Recibido: 28-11-2024
Aceptado: 01-08-2025

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REVISTA URBANO Nº 52 /NOVIEMBRE 2025 - ABRIL 2026
PÁG. 36 - 51
ISSN 0717 - 3997 / 0718 - 3607

URBAN MORPHOGENETICS AND THE QUALITY OF PUBLIC SPACE IN CHAUPIMARCA, CERRO DE PASCO, PERU[1]

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1 Article funded by the National University of Central Peru, through the 2023 ordinary resources fund, 2023 Undergraduate Thesis Competition, via Resolution 1601-R-2023, Project No. 03 Architecture.

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https://doi.org/10.22320/07183607.2025.28.52.03

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Actualmente, las ciudades latinoamericanas presentan formas urbanas complejas y fragmentadas, producto de procesos históricos y sociales. Estas configuraciones representan desafíos importantes para la planificación, ya que pueden incidir directamente en la calidad del espacio público. Con el objetivo de reinterpretar la morfología urbana desde un enfoque morfogenético, se plantea comprender la ciudad como un sistema en evolución, compuesto por genes tipológicos que configuran su estructura y dinámica. La investigación busca contribuir a cerrar el vacío científico existente en torno a la relación entre la morfogenética urbana y la calidad del espacio público. El estudio, desarrollado en el distrito de Chaupimarca, Cerro de Pasco (Perú), empleó un enfoque cuantitativo, apoyado en Sistemas de Información Geográfica (SIG), para identificar genes tipológicos y evaluar sus características morfogenéticas en relación con la calidad de sus espacios públicos asociados. Los resultados revelan que no existe una correlación estadísticamente significativa entre ambas variables; sin embargo, se observó que la diversidad funcional influye positivamente en la calidad del espacio público. Pese a la débil correlación general, se destaca el valor del enfoque morfogenético para orientar intervenciones urbanas más integrales y contextualizadas.

Palabras clave: desarrollo urbano, espacio público, morfología urbana, tipología urbana

Currently, Latin American cities have complex and fragmented urban forms, the result of historical and social processes. These configurations pose significant challenges for planning, as they can directly affect the quality of public space. To reinterpret urban morphology from a morphogenetic perspective, this study conceives the city as an evolving system comprising typological genes that shape its structure and dynamics. The research looks to contribute to closing the existing scientific gap regarding the relationship between urban morphogenetics and public space quality. This study, conducted in the district of Chaupimarca, Cerro de Pasco (Peru), employed a quantitative approach supported by Geographic Information Systems (GIS) to identify typological genes and assess their morphogenetic characteristics regarding the quality of their associated public spaces. The results reveal no statistically significant correlation between the two variables; however, it was observed that functional diversity has a positive influence on public space quality. Despite the weak overall correlation, the value of the morphogenetic approach is emphasized to guide more comprehensive and context-sensitive urban interventions.

Keywords: topography, urban development, public space, urban morphology, urban typology

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I. INTRODUCTION

The urban structure, historically approached from morphology, has focused its study on the physical form of the city (Capel, 2002; Fernández-Ges, 2016; De Solà-Morales i Rubió, 1997). However, given the increasing urban complexity in contemporary cities, the need for more dynamic approaches has arisen. Faced with this, urban morphogenetics presents a new territorial landscape, considering not only the forms but also the historical, spatial, and typological processes that shape them.

This approach, proposed seminally by Conzen (1960), in his studio in Alnwick, Northumberland, was expanded upon by Gauthirt (2015), in Larkham and in Conzen's 2014 work, *Shapers of Urban Form*.

Unlike traditional urban morphology, which describes the physical forms of the city, the morphogenetic approach analyzes the territory as a dynamic system comprising "typological genes": units with historical, spatial, and functional information, capable of anticipating urban behavior (Vargas, 2016). This study adopts and reinterprets this approach, considering the city as a complex system, where urban fabrics cease to be static forms to become structures with measurable information that guides intervention decisions.

This is an approach applied in recent studies, such as those by Solís Trapero et al. (2019), Vargas (2016) and Reyes (2015), who highlight its usefulness to understand the evolutionary dynamics of the territory beyond its static configuration.

Although the study uses new technologies to obtain quantitative information reliably, it also provides an essential space for observation, proposing a flexible methodology that is capable of adapting to specific urban contexts. In parallel, studies on the quality of public space have adopted regulatory models based on global standards, often disconnected from the immediate context (Giraldo Ospina et al., 2022; Murshed et al., 2021; Praliya & Garg, 2019; Sabogal Dunin Borkowski et al., 2019; Orellana Tapia, 2015), which have limited a comprehensive understanding of the urban phenomenon.

Therefore, it is essential to test the versatility of the morphogenetic approach in a real context to understand how urban morphogenetics relates to the quality of public space. This approach will not only contribute to the theoretical knowledge of the territory but also generate a tool applicable to future interventions in intermediate cities with similar conditions. In this sense, Chaupimarca, a city in the center of Peru, is an ideal case study to reflect a complex and fragmented urban process, marked by historical and geographical factors that have deteriorated its urban structure, degraded its public spaces, and affected the quality of life of its inhabitants (Blanco Muñoz, 2021; Lefevre Fatosme, 2017; Vega Centeno, 2007)

II. THEORETICAL FRAMEWORK

BACKGROUND

Zelelew and Mamo (2023) explored the morphogenesis of Dire Dawa through a comparative approach of urban forms, discovering notable differences with cities in northern and central Ethiopia. The study emphasizes the significance of incorporating local identity into urban processes to achieve optimal morphological integration.

On the other hand, the quantitative morphogenetic approach used by Solís Trapero et al. (2019) in Toledo, allowed quantifying urban forms, generating graphic and alphanumeric data that facilitate the analysis of the impact of urban spatial configurations.

Similarly, De Santiago Rodríguez and González García (2021) addressed the structural problems in rural villages through a dynamic approach. They identified urban elements with critics and concluded that current urban planning tools do not allow addressing these challenges. For their part, Zhao et al. (2020) applied LIDAR technology to map the evolution of urban typologies, demonstrating the benefits of using new technologies in territorial planning.

