LEX LOCALIS-JOURNAL OF LOCAL SELF-GOVERNMENT
ISSN:1581-5374 E-ISSN:1855-363X
VOL. 23, NO. S6(2025)

URBAN VACANT LOTS AND UNDERUTILIZED PUBLIC PROPERTIES, AND THEIR CATALYTIC POTENTIAL FOR CITIZEN SECURITY AND SOCIAL INTEGRATION IN THE DISTRICT OF VILLA EL SALVADOR - LIMA

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Summary
The research provides an integrated diagnosis of urban voids and underutilized public properties in Villa El Salvador, Lima, combining GIS mapping, surveys, and spatial analysis; 214 units were inventoried totaling 93.6 ha, with a median parcel size of 3.2 ha, reduced visibility in 59%, and high deterioration in 34%. An operational typology and a catalytic potential index weighing physical, social, and security domains are proposed. Monte Carlo validation showed an average stability of 0.88, and prioritization identified 20 properties concentrating 31% of the total area with scores between 0.78 and 0.94 and an intervention threshold of 0.75. Spatial correlation between the index and reported thefts was r = 0.46, and SAR models estimated that a 10% increase in void density predicts a 1.8% rise in property crimes. Citizen perception associates 68% of the voids with insecurity, and spontaneous use reached 12%. Intervention proposals are articulated into tactical, mixed, and permanent scenarios based on CPTED, co-management, and tactical urbanism. The research contributes methodological and operational criteria to prioritize municipal actions and design pilot evaluation programs.

Key words: Urban Planning; Urban Rehabilitation; Human Settlements; Urban Areas; Urban Sociology.

INTRODUCTION

Latin American cities face increasing challenges linked to the disorderly expansion of land use. Underutilized public properties and urban vacant lots remain without clear management or defined social function. These spaces emerge as symptoms of fragmented urban planning, institutional weakness, and deep inequalities that limit social cohesion, citizen security, and quality of life in popular districts. Villa El Salvador in Lima combines a history of self-managed popular urbanization with a current urban fabric abundant in vacant lots, abandoned state properties, and infrastructural strips without clear use, causing potential losses of public space, community opportunities, and worsening perceptions of insecurity.

Previous international studies have documented the positive effects of physical interventions on vacant lots in U.S. cities through randomized trials. Branas, South, Kondo, Hohl, Bourgois, Wiebe, and MacDonald show that restoring deteriorated lots reduces violence and theft and improves the perception of safety [1]. Garvin, Cannuscio, and Branas demonstrated that "greening" vacant lots enhances the sense of security among nearby residents [2]. MacDonald, Nguyen, Jensen, and Branas identify that surrounding land uses modulate the effects of such interventions and develop a typology of vacant lots as a tool to manage these spaces [3,4] have proposed evaluation methods and urban regeneration typologies applicable to diverse contexts.

Research such as "Effects of greening and community reuse of vacant lots on crime" demonstrates that community interventions like community gardens or greening clean-ups reduce specific crimes such as assaults and theft when properly applied, using difference-in-differences comparing treated

and untreated lots [5] show that the effect of "vacant lot greening" on crime is greater in residential and civic areas with low public transportation presence and businesses that attract illicit activities [6]. There is also evidence that adult mental health improves after greening interventions in vacant lots. South, Hohl, Kondo, MacDonald, and Branas associate these interventions with reductions in depression, feelings of worthlessness, and improvements in psychological well-being [7].
colonial Andean murals in teaching the Catholic religion. The pigments used included metals like gold and silver, derived from minerals such as ochre or natural earths that impart earthy and warm colors. Additionally, malachite, along with green earths, contributed to the landscapes' hues, as did natural pigments like indigo and cochineal.
In identifying Cuzco art throughout history, three important periods can be recognized: the pre-colonization period, the colonial period, the republican era, and the present day. In all of these, mineral pigments have played a significant role in various artistic expressions.

Rock art in the Cuzco valley prior to colonization.
The rock paintings of Cuzco are a valuable testament to the history and culture of the ancient civilizations of the region. Some of the pigments commonly include iron oxide, which is used to produce reddish and ochre colors; charcoal used to make black paint; and copper sulfate, which is used to create blue and green dyes (Guffroy, 2015). Ancient artists also employed a variety of techniques, including brushes made from natural materials such as plant fibers or animal hair, and applied paint directly with their fingers or with tools made of bone or sHue (National Institute of Culture, 1986). These paintings served ritual or communicative functions and reflect the beliefs and experiences of ancient civilizations. Furthermore, rock images might have served as a way to delimit territory or record important events (Lumbreras, 2015).

