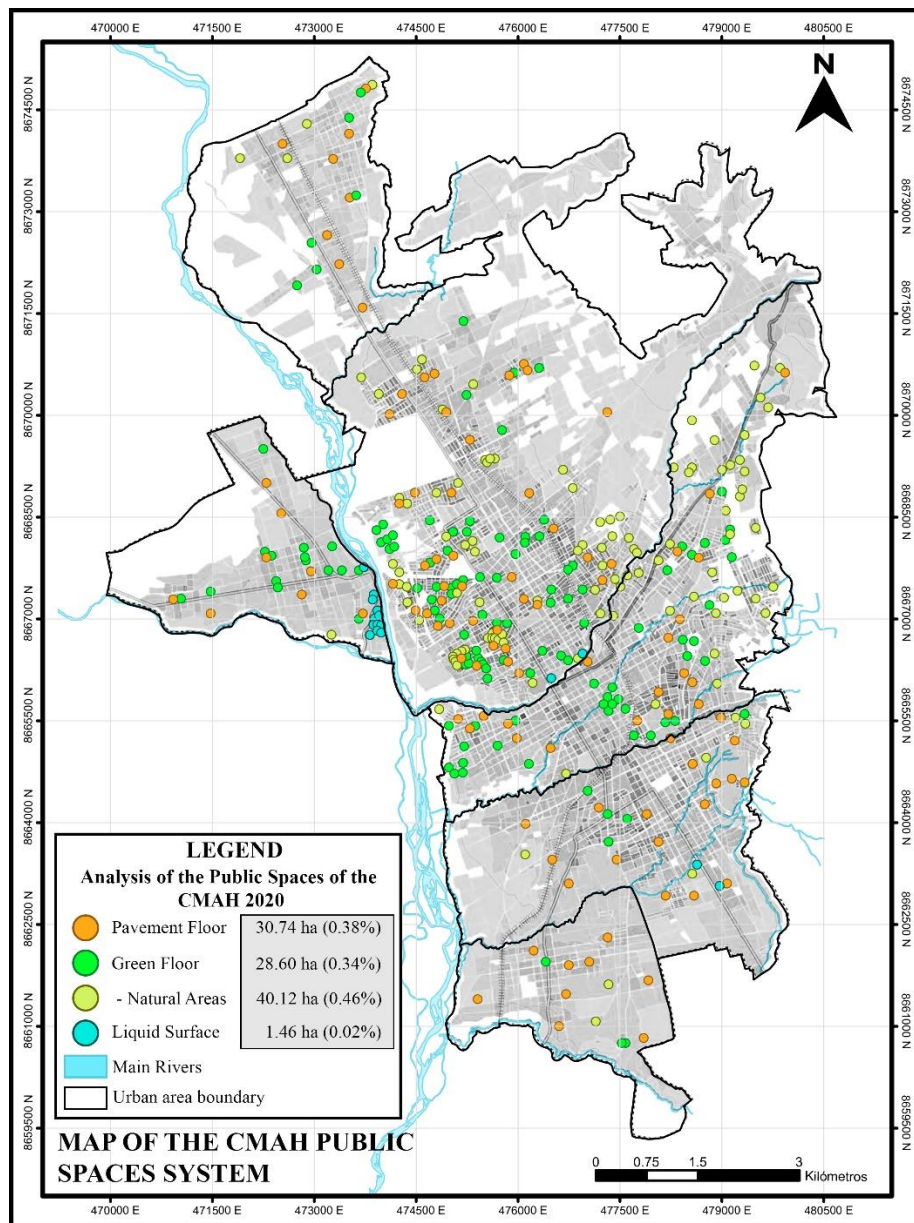


Figure 4. Map of the CMAH public spaces system

The thematic map above (Figure 4) displays the Public Spaces of the Central Metropolitan Area of the City of Huancayo for each typology in relation to the total area of 8752 ha. The data obtained shows that paved floor covers 30.74 ha (0.38%), green floor including natural areas covers 68.72 ha (0.80%), and liquid surface covers 1.46 ha (0.02%). It is important to note that there is a deficit of public green spaces, specifically those with a green floor type, which accounts for 28.60 ha (0.34%) excluding natural areas such as natural parks, and there is also a shortage of liquid surface spaces. This information can be found in Tables 6-7.