Fleischmann et al. (2022) propose a quantitative approach to describe urban configurations through the analysis of street networks, building footprints, and morphological tessellation, allowing the identification of homogeneous urban configurations.

In another context, Łaszkiewicz et al. (2022) analyzed the relationship between accessibility to green spaces and morphology, demonstrating the interaction between sociological processes and urban structure. Meanwhile, D'acci and Voto (2023) presented the "Isobenefit" model, which promotes a pedestrian-friendly city with nearby essential services. This approach, based on urban simulations, proposes optimizing urban processes to achieve a more efficient city engineering.

Aligned to this, Vargas (2016), in his thesis, *"In Search of the Urban Genome,"* proposes the genetic engineering of cities as a tool to identify and modify harmful genes, thereby preventing their future collapse. Using computer simulations, he proposes scenarios that allow anticipating and correcting dysfunctional urban dynamics.

Research such as that of De Santiago Rodríguez and Prada Llorente (2021) reinforce the need to study urban morphology

Typological genes	Concept	Authors
Old town	With an irregular layout, adapted to the topography, a mixture of uses, and renovated old buildings, with historical identity.	Capel (2002); López de Lucio (1999); Moneo (1982); Fernández-Ges (2016) and De Solà-Morales i Rubió (1997).
Widening	Planned, regular layout. Hierarchical streets, regular blocks, and diverse buildings, often closed.	
Integrated rural centers	Suburban growth that adapts rural housing. Smallholdings with minimal access, house-yard typology, and low density.	
Garden City neighborhoods	Large lots (>400 m2) with gardens. Curved or long straight roads, single-family houses predominate.	
Temporary housing - Marginal urbanization - self-construction	Product of the housing shortage and self-construction. Small plots, unpaved streets, and precarious housing without services or public space.	
Residential estates - exempt blocks	Modern official policies. Single- or multi-family blocks in regular estates, whose homogeneity causes social and mobility problems.	
Industrial estates - productive fabrics	Planned industrial sites (50s-60s), linked to roads. They house factories and mining settlements with large-scale buildings.	
Large facilities (public and private)	Health, education, or other facilities emerging with the road expansion. Modern buildings that decentralize services.	
Shopping malls	Since the 1980s, markets and peripheral galleries with restricted access have promoted social segmentation.	
Large mixed operations	Rehabilitation, revitalization, or public-private planning of urban restructuring.	

Table 1. Typological genes. Source: Prepared by the authors.

and the quality of public space. These works highlight the usefulness of GIS and sustainability parameters to improve urban habitability.

In addition, studies such as those of Martino et al. (2021), Pesántez-Yepez and Cabrera-Jara (2024) demonstrated that socioeconomic and habitability indicators are directly related to urban morphogenetics, confirming their relevance as a structuring variable of urban development.

Finally, Orellana Tapia and Ruiz Sánchez (2020) analyzed the historical nucleus of Cusco, concluding that its shape reflects a Hispanic-Andean syncretism. Previously, Orellana Tapia (2015) studied the public space in Huancayo, Peru, highlighting that its proper management enhances urban development. Together, these antecedents consolidate the link between urban morphogenetics and the quality of public space, offering conceptual and methodological tools to address contemporary urban challenges.

URBAN MORPHOGENETICS

Urban morphogenetics articulates the geographical, morphological, and temporal dimensions to understand the evolution of cities. This concept, proposed by Conzen (1960), proposes a methodology based on three key elements: urban plan, land use, and building, to identify and characterize morphological units as dynamic elements that carry historical, spatial, and functional information. Subsequently, authors such as Whitehand (2001) and Gauthier (2015) have expanded upon the Conzenian panorama, which confirms the validity of the morphogenetic approach in contemporary urban studies.

In this framework, urban typologies are no longer conceived as static forms, but are reinterpreted and understood as typological genes: dynamic units with the ability to reflect urban processes over time (Solís Trapero et al., 2019). Thus, the traditional morphological categories, widely addressed by different authors (Table 1), no longer represent the endpoint of the analysis, but rather the beginning of understanding urban behavior and projecting its future morphological trends. Thus, the city is conceived as a living and complex system, whose components interact responding to the needs of its inhabitants.

QUALITY OF PUBLIC SPACE

For Szczepańska and Pietrzyk (2020), public spaces are a manifestation of the processes that take place in a city; therefore, they significantly influence the quality of life. Girardo Ospina et al. (2022), for their part, support this argument, highlighting

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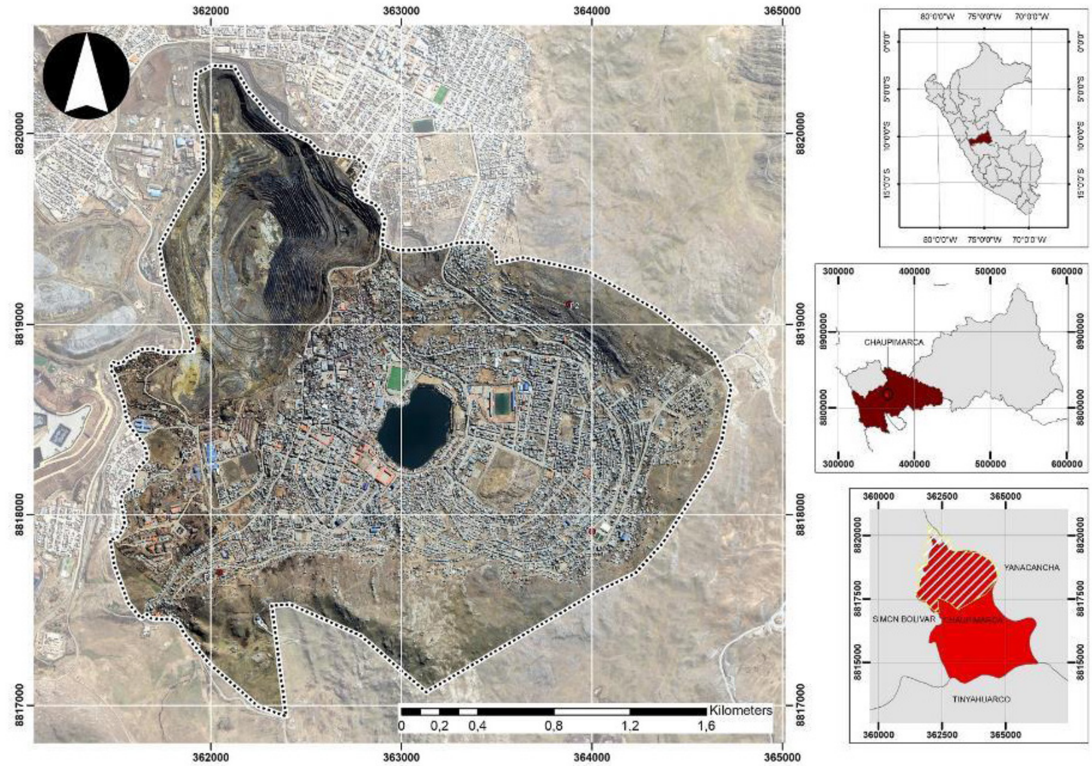