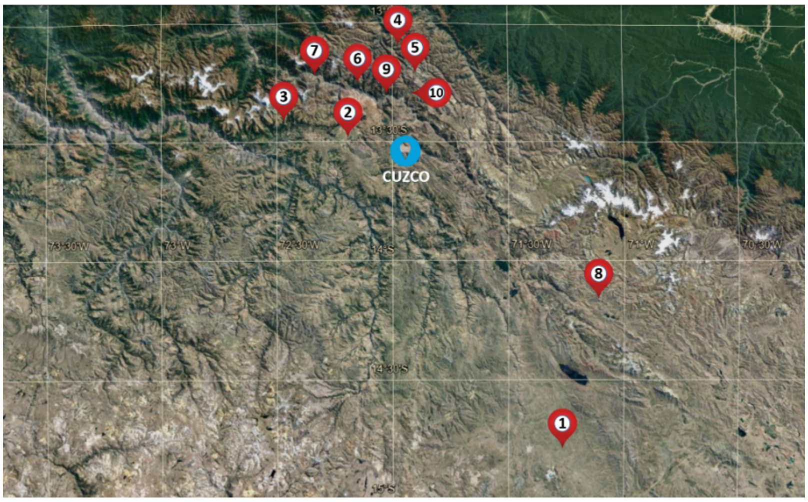

Figure 1. Location of rock paintings in the Cuzco Region (1. *Espinar*, *2. Intiyoq Maraskay*, *3. Llamachayoq Qapa*, *4. Llamayoq*, *5. Banderayoq*, *6. Inkapintay*, *7. Kechuqaqa*, *8. Intimarkana*, *9. Chichero*, *and 10. Yucay.*

The recorded existence of inorganic pigments used in cave paintings in the Cuzco region primarily encompasses the Andean region, concentrating in the area known as the Sacred Valley of the Incas, covering cities such as Yucay, *Intiyoq Maraskay* (Ccorca), *Intimarkana* (Combapata), *Banderayoq* (Calca), *Kechuqaqa* (Ollantaytambo), *Inkapintay* (Urubamba), among others (Figure 1). The motifs of the cave paintings in the Cuzco valley include representations of South American camelids both individually and in groups, geometric figures, possibly representing the sun and stars, and even humanoid figures like those found in the district of Ccorca (Figure 2).

Figure 2. Representation of motifs in the cave paintings present in Cuzco
Note: The cave paintings in the Cuzco Valley are documented at the National University of San Antonio Abad of Cuzco.

Colonial Paintings

The paintings of the Cuzco School have a rich history and tradition in the use of color (Figure 3). Artists from Cuzco used a variety of pigments to create their art (Girard, 2023). These pigments come from soils, plants, minerals, and insects. One of the most commonly used pigments is ochre, which is obtained from clay deposits rich in iron oxides (Balta Campbell, 2009).

Figure 3. Mural painting of the Cuzco School. From left to right, above: façade with mural painting of the Church of Andahuaylillas, mural painting in the coffered ceiling of the Church of Huaro, Baroque mural painting on the walls of the Church of Andahuaylillas. Below: The three murals correspond to the walls of the Church of Huaro, showcasing the technique of the Baroque painter Tadeo Escalante and other unidentified artists.

The scanning electron microscopy (SEM) tests conducted by Balta Campbell were applied to samples of colonial Andean paintings from Cuzco. Red, ochre, and base colors with variations were detected. Chemical elements such as sulfur, metallic mercury, lead, aluminum, silicon, chlorine, calcium, iron, carbon, and oxygen were recorded in various samples (Balta Campbell, 2009). Among the highlighted inorganic pigments is Vermilion (Paria or llimpi), extracted from mines in the central highlands of Peru. This pigment was mixed with white lead pigment and applied over a layer of yellowish ochre to enhance the skin Hues in the paintings. White lead (albayalde), imported from Spain but also mined in southern Peru, was also used. Other mentioned pigments include azurite, indigo, hematite (almagre) characteristic of the red soils of Cuzco, and yellow ochre (quellu) present in the representations of flowers and vases as depicted in figure 4 (Siracusano & Maier, 2005).