Figure 5 displays data on each component and typology in relation to the total surface area of 8752 ha, where natural parks predominate with 40.12 ha; sports complexes with 22.10 ha; local parks with 22.05 ha; theme parks with 6.55 ha; plazas with 5.94 ha; liquid surface with 1.46 ha; small plazas with 1.23 ha; seawalls with 1.05 ha; and highlighting that the area with the smallest surface area is the alamedas with 0.42 ha. Table 7, shows that public spaces in the Central Metropolitan Area of the City of Huancayo are scarce and are not at the territorial level.

Figure 6 shows the percentages of the components in relation to the total surface area of 8752 ha. of the CMAH. Obtaining the following data: 0.46% in natural parks; 0.26% in sports complexes and slabs; in the same percentage as the previous one, they are in local parks; and 0.07% in plazas. In the same way, it is shown that the surface of the urban area is 4673.76 ha of the CMAH, and only 0.09% is oriented to public space, demonstrating the lack of these spaces dedicated to the population (Table 7).

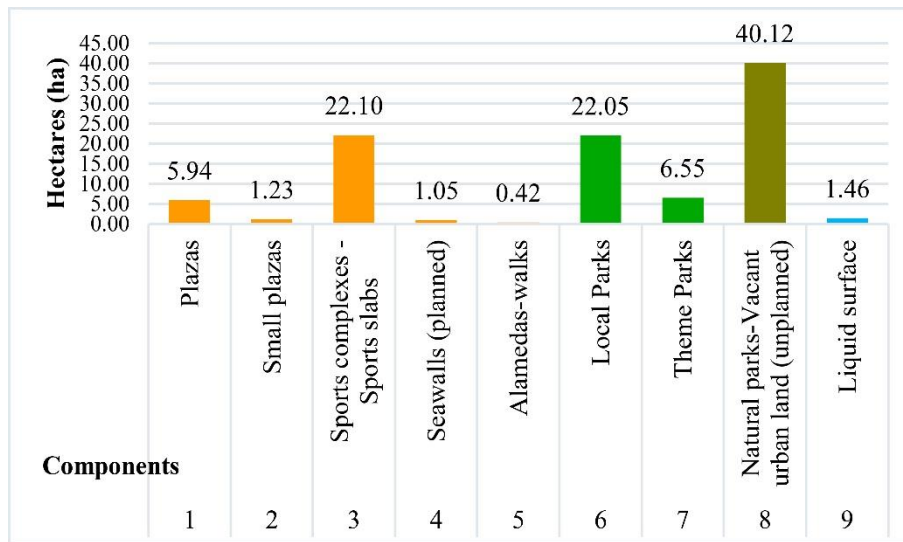


Figure 5. Public Spaces of the CMAH (2020). Extension of surface area by components and typologies (hectares)

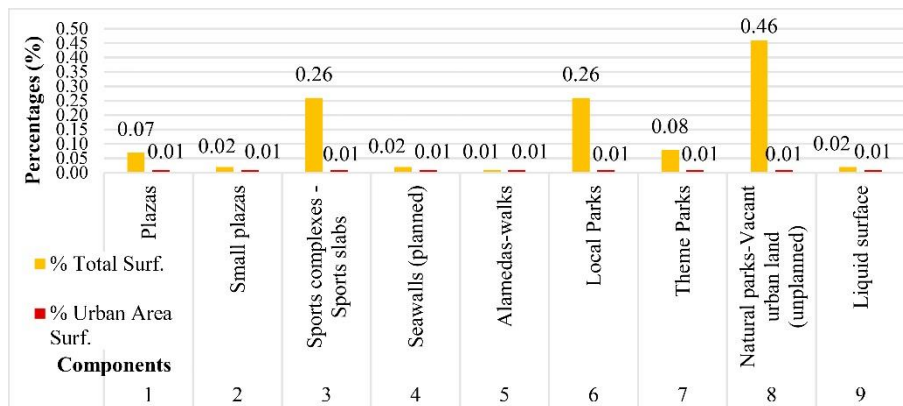


Figure 6. Public Spaces of the CMAH (2020). Percentage of component area with respect to the total surface and "urban area" of the CMAH (%)