Figure 1. Location map. Source: Prepared by the authors.

the importance of these, considering the Sustainable Development Goals proposed by the United Nations [UN] (UN, 2015).

For the *Project for Public Spaces (PPS)* collective, an initiative based on the postulates of Silverman (1982), quality public spaces are those that promote events, cultivate socio-economic encounters, and strengthen socio-cultural ties. To do this, they must offer good accessibility, comfort, functional diversity, and conditions that promote social interaction (Project for Public Spaces [PPS], 2023; PPS, 2021; Silverman, 1982).

III. CASE STUDY

The Chaupimarca district, situated in Cerro de Pasco, Peru (Figure 1), features a highly complex urban environment, the result of an evolution influenced by mining activity, which has had a profound impact on the urban structure. This has impacted mobility, commerce, and the preservation of traditions, thereby degrading the district's public space and diminishing the quality of life for its inhabitants.

Given this context, Chaupimarca is ideal for examining the relationship between urban morphogenetics and the quality of public space. This research aims to contribute to the theoretical understanding of the territory and, simultaneously, provide a replicable methodology for future urban interventions in intermediate cities with similar dynamics.

IV. METHODOLOGY

DESIGN OF THE STUDY

The study comprised four phases. In the first, it identified the typological genes of the district through a historical and cartographic analysis of 1862, 1951, and 2024. In the second step, these were categorized using tools such as the N-Diagram, the Functional Urban Mix Model, and the Spacemate Graph.

Subsequently, the representative public spaces (one for each typological gene present) were evaluated using questionnaires and observation sheets. Finally, the Spearman coefficient was used to determine the relationship between the two variables, ensuring a rigorous and systematic analysis (Figure 2).

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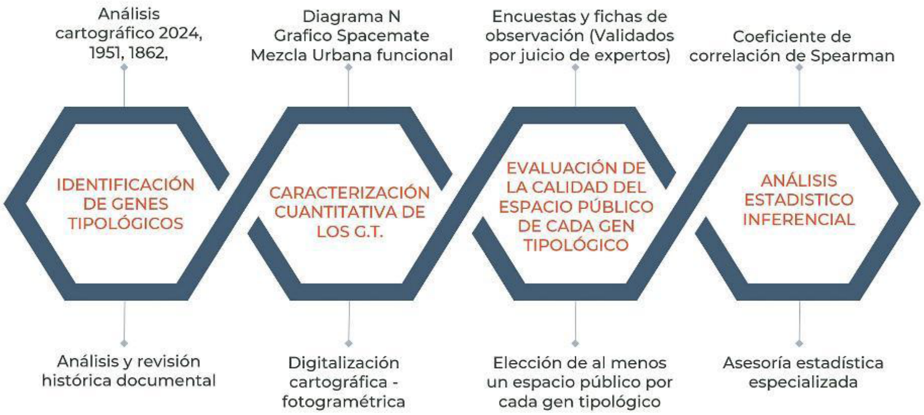

Figure 2. Methodological outline. Source: Prepared by the authors.

This study, adopting a non-experimental correlational design with a quantitative and cross-sectional approach, initially conducted a historical-cartographic analysis of urban plans from 1862, 1951, and 2024 for the Chaupimarca district, aiming to identify, track, and decode typological patterns found in its urban structure. This analysis allowed recognizing transformation processes, mutations, and morphological persistence over time, leading to the identification of typological genes, defined by their morphofunctional attributes and in reference to widely addressed urban typologies (Table 1).

From this basis, the typological genes were analyzed and categorized by morphogenetic variables, such as urban plan, land use, and building, translating their structure into comparable, replicable, and suitable data for quantitative treatment. Hence, these genes represent the accumulated result of urban processes that, although originating in different historical moments, still affect the contemporary spatial structure of Chaupimarca.

Following this, the quality of the public space was evaluated using observation cards and surveys, both based on the Project for Public Spaces model. These instruments permitted establishing a solid basis to statistically contrast the relationship between urban morphogenetics and the quality of public space within the context of the study.

The research considers two types of population. The first, of a demographic nature, corresponds to the 21,007 inhabitants of Chaupimarca between the ages of 15 and 64, from which a sample of 264 people was selected, calculated under the formula for finite populations, with a confidence level of 95% and a margin of error of 6%, using a non-probability random sampling.

The second population consists of the typological genes previously identified, with representative public spaces linked to these serving as the unit of analysis. For this, a non-probabilistic sampling was used for convenience, prioritizing its accessibility, use, and representativeness.