Figure 4. Mural painting of the Cuzco School

Note: The mural paintings of the Cuzco School found in the San Bernardo House depict religious scenes, such as the life of Jesus and the saints, as well as landscapes and portraits of important figures from the 17th century.

Paintings from the Republican period

During the Republican period of Cuzco, many artists continued to use earth pigments in their works to connect with the traditional and ancestral techniques of Cuzquenian painting. These pigments came from different parts of the region and were used to create the various colors depicted in canvases and murals. A notable example of the use of soil pigments from Cuzco is the work "The Bound Indian" by the renowned Cuzquenian painter Juan José Bueno. In this piece, Bueno used the color of the earth to represent the image of a bound native, symbolizing the oppression of the time and the struggle for freedom. The ochre and earthy colors of the painting provide a sense of authenticity and a connection to the land of Cuzco (De Mesa, 1982).

Another relevant example is the work of painter Rafael Santa Cruz titled "Cuzquenian Landscape." In this painting, Santa Cruz utilized earth-Hue pigments to represent the diverse colors of Cuzquenian nature, such as the greens of the fields and the ochres of the mountains. These pigments impart a sense of roots and authenticity to the landscape, capturing the essence of the area. The ochre provides warm Hues and brown shades that are used to depict landscapes, figures, and architectural elements in republican paintings. In addition to ochre, pigments from manganese-rich clays were also employed.

The use of Siena provided the yellow and ochre Hues used to represent skin, fabrics, and other elements in Cuzco paintings Mujica (2012). Red cinnabar, obtained from mercury, was also utilized to achieve intense red shades using the tempera technique (Figure 5).

Figure 5. Representations of religious scenes by the Baroque painter Tadeo Escalante. Left: mural painting "The Triumph of Death" or "The Dance of Death" from the Gospel in the church of San Juan Bautista de Huaro. Right: "The Last Judgment" belongs to the Cuzco School, (1802).

The Production of Artisan Paintings Today

Currently, there are initiatives in different South American countries to produce paints from mineral pigments obtained from the surrounding territory. This allows, on the one hand, to recover the chromatic identity of a place and favour the color palettes typical of local tradition, as well as to provide an opportunity to stimulate the local artisanal economy. In Ecuador, there are experiences of ecological and economic alternatives for the production of artisan paintings, focused on the production and application of colored earths, aimed at preserving architectural heritage and enhancing contemporary buildings. Experiences were gathered from local builders who applied colored earths for the artisanal production of paints, thereby identifying and safeguarding the traditions, techniques, and materials of the region. The typical historical colorimetric palette of exterior walls of heritage buildings was cataloged; similarly, paintings were reproduced with chromatic approaches to the originals (Amaya Ruiz et al., 2018).

There are experiences of ecological and economic alternatives to the protection of adobe walls using earth colors. Ana Aracelia Quiteño (2018), a civil engineer from the Faculty of Engineering and Architecture at the Pontifical Catholic University of El Salvador, conducted the research. The study's purpose was to experiment with colored soil by mixing it with lime and polyvinyl acetate to produce ecological and economical paints in various shades. To achieve this, soil samples from different regions of western El Salvador were collected, tested, and analyzed to determine their chemical and mineral composition. Once the sifted earth was obtained, a variety of natural colors were produced consisting of a base, a binder and colored earth. Water was used as the vehicle, while slaked lime and polyvinyl acetate served as the binders. Additionally, the use of earth Hues contributes to the preservation of the community's culture and identity through traditional materials and techniques (Quiteño, 2018).

It is evident, therefore, that natural pigments have been integral to the artistic manifestations of the Cuzco region in Peru throughout its history, spanning pre-colonial, colonial, and republican periods, with examples of mural paintings and architecture of undeniable artistic value. Currently, there are initiatives aimed at reviving the use of local mineral pigments in the production of artisanal paints, although these have been developed in countries other than Peru. The production of artisanal paints could represent an ecologically sustainable alternative for the economic development of local communities in Cuzco. However, there is no colorimetric characterization study of the paints that could be obtained from such mineral pigments. Therefore, the objective of this article is to carry out a colorimetric characterization in Natural Color System (NCS) of the colors obtained from mineral pigments extracted in the Cuzco area in Peru, using different extraction and dosage systems.