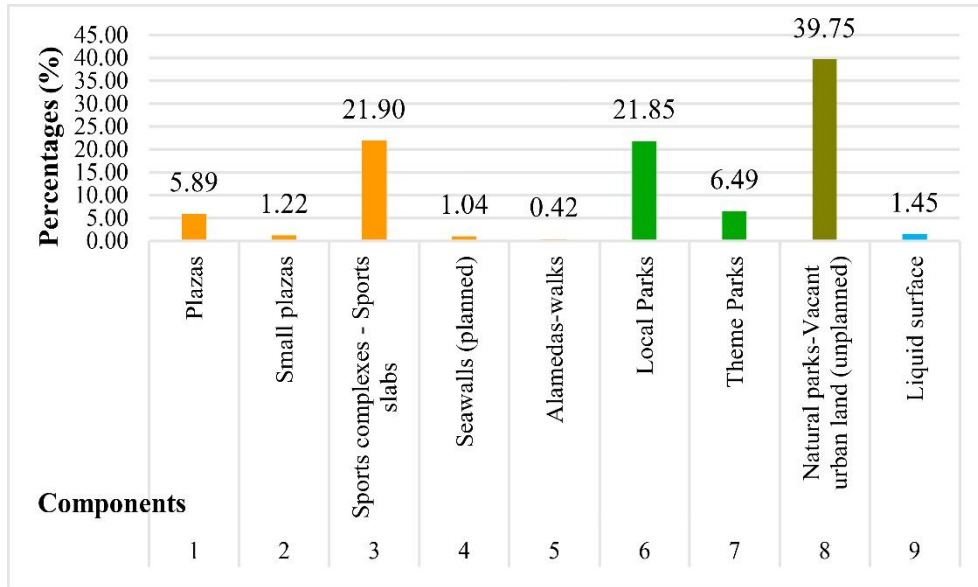


Figure 7. Public Spaces of the CMAH (2020). Percentage of component area with respect to the total surface area of the CMAH public spaces (%)

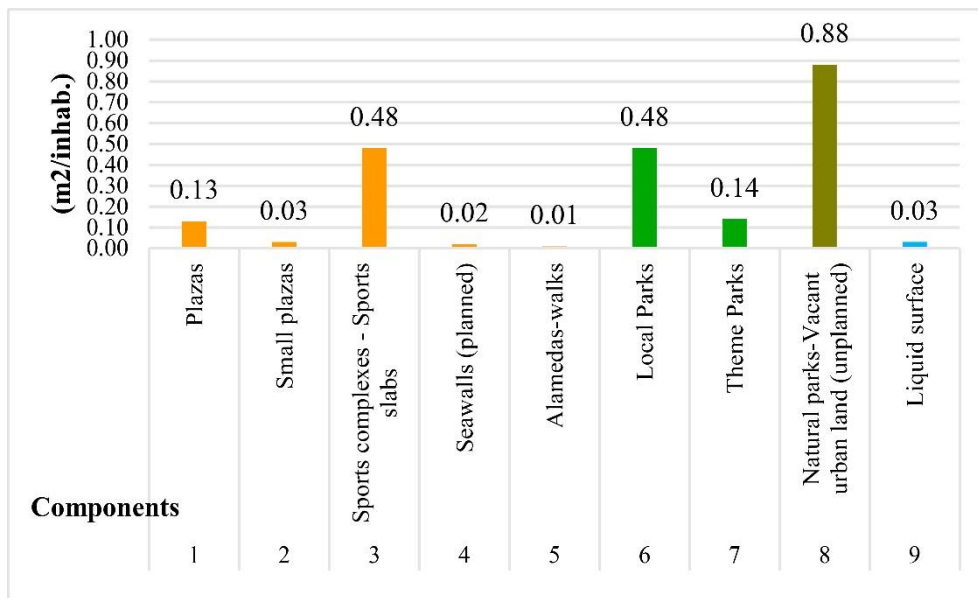


Figure 8. Public Spaces of the CMAH (2020). Component surface (m²) by the number of inhabitants (m²/inhab.)