DEFINITIONS AND MEASUREMENTS

The morphogenetic approach enabled the identification and delimitation of the typological genes that the urban structure of the district comprises, following criteria established in the specialized literature. Once recognized, categorization and quantitative analysis were carried out based on three dimensions proposed by Conzen (1960) (Table 2). For this:

- In the analysis of the urban plan, the "N Diagram" was applied, which shows the variations of the urban layout regarding the oversizing of the public space, qualifying this relationship as high, medium, or low (Berghauser Pont & Haupt, 2020).
- In the land use analysis, the "Functional Urban Mix Model" was used, which evaluates the degree of multifunctionality, classifying the genes as mono-functional, bifunctional, or multifunctional (Van den Hoek, 2008; Solís Trapero et al., 2019).
- To analyze buildings, "Spacemate Graphs" were used, a tool that offers a two-dimensional reading of the built nature, facilitating the interpretation of the space and classifying it into areas such as the garden city, suburban, dense suburban, dense urban, compact urban, or high-rise building (Berghauser Pont & Haupt, 2020).

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Dimension	Indicator	Formula	Variables
N DIAGRAM	N: Road density	$N = \frac{(\Sigma l_i + \frac{\Sigma l_e}{2})}{A}$	l_i= Inner road l_e= Outer road A = Total area A_{ep}= Public area A_{epr}= Private area
	b: Street width	$b = \frac{2(1+\sqrt{1-T})}{N}$	
	T: Tare	$T = \frac{A_{ep}}{A_{epr}}$	
FUNCTIONAL URBAN MIX MODEL	% residential land	$\%Ur = \frac{S_r}{S_t} x100$	Sr = Residential land Sl = Working land Se= Facilities land St = Total area
	% land intended for commerce, offices, industry, leisure, hospitality	$\%Ul = \frac{S_l}{S_t} x100$	
	% land of facilities	$\%Ue = \frac{S_e}{S_t} x100$	
SPACEMATE GRAPH	GSI: Space index	$GSI = \frac{S_o}{S_t}$	So = Occupied area Se = Built area Sec = Built space area Senc = Free area St = Total area
	FSI: Buildability coefficient	$FSI = \frac{S_e}{S_t}$	
	OSR: Spaciousness	$T = \frac{S_{ec}}{S_{enc}}$	
	L: Height	$L = \# plantas$	

Table 2. Characterization parameters. Source: Prepared by the authors based on Berghauser Pont & Haupt, 2021, Solís Trapero et al., 2019, and Van den Hoek, 2008.

Dimension	Indicator	Instrument	Measurement
ACCESSIBILITY	Continuity, Connectivity, Readability, Accessibility	Questionnaire + Observation form	Likert Scale (1-5)
COMFORT	Security, Cleanliness, greenery, and Historical value		
ACTIVITIES	Versatility, Dynamism, Utility, Locality		
SOCIABILITY	Diversity, Sense of Community, Interactivity, Solidarity		

Table 3. Dimensions of evaluation of public space. Source: Prepared by the authors based on PPS (2023).

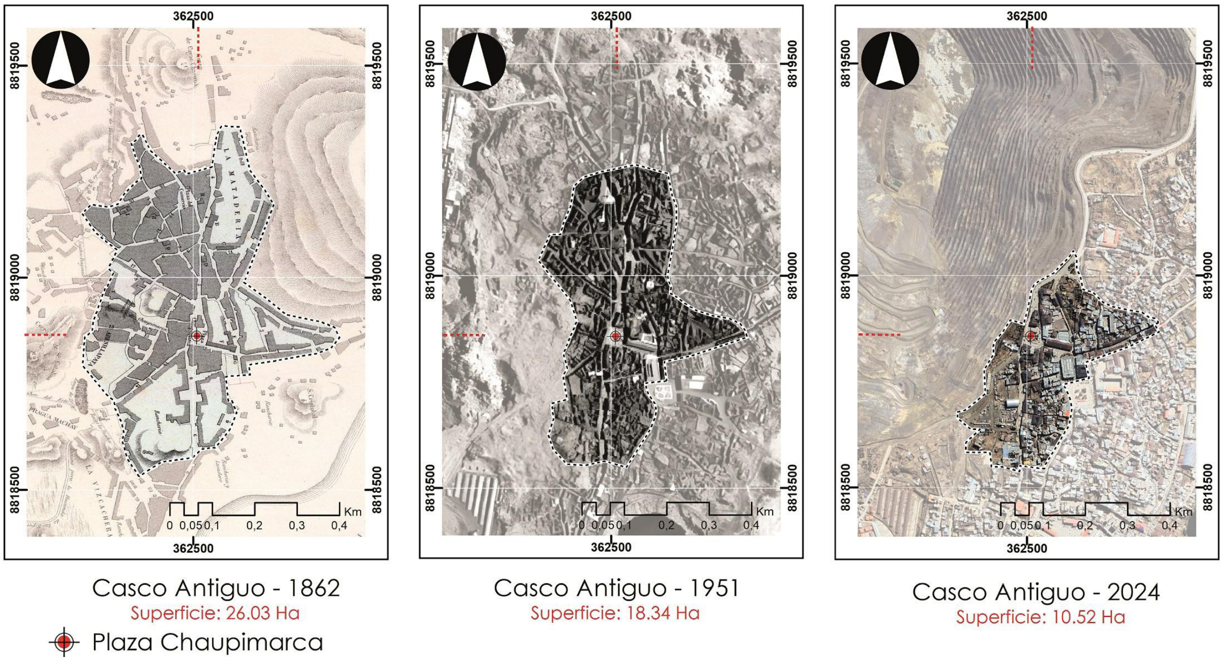

Figure 3. Identification and delimitation of the old city typological gene. Source: Prepared by the authors.