MATERIALS AND METHODS

This section describes (1) the characteristics and location of the quarries in the Cuzco valley from which pigment samples were extracted, (2) the process of extraction and preparation of the pigments, (3) the process of paint manufacture, and (4) the colorimetric characterization in NCS.

1. Pigment quarries located in the Cuzco valley

The city of Cuzco is characterized by a diverse geomorphology, allowing it to possess a variety of soil quarries with inorganic pigments that offer a wide range of colors. This research produced a series of 13 paints using these pigments.

One of the most notable minerals in the geology of Cuzco is iron oxide, which appears as hematite and goethite present in the south of the city, characterized by the production of semi-industrial bricks for the construction sector. These minerals create the red and ochre Hues used in the region's traditional paints. In addition to iron oxide, other inorganic minerals have been found, such as copper oxide, which has green and blue hues located southeast of the city in the area known as ENACO, and manganese oxide, which has black and brown Hues found in the peripheral area of the city (community of Pumamarca).

Found in the geology of the city of Cuzco, these inorganic pigments were used by pre-Columbian cultures in the area, such as the Incas. Extracted from nearby mines, these pigments are processed to create artistic colors.

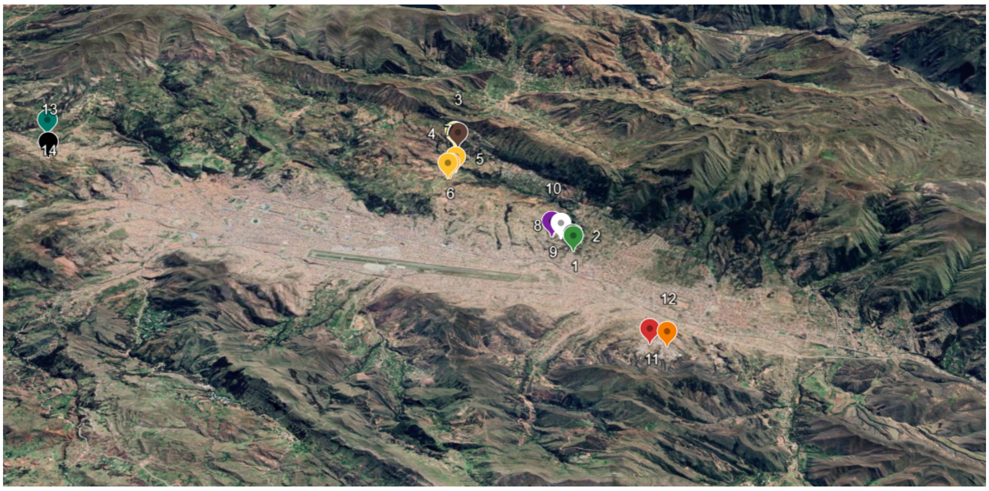

Figure 6. Location of quarries in the Cuzco Valley

2. Extraction and Preparation of the Pigment

Once the designated extraction point is identified, samples are collected following the steps outlined below:

Surface cleaning of the selected area to remove organic matter, such as roots, stems, leaves, and other elements that could alter the pigment's color.

Excavation of the surface layer of the ground to remove impurities caused by exposure to environmental factors such as rain and sun, as well as the presence of animals and other agents that significantly influence the contamination of the samples.

Sample extraction using manual means, such as a pick and shovel, with the extracted fragments stored in a polypropylene bag to ensure their preservation during transport.

Coding of the extracted samples by assigning unique identifiers for precise tracking.

For the pigment preparation process, various stages were followed to ensure the consistency and quality of the final product, and precise protocols were implemented for their handling and processing. The following stages were developed for this purpose:

Natural drying: The samples were placed on plastic surfaces to prevent moisture absorption and were exposed to sunlight and local climatic conditions for a period of 3 days.

Coarse grinding: The grinding process was carried out using traditional tools, such as a hammer and/or mallet, to reduce the particle size to no more than two centimeters.

Sieving: In the sieving process, ASTM sieve mesh number 20 was used with an opening of 850 μm (micrometers) or 0.85 mm. This mesh was precisely selected, considering the specific dimension of the opening, to allow the controlled passage of particles smaller than the established value. Sieving, as a method of granulometric separation, involves applying vibrations to the mesh, which facilitates the passage of smaller particles while retaining those whose size exceeds the opening.