Figure 7 displays the percentage of components in relation to the total surface area of public spaces in the Central Metropolitan Area of the City of Huancayo (CMAH), which amounts to 100.92 ha. The following data was obtained: 39.75% of natural parks; 21.90% in sports complexes and slabs; 21.85% in local parks; and highlighting that only 0.42% of the area is made up of alamedas-walks. This shows that the CMAH has a higher percentage of natural parks that are not planned as opposed to the other public spaces that do have intervention (Table 7).

Figure 8 shows data on the surface area of components

per number of inhabitants (m²/inhabitant) in the Central Metropolitan Area of the City of Huancayo (CMAH). The following data were obtained: 0.88 m²/inhabitant in natural parks; 0.48 m²/inhabitant in sports complexes and slabs; the same area per inhabitant in local parks; 0.14 m²/inhabitant in theme parks; 0.13 m²/inhabitant in plazas; 0.03 m²/inhabitant in liquid surfaces and small plazas; 0.02 m²/inhabitant in seawalls; and, finally, only 0.01 m²/inhabitant in alamedas (Table 7). Although Table 6 provides a projection from 2020 to 2030, there is still a shortage of public spaces that meet the m²/inhabitant endowment in the CMAH.

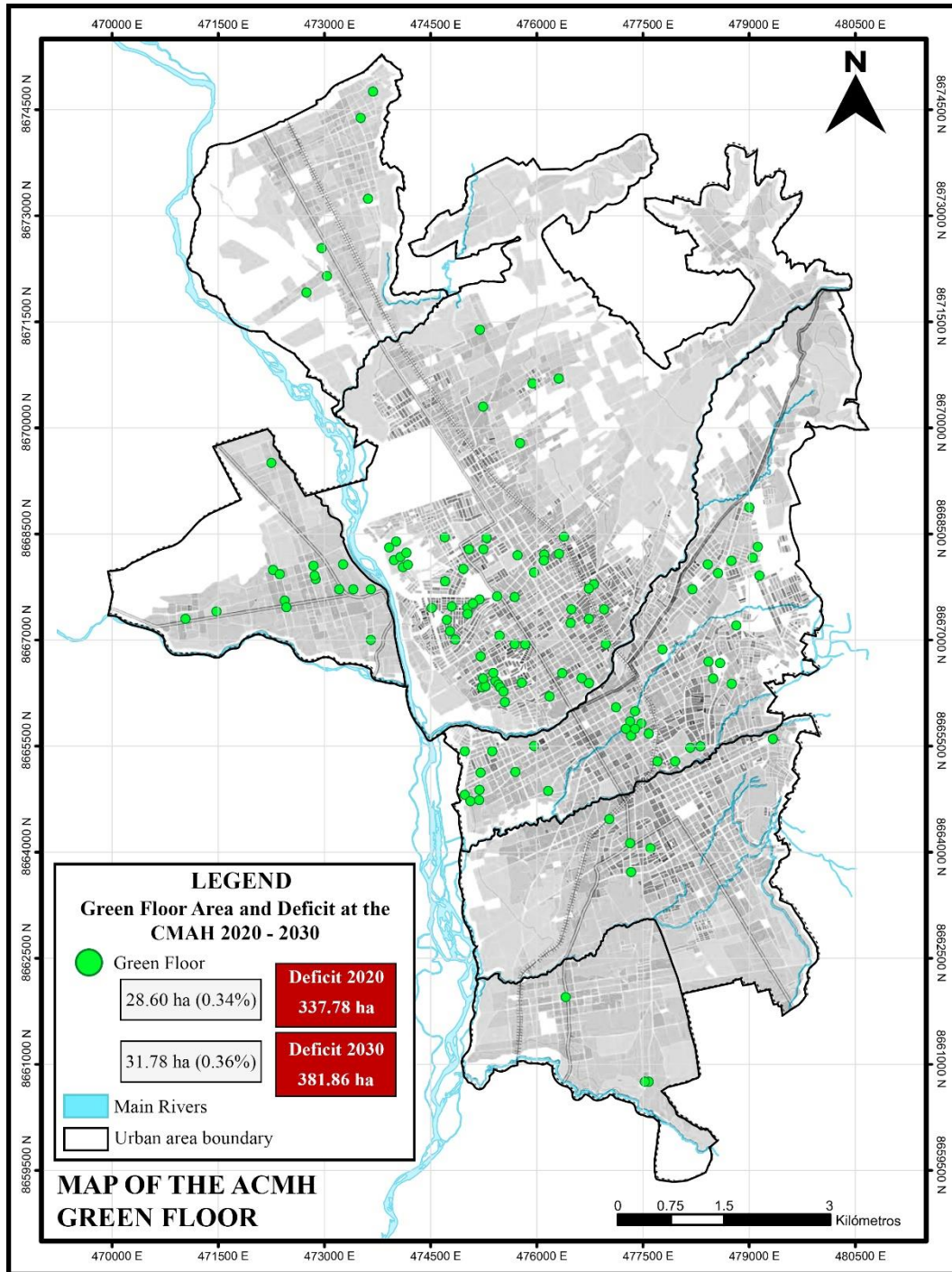


Figure 9. Map of the CMAH green floor

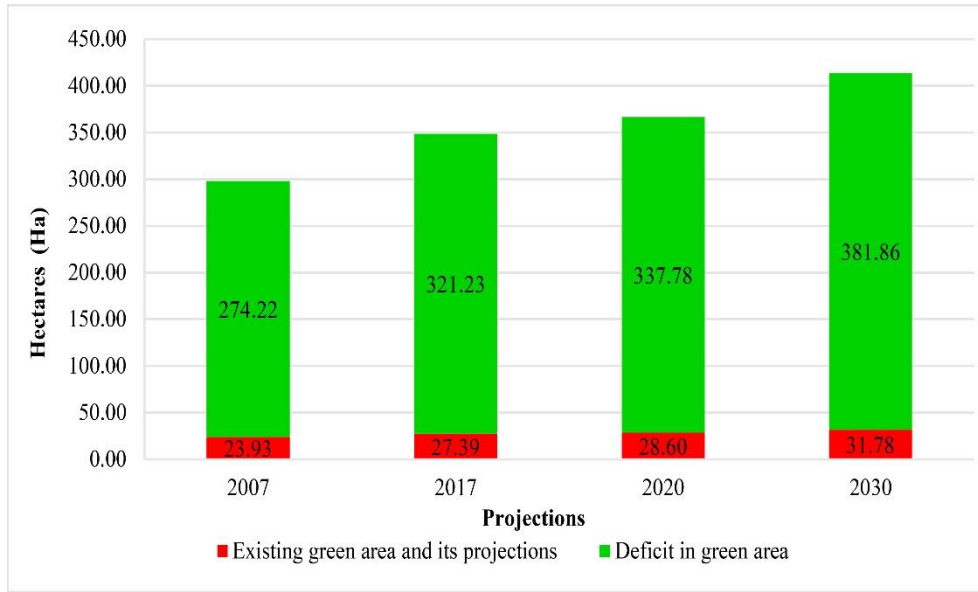


Figure 10. Public Green Spaces (Green Floor) of the CMAH (2007 - 2030). Deficit of Green Areas in relation to the Optimal Green Area (ha)