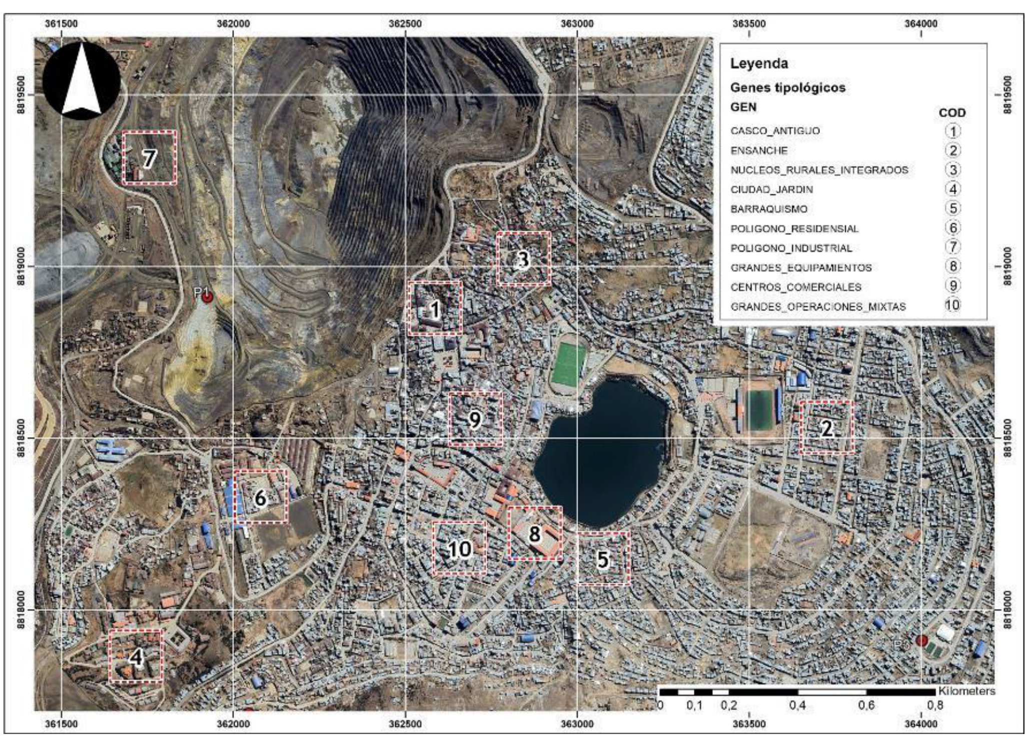

Figure 4. Typological genes of Chaupimarca. Source: Prepared by the authors.

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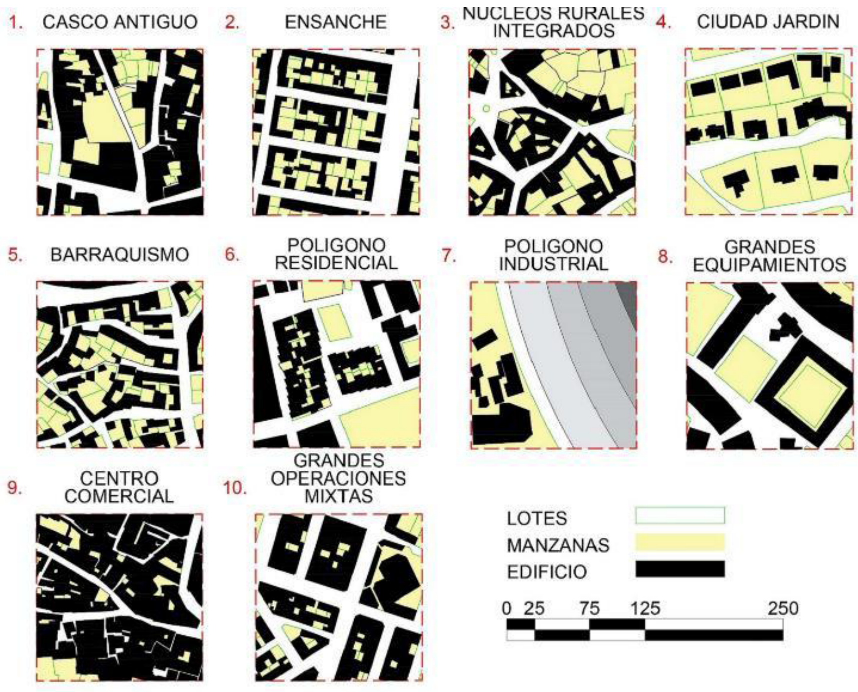

Figure 5. Urban stain of typological genes. Source: Prepared by the authors.

The quality of the public space was evaluated using a structured observation form and a questionnaire applied in situ, both designed based on the methodological lines of the Project for Public Spaces (PPS, 2023) (Table 3), and validated by expert judgment.

The observation sheet aimed to record the in situ physical and functional attributes of public spaces, organized into four dimensions (Table 3). This tool allowed researchers to assess each indicator with a Likert-type scale, strengthening the visual evidence with photographic records and photogrammetric mapping.

The questionnaire was administered to a significant sample of the inhabitants, investigating their perception on the same lines (Table 3). It consisted of closed questions with ordinal scales to measure the level of satisfaction regarding the functionality and quality of the public space. Thus, quantitative data were obtained that reflect the users' experience and assessment, allowing them to be contrasted with the structured observation findings.

Thus, the combination of both instruments made it possible to objectively evaluate the physical characteristics of public spaces, integrating the professional perspective of researchers with the perceptual sense of their users.

Finally, the results revealed the quality levels (high, medium, or low) of the public spaces evaluated according to the weights obtained.

V. RESULTS

IDENTIFICATION OF TYPOLOGICAL GENES

As a result of the historical-cartographic analysis of the urban plans of Chaupimarca (1862, 1951, and 2024), ten urban typological genes were identified. This process involved a comparative study of urban morphology over time, examining the persistence, transformation, or emergence of urban patterns. From this reading, sectors with formal features consistent with those described in the literature were identified (Table 1).

Each typological gene was spatially delimited according to its morphological, functional, and structural coherence. This made it possible to typify the sectors, distinguishing those with historical continuity since 1862 and others arising from more recent urban processes. The results show a typological mix in the district (Figure 4 and Figure 5).

An example of this evolutionary analysis, including the identification and delimitation of a typological gene, is illustrated

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in Figure 3, which shows the morphological evolution of the old town for 1862, 1951, and 2024.