After the general sieving, the samples are divided into two groups, weighing them in 1 kg samples that will undergo two methods of pigment extraction: the first called sedimentation (MS) and the second obtained through ball milling (MG).

Sedimentation (MS): In this method, the goal is to achieve the pigment with the highest integrity and quality, for which a liquid grinding process is carried out. This procedure begins with the addition of a precise proportion of 3 liters of water and 1 kg of sample in a container. Next, mechanical disintegration is performed using a stainless-steel Cowles disk, which is coupled to a galvanized threaded rod of 3/8". This rod is secured to the rotor of a motor, initiating a crushing process that lasts for 15 minutes. Upon completion of the crushing process, the mixture is allowed to rest for 24 hours. During this phase, a natural decantation occurs, where pigment particles settle at the bottom while organic matter remains on the surface. Subsequently, water containing organic matter is extracted using a 1/2" levelling hose. This device allows for the selective absorption of the contaminated liquid, leaving only the pigment intact. Finally, the wet mixture is poured into galvanized trays, which are then placed in a dehydration oven to remove residual moisture and sediment the pigment. The oven operates continuously for two days at a temperature of 100°C, allowing for gradual and controlled dehydration. At the end of this process, the final percentage of pigment is obtained, exhibiting optimal characteristics, ready for application.

Ball Milling (MG): This procedure is carried out by introducing 100g of sample into the container of the ball milling equipment, which contains 12 porcelain balls. Once the container is sealed, it undergoes the milling process for periods of 20 minutes each time until a powdered sample is obtained, which is then screened through sieve No. 4. At the end of each milling period, the porcelain balls are removed, and the pigment is weighed until specific groups of 1 kg of pigment are formed.

Once the milling of each sample is completed, general cleaning of the balls and container is performed using 100g of quartz sand, which is rotated for periods of 20 minutes. This process is repeated until it is observed that the pigment does not adhere to the walls of the container and the surfaces of the balls. The contents are poured through a mesh that retains the balls while allowing excess material to pass; once completed, the milling process is repeated with the next color sample. The result is the production of the pigment that will be used in paint manufacturing (Figure 7).

Figure 7. Pigments obtained by sedimentation and bead milling

3. Design and Production of Paint

The paint production was formulated using water as a diluent, inorganic pigment, and polyvinyl acetate as a synthetic binder, along with potable water as a binding agent.

The production process consisted of the following steps:

I. Calculation of Pigment Yield: Prior to weighing each of the samples, the samples were homogenized using a "Cowles" mechanical agitator adapted to a drill at 2800 rpm for 10 minutes. Subsequently, the samples were weighed, placed in a dehydrator oven for 24 hours, and weighed again to calculate the pigment yield in each dispersion.

II. Preparation of the Dispersions: Each dispersion was homogenized again using a "Cowles" mechanical agitator adapted to a drill at 2800 rpm for 10 minutes.

III. Addition of solvent (water): According to the proportions designed in the experiment, 1 part of pigment was mixed with 30% water as a solvent. The mixing was performed using stainless steel paddles with star-shaped blades, also made of the same material, which help to liquefy the pigment and convert it into an aqueous solution.

IV. Addition of binders: The dosing was planned under serial repetitions considering two blocks: the first with pigments obtained from sedimentation (MS) and the second from milling (MG); each was mixed volumetrically, altering the proportion of the synthetic binder. These were gradually added using a "Cowles" mechanical stirrer adapted to a drill operating at 2800 rpm, over a period of 15 minutes (Table 1).