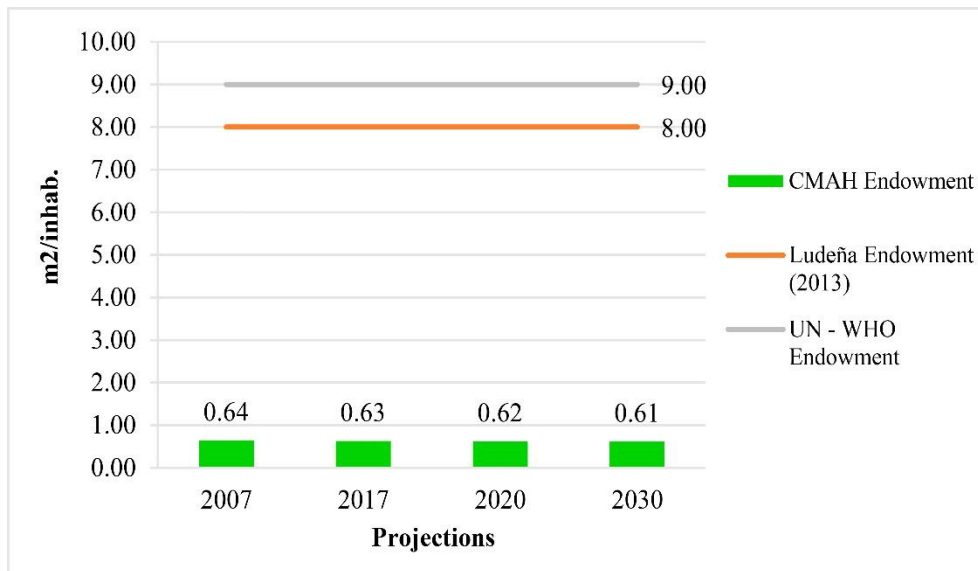


Figure 11. Public Green Spaces (Green Floor) of the CMAH (2007 - 2030). Endowment of Public Green Spaces per Inhabitant (m²/inhabitant) compared to the Optimal Endowment (m²/inhabitant)

The total area of public green spaces in 2020 is 28.60 ha. with a deficit of 337.78 ha., and in 2030 it is projected to have a total area of 31.78 ha. with a deficit of 381.86 ha. as shown in Figures 9 and 10, data obtained from Tables 6, 7 and 8. This indicates a concerning trend of increasing deficit in public green space areas within the CMAH.

Figure 11 displays data on the endowment of public green spaces per inhabitant (m²/inhabitant) in the Central Metropolitan Area of the City of Huancayo. Obtaining the following data: in 2007 there was 0.64 m²/inhabitant; in 2017 there was 0.63 m²/inhabitant; in 2020 there was 0.62 m²/inhabitant; and it is projected that by 2030 there will be 0.61 m²/inhabitant. This means that the recommended indices of 9 and 16 m²/inhabitant by the UN and WHO, respectively, are not being met [7].

5. Discussion

The discussion that follows:

In his analysis of the public spaces of Metropolitan Lima, Ludeña [2] emphasizes the importance of questioning the design and function trends of public spaces in order to address the need for more public spaces in the future. He concludes that any policy or action related to public spaces must be based on precise, detailed, and up-to-date information on all components and structures. This is the only way to truly understand the reality of public spaces and plan for their future.

This research develops a precise and updated database of public spaces using Ludeña's methodology. The profiles and statistics are applied to obtain the typologies,

categories, and components of public spaces and relate them to variables (indicators). The aim is to identify the surface area of green spaces per inhabitant in the Metropolitan Central Area of the City of Huancayo for the years 2020 and 2030. The main result shows that the surface area of green spaces is 0.62 m² per inhabitant.

However, the WHO and UN recommend using the indicator of 9 to 16 m² of green space per inhabitant. This suggests that there is a deficit of public green spaces in the Central Metropolitan Area of the City of Huancayo that needs to be addressed.

The INEI study reports that Huancayo has 1.1 m² of public green spaces per inhabitant [10]. However, the Urban Development Plan of Huancayo from 2015 to 2025 diagnoses an endowment of 0.92 m² per inhabitant [6].

The current study presents new data obtained through a scientific methodology, as developed in morphological analysis. This information can help achieve sustainable urban development that balances social, environmental and economic factors in the Central Metropolitan Area of Huancayo.

6. Conclusions

This research work shows that the identification and study of components such as: plazas, small plazas, sports complexes, seawalls, alamedas, local parks, theme parks, natural parks and liquid surfaces; and the application of indicators in the public green spaces of the Central Metropolitan Area of the City of Huancayo (CMAH), has generated a data based on the current state of these spaces. The percentage of surface area components with respect to the total surface area of 8752 ha. are: 0.46% natural parks; 0.26% sports complexes; 0.26% local parks; 0.08% theme parks; 0.07% plazas; 0.02% small plazas; 0.02% seawalls; 0.02% liquid surface; and 0.01% alamedas (Figure 6).