CHARACTERIZATION OF TYPOLOGICAL GENES

The characterization of typological genes is structured based on three key morphogenetic dimensions: urban plan, land use, and building. These are synthesized graphically in Figure 6, Figure 7, and Figure 8, allowing the identification of specific characteristics and structural differences between the genes.

Urban plan – N-Diagram

Figure 6 (N-diagram) allows visualizing and classifying the typological genes of Chaupimarca according to three indicators: street width (X-axis), road density (Y-axis), and tare (blue curves). Each numbered point corresponds to one of the ten typological genes identified, typified in the respective legend.

The graph is divided into color areas representing five types (A, B-1, B-2, C-1, and C-2), which group the genes according to specific combinations of road infrastructure and proportion of public space:

- Type A (green): High over-dimensioning of the public space, with wide streets (>30 m), high tare (>60%), and medium road density.
- Type B (yellow): Medium oversizing, subdivided according to road density and tare ratio.
- Type C (pink/red): Low oversizing, narrow streets, and less availability of public space.

Gen 2 (Width) is located in the green zone (Type A), indicating that it features wide streets, high road density, and generous public spaces. In contrast, gene 10 (Large Mixed Operations) appears in the red area (Type C-2), reflecting a lower structural quality in terms of the proportion and accessibility of the public space.

Land uses - Functional urban mix model

Figure 7 permits classifying typological genes based on the proportion of three types of land use: residential, facilities, and work/commerce. Each vertex of the triangle represents 100% of one of these uses, and the intermediate points show proportional combinations.

Each red number indicates the position of a typological gene, typified in the respective legend. The location of each point in the triangle reflects the actual mix of uses within the corresponding area.

The background is divided into four tonal areas that indicate the level of multifunctionality:

- Mono-functional (light grey): One use exceeds 90% of the total. For example, the Industrial Estate (7).

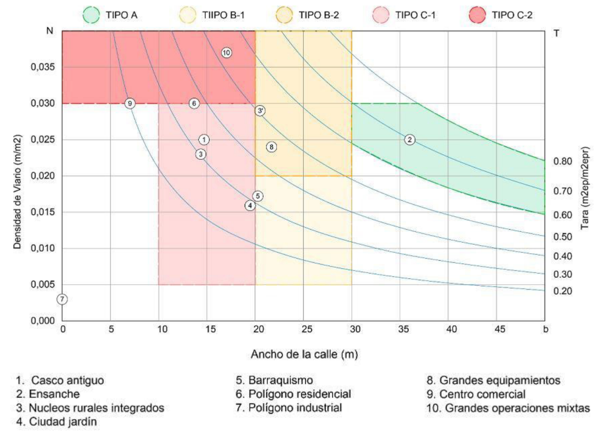

Figure 6. N-Diagram. Source: Prepared by the authors.

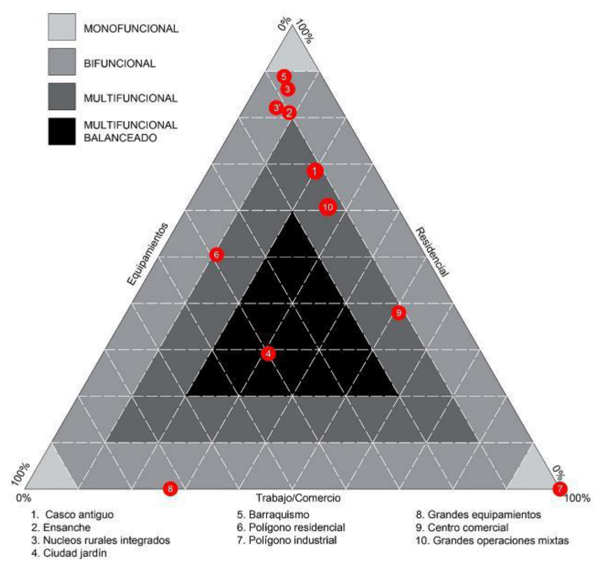

Figure 7. Functional Mix Model. Source: Prepared by the authors.

- Bifunctional (medium grey): Two uses predominate in relatively balanced proportions.
- Multifunctional (dark grey): All three uses are present, but with noticeable differences.
- Balanced multifunctional (black): The three uses are distributed proportionally, about 33% each. Only Garden City (4) is located here.

This classification enables the visualization of the diversity of functional structures within each area and how this diversity is related to its urban behavior.

Building features - Spacemate Graph

Figure 8 (Spacemate) classifies the typological genes according to their building characteristics, considering four indicators: space index (Lower side), average number of floors (upper side), amplitude (Right side), and built coefficient (Left side). Each numbered point represents a typological gene of the district, identified in the legend below.

The color areas delimit different morphological areas, defined according to the mentioned indicators, and show the relationship between constructive density and urban form:

- Traditional Compact Urban (dark orange): High land occupancy with low height.
- Dense Urban (pink): High building density with higher height, usually the result of formal planning.
- Dense Suburban (cream): Dense constructions, but without clear formal planning.
- Low-density Suburban (yellow): Low density, large urban voids, and scattered buildings.
- Garden City (light blue): Low density with detached

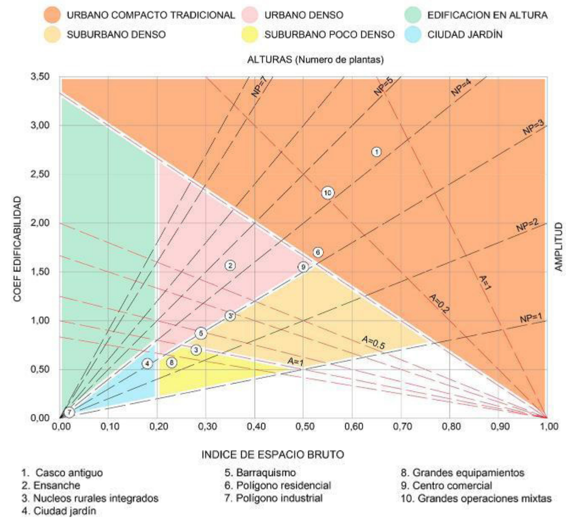

Figure 8. Spacemate graph. Source: Prepared by the authors.