V. Measurement of viscosity: After completing the mixing of the pigment dispersion, the viscosity was measured using a Ford cup viscometer, with an estimated time between 14 and 16 seconds. If the viscosity does not meet the specification—specifically, if the sample takes less than 14 seconds—it indicates that the mixture lacks the appropriate viscosity. In this case, 10 ml of water is added and mixed again. If the desired viscosity is still not achieved, the process is repeated, adding 10 ml each time until the required viscosity is reached. If it exceeds 16 seconds, this indicates that the mixture is very fluid, so adjustments should be made by adding 10g of pigment at a time until reaching the required viscosity time of 14 to 16 seconds.
VI. Storage: The paints were stored in five-liter containers.
VII. Application of Paint: For the application of the samples, test pieces measuring 25cm x 50cm were cut from 4 mm thick Superboart ST fiber cement sheets. A first layer of sealer made from stretched acrylic latex resin (brand CPP) was applied to these test pieces; it took 4 hours to dry. After drying, a wall primer made from stretched acrylic latex resin (brand CPP) was applied. Following an additional 2 hours of drying, the surface was smoothed with #180 sandpaper, repeating the process until the desired finish was achieved. Once the test pieces were sanded, they were cleaned with a dry brush to remove any dust, and then the first layer of paint was applied using a #22 brush in one direction. After the first layer was applied, it was left to rest for 4 hours before applying the second layer of paint, thus completing the process. This procedure was repeated for each color and each dosage scheduled in the research.
The proportions of the thinner varied depending on the characteristics of the pigments and paint formulations, making it impossible to define them a priori. The proportions were determined by viscosity.

4. Colorimetric characterization of the samples:

The colorimetric identification of the samples was conducted through visual comparison by 3 expert observers with normal color vision, illuminating the samples with a D65 illuminant in a Verivide light booth and utilizing the NCS Atlas 2050. The Natural Color System (NCS) is a perceptual color model based on the theory of opposite perceptual colors, which identifies colors according to their *blackness* in percentage, their *chromaticness* in percentage, and their hue, based on the position of the color on a color wheel with 4 main hues and 9 intermediate hues.

RESULTS

Table 2 describes the color notation of the various samples in NCS, based on the dosages of polyvinyl acetate (20%, 40%, and 60%) and whether the pigments were obtained through sedimentation (MS) or villa milling (MV). Figure 8 provides a visual approximation of the colors of the analyzed samples.

SAMPLE	Polyvinyl Acetate Dosage					
	MS 20%	MG 20%	MS 40%	MG 40%	MS 60%	MG 60%
M-01	S 2005-Y50R	S 1010-Y30R	S 2005-Y50R	S 1010-Y30R	S 3010-Y70R	S 1020-Y20R
M-02	S 0505-Y50R	S 1005-Y30R	S 1005-Y30R	S 1005-Y30R	S 1005-Y30R	S 1005-Y30R
M-03	S 2030-Y20R	S 2030-Y20R	S 3030-Y20R	S 2040-Y20R	S 3040-Y30R	S 3040-Y20R
M-04	S 1010-Y30R	S 2005-Y40R	S 1010-Y30R	S 2005-Y40R	S 1010-Y30R	S 2005-Y40R
M-05	S 2030-Y20R	S 1010-Y20R	S 2020-Y20R	S 2020-Y20R	S 1020-Y10R	S 3040-Y20R
M-06	S 4020-Y70R	S 4020-Y70R	S 5020-Y60R	S 4020-Y70R	S 5020-Y70R	S 4020-Y70R
M-07	S 2005-G90Y	S 2005-G80Y	S 2005-G90Y	S 3010-G80Y	S 2005-G90Y	S 3010-G90Y

M-08	S 1010-Y20R	S 1005-Y20R	S 2020-Y10R	S 2010-Y20R	S 3020-Y10R	S 3020-Y10R
M-09	-	-	-	-	-	-
M-10	S 2030-Y30R	S 2040-Y20R	S 2040-Y30R	S 2040-Y30R	S 3040-Y30R	S 2040-Y30R
M-11	S 2030-Y20R	S2020-Y20R	S 2030-Y20R	S 2020-Y20R	S 3030-Y20R	S 2030-Y20R
M-12	S 3010-Y60R	S 3010-Y60R	S4010-Y50R	S 4010-Y50R	S 4010-Y50R	S 4010-Y50R
M-13	S 8005-Y20R	S 8005-Y20R	S 8005-Y20R	S 8005-Y20R	S 8005-Y20R	S 8005-Y20R
M-14	S 4020-Y70R	S4020-Y80R	S 4020-Y70R	S 4020-Y80R	S 4020-Y80R	S 4020-Y70R

Table 1. Characterization of visual appearance according to NCS, considering the binder addition dosages (polyvinyl acetate) at 20%, 40%, and 60%, compared by type of grinding (MS = Sedimentation; MG = Villa Milling). Sample M-09 was not included as the pigment did not form paint.