The thematic and graphic plans reflect the current context of public spaces in the Central Metropolitan Area of the City of Huancayo. This allows us to calculate the endowment of green spaces per inhabitant for the year 2020 having had 0.62m²/inhabitant with a deficit of 337.78 hectares, and for the year 2030 it is projected that the endowment of green spaces will decrease to 0.61 m²/inhabitant, this line of decline will be extended if are not reached the indexes recommended by the WHO and UN (Table 5 - Figures 10 - 11).

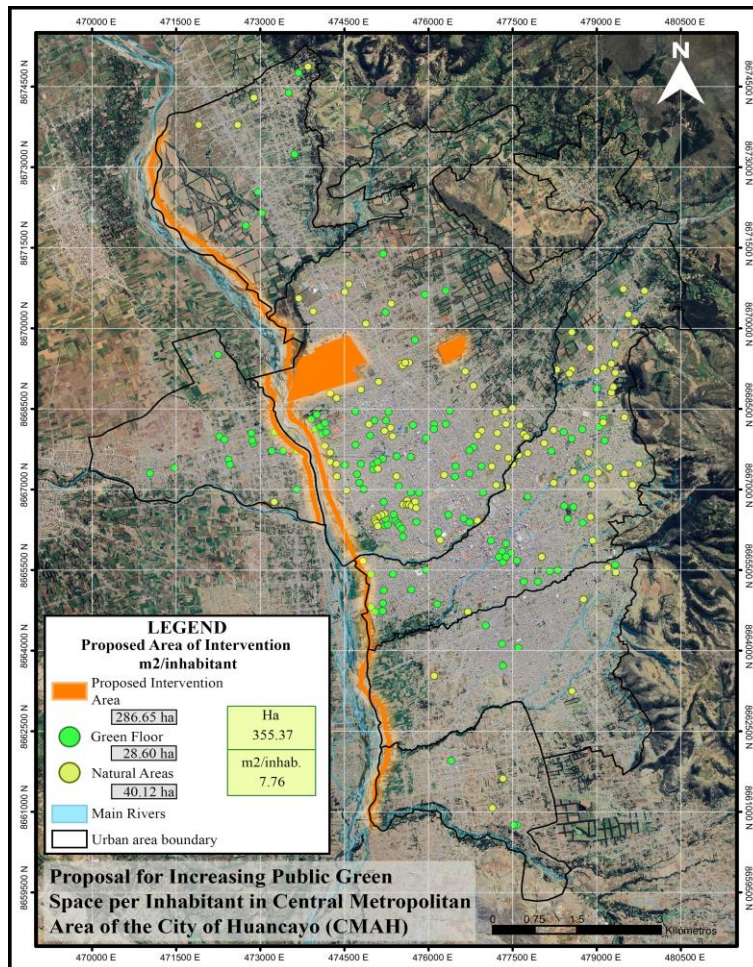


Figure 12. Proposal for Increasing Public Green Space per Inhabitant in CMAH

It has been determined that there is currently a low endowment of public green spaces in proportion to the needs of the population, due to rapid urbanization and lack of municipal planning. Therefore, interventions are necessary for the development of these spaces, as shown in Figure 12.

7. Recommendations

The present research shows that the database not only contributes to the current urban social development, but also to the future, which is why we consider that it should be taken as a basis for further research related to public green space in the Central Metropolitan Area of the City of Huancayo in order to have an urban development that goes hand in hand with the environmental, society and economy.

Based on the above, it is recommended that the regional and local authorities of the Central Metropolitan Area of the city of Huancayo take into consideration the database of this research for the approval of future sustainable urban development projects in the city. Likewise, to generate projects that preserve the urban environmental reserve sites (ecological protection zones) and intervene in the natural parks - vacant urban land that has a higher percentage than the other public spaces that are located within the Huancayo Metropolis, with the purpose of increasing the endowment of public green spaces in relation to the needs of the current and future population.

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