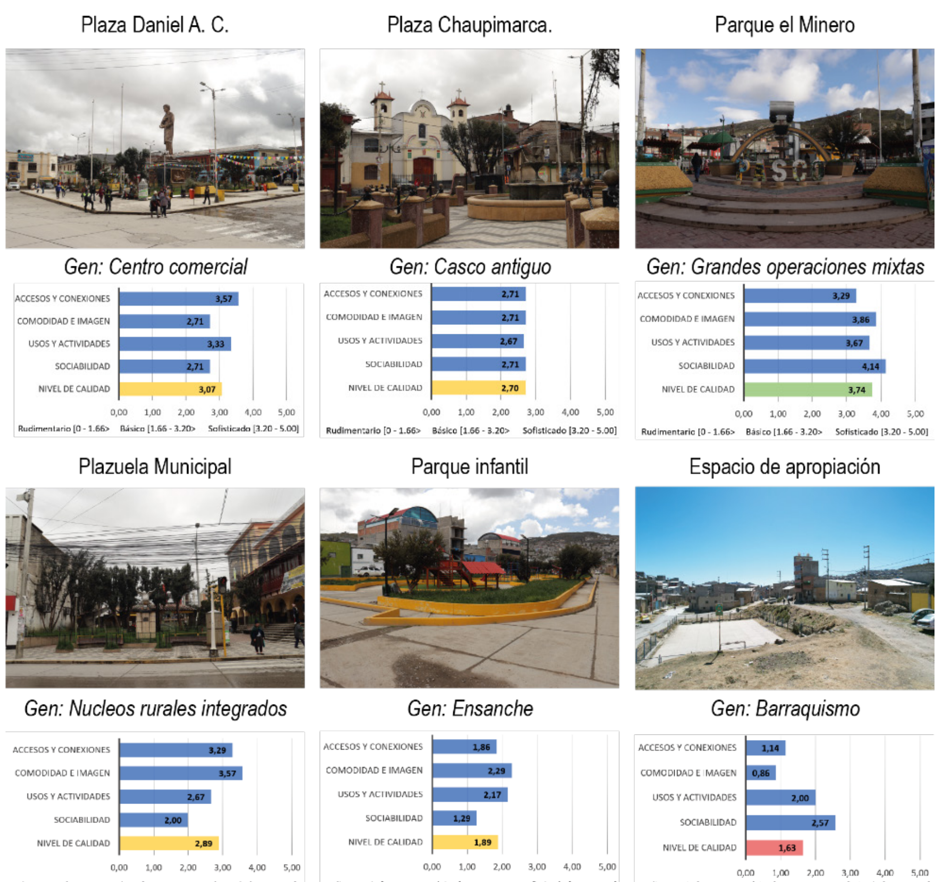

Figure 9. Quality of public space. Source: Prepared by the authors.

Code	Typological gene	N DIAGRAM	Functional urban mix model	Spacemate graphic
1	OLD TOWN	Low	Multifunctional	Traditional compact urban
2	WIDENING	Alto	Bifunctional	Dense Urban
3	INTEGRATED RURAL CENTRES	Low	Bifunctional	Sparsely Populated Suburban
4	GARDEN CITY	Low	Multifunctional	Garden city
5	TEMPORARY HOUSING	Medium	Monofunctional	Dense Suburban
6	RESIDENTIAL ESTATE	Low	Multifunctional	Traditional compact urban
7	INDUSTRIAL ESTATE	Low	Monofunctional	-----
8	LARGE FACILITIES	Medium	Bifunctional	Sparsely Populated Suburban
9	SHOPPING CENTERS	Low	Multifunctional	Dense Urban
10	LARGE MIXED OPERATIONS	Low	Multifunctional	Traditional compact urban

Table 4. Summary of morphogenetic characterization. Source: Prepared by the authors, based on Figures 6, 7, and 8.

Urban morphogenetics		Quality of public space
Level-of-Over-dimensioning of public space-(Urban plan)	Correlation coefficient	-0.456
	Sig.(bilateral)	0.363
	N	6
Functional Urban Mix- (land use)	Correlation coefficient	0.822
	Sig.(bilateral)	0.045
	N	6
Built nature- (Building)	Correlation coefficient	-0.609
	Sig.(bilateral)	0.199
	N	6
General morphogenetic nature	Correlation coefficient	-0.456
	Sig.(bilateral)	0.363
	N	6

Table 5. Spearman's correlation. Source: Prepared by the authors.

houses and significant frontal setbacks.

- High-rise buildings (green): High density where buildings of considerable height predominate; no typological gene in Chaupimarca is circumscribed in this area.

The Industrial Estate (7), due to its closed character and the virtual absence of buildings, is not circumscribed in any of the areas shown.

EVALUATION OF THE QUALITY OF PUBLIC SPACE

Six representative public spaces were evaluated, each linked to a different typological gene. This is because only six of the ten typological genes identified in the district have consolidated public spaces that allow their analysis. Observation cards and surveys were applied to a sample of 264 inhabitants, distributed proportionally according to the estimated number of users of each space, as determined by a preliminary survey.

Each public space was analyzed following the PPS model. The results of the observation sheets and surveys were averaged to obtain an overall assessment by space, ensuring an integrated evaluation from both perceptual and technical perspectives.

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The results show an uneven quality of public space in Chaupimarca. The space associated with the temporary housing gene obtained the lowest score (1.63), primarily due to its fallow condition and low accessibility, despite its sociable nature. In contrast, the space linked to Large Mixed Operations achieved the highest score (3.74), with consolidated conditions. The other spaces presented intermediate values (1.89 to 3.07), reflecting deficiencies linked to morphology and appropriation. Overall, it is concluded that the quality of public space is primarily low, mainly due to morphological and infrastructural inequalities between the different typological groups analyzed.

INFERENTIAL STATISTICAL ANALYSIS

The relationship between the variables was determined by the Spearman correlation coefficient, a non-parametric method ideal for ordinal data (Casas Sánchez et al., 2010). This analysis assessed the quality levels of the public space obtained (Figure 9), evaluated based on the PPS model, in conjunction with the three morphogenetic dimensions identified according to the Conzen (1960) approach: urban plan, land use, and building (Table 4).

The results reveal that the built nature and urban plan have no significant correlations with the quality of public space, showing a weak and statistically unreliable influence. In contrast, land use showed a positive and significant correlation (Rho = 0.822; $p < 0.05$), suggesting that a homogeneous functional mixture is associated with higher-quality public spaces (Table 5).

A slight statistical significance relationship was found between morphogenetics and the quality of the public space in Chaupimarca (R = -0.856; $p > 0.05$), indicating that morphogenetic characteristics do not significantly determine the quality of public spaces. This result, which cannot be generalized, is specific to the conditions of the case studied.

VI. DISCUSSION

This research presented the necessary limitations to be known, in order to contextualize the scope of its results. Firstly, the absence of similar urban studies in the district limited the possibility of contrasting the findings with local research, forcing turning to external referents.

Secondly, not all the typological genes identified had public spaces that could be evaluated. This situation reduced the universe of analysis between both variables, limiting the representativeness of the results.

Despite these limitations, the study lays important foundations for future research in complex urban contexts and proposes a methodology replicable in other similar realities.

Although the results show that the morphogenetic nature can slightly influence public spaces, it does not significantly determine or condition their quality. This aligns with what was proposed by De Santiago Rodríguez and Prada Llorente (2021), who identified a disconnect between urban planning, the preservation of traditions, and the urban landscape. Both agree that the lack of integration between urban layouts and planning strategies can negatively affect the quality of public space.

In this sense, it is proposed that an articulation between urban morphogenetics and territorial planning improves the quality of public space, a perspective supported by the contributions of Maretto et al. (2023), who conclude that a comprehensive assessment of morphological factors is essential. Both studies suggest that an understanding of public space requires a multidimensional methodological approach.

It was evidenced that the spatial distribution of land use enhances the quality of public space, coinciding with Martino et al. (2021), who identified that urban-functional distribution is a determining factor for socio-economic habitability, maintaining that the multifunctional configuration of urban land is key in plans aimed at improving public spaces. This is reinforced by what has been pointed out by Pesántez-Yepez and Cabrera-Jara (2024), who demonstrate how the morphological conditions of the peripheries directly influence the quality of habitability. Thus, both studies agree that an adequate distribution of urban elements is essential.

On the other hand, the results obtained by Orellana Tapia and Ruiz Sánchez (2020) showed that, in Cusco, the urban form maintains historical coherence, positively influencing the quality of its public spaces. On the contrary, this study reveals that, in Chaupimarca, the influence of morphogenetics on the quality of public space is not decisive. This contrast responds to differences in the context between the two cities. In Chaupimarca, the absence of a significant relationship suggests that other external factors could have a more decisive influence on the quality of public spaces. This comparison highlights the importance of considering the local context in the analysis, in line with Zelelew and Mamo (2023).

Finally, the identification and characterization of the typological genes provide a quantifiable overview of the urban reality of Chaupimarca, establishing priorities among these typological genes. This aligns with

Fleischmann et al. (2022), who obtained similar results in their respective study, thus reinforcing the methodological versatility of the morphogenetic approach.

VII. CONCLUSIONS

The research reinterprets the traditional morphological approach through a morphogenetic lens, applying it to the Chaupimarca district, which allowed identifying ten typological genes that configure its urban structure. This approach offered analytical tools to understand not only the physical forms of the territory, but also the processes that sustain them.

Among the identified genes, it was observed that some present more structured and coherent urban layouts in terms of the organization of the urban plan, land use allocation, and building consolidation. Such is the case of the Widening, the Garden City, and the Large Facilities, whose characteristics reflect a greater internal functionality. In contrast, others, such as the Industrial Estate and the Old City, reveal conditions of spatial fragmentation, infrastructural weaknesses, and low morphological cohesion. This characterization identified patterns that enrich the morphofunctional reading of the territory and show the potential of morphogenetics in urban analysis.

The evaluation of the public spaces revealed contrasts between the different morphogenetic environments of the district. The Widening typological gene, for example, received the best rating by excelling in dimensions such as accessibility, maintenance, and functionality of the space, reflecting a more orderly urban configuration that is consistent with the user's needs. On the other hand, the public space, framed within the Temporary housing typological gene, had a low quality, with deficiencies in infrastructure and management, reflecting a precarious morphological structure. This disparity shows that the quality of public space depends not only on its surface design, but also on the internal logics of urban configuration.

However, using the Spearman correlation, a statistically insignificant relationship was found between urban morphogenetics and the quality of public space. This finding fills a gap in the scientific literature, demonstrating that structural, building, and land use characteristics, by themselves, do not determine the quality of public space; instead, factors such as socio-economic or institutional influences exert a more significant influence.

The results show that the degree of functional mix (land use) of the typological gene has a positive influence on the quality of public space. This condition not only promotes long-term urban transformations but also encourages greater attention to the aesthetic and functional qualities of the built environment, resulting in attractive public spaces that are adapted to the needs of the user.

Finally, and despite the insignificant correlation, typological genes emerge as a key analytical tool for urban planning, providing a deeper understanding of the territory. Their analysis, therefore, is valuable to support comprehensive and contextualized proposals.

VIII. CONTRIBUTION OF AUTHORS CRediT:

Conceptualization, P.D.S.; Data curation, N.H.L.; Formal analysis, P.D.S.; Acquisition of financing, F.A.V.; Research, P.D.S. And N.H.L.; Methodology, P.D.S.; Project management, N.H.L.; Resources, F.A.V.; Software, P.D.S.; Supervision, N.H.L.; Validation, C.M.V., N.H.L., L.M.Z..; Visualization, P.D.S.; Writing - original draft, P.D.S.; Writing - revision and editing, P.D.S.

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