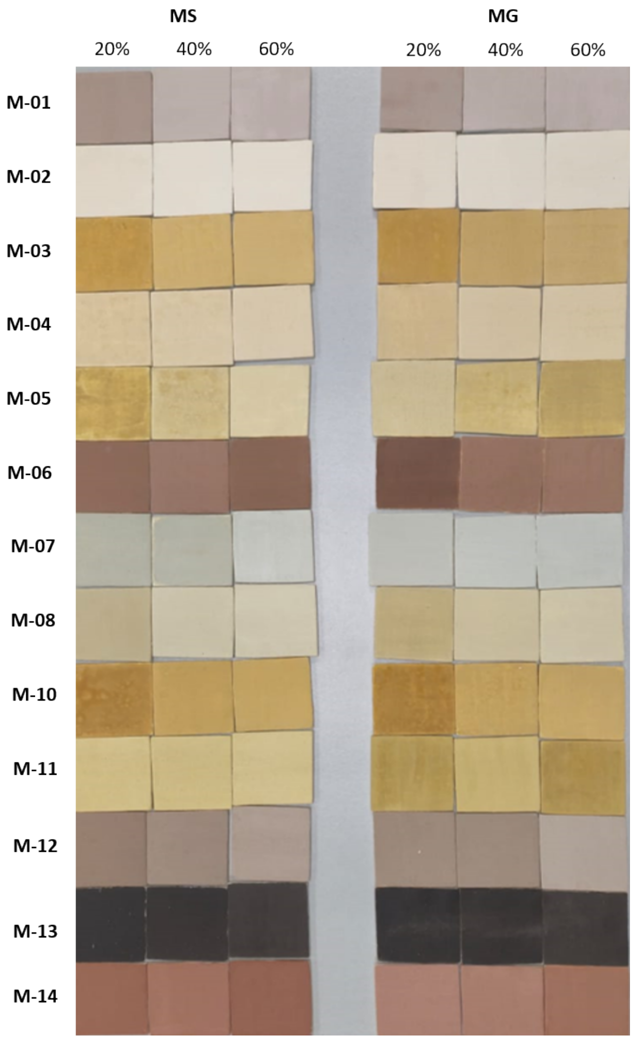

Figure 9. Graphical comparison of samples with the addition of polyvinyl acetate at 20%, 40%, and 60% between paints derived from pigments by sedimentation (MS) and ball mill grinding (MG).

ANALYSIS OF RESULTS

After obtaining the colorimetric characteristics of the colors in NCS, a comparison was made of the MS sedimentation samples (MS) and the ball mill grinding samples (MG)to determine if there were perceptible differences in the colorimetric characteristics of the colors based on the pigment extraction method. Similarly, a comparison was made to determine perceptible differences in the colorimetric characteristics of the colors based on the concentrations of polyvinyl acetate (PVA) at 20%, 40%, and 60%. For each pair of samples, the difference in blackness (ΔS), difference in chromaticness (ΔC), and difference in hue (ΔH) were obtained according to the extraction method (MS, MG) and the concentrations of PVA.

Results according to the pigment extraction method MS-MG

Previous research indicates that the visual characteristics of paint color are related to the particle size of the pigments it contains (Cardoso, 2020). Thus, the mineralogical composition of the pigments can be a primary factor influencing aggregate stability and optical properties. In this context, the pigment extraction method MS and MG might influence the color notation in NCS.

Considering the pigment extraction method MS-MG, when making the 39 comparisons of the 78 samples studied, we observe that, regarding the blackness, in 24 ΔS=0, in 8 ΔS=+10, in 1 ΔS=+20, in 5 ΔS=-10, and in 1 ΔS=-20. It is observed, therefore, that in more than 50% of the samples, the color blackness is not altered by the pigment extraction method MS or MG (Table3).

Regarding color chromaticness, of the 39 comparissons, 23 showed ΔC=0, 4 showed ΔC= +5, 3 showed ΔC=+10, 1 showed ΔC=+20, 4 showed ΔC=-5, 3 showed ΔC=-10, and 1 showed ΔC=-20. Thus, it is observed that in 50% of the samples, the chromaticness of the color is not affected by the pigment production system MS or MG.

Regarding the color hue, of the 39 comparisons, 22 showed ΔH=0, 8 showed ΔH=-10R, 3 showed ΔH=+10R, 2 showed ΔH=+10Y, 3 showed ΔH=+20R, and 1 showed ΔH=+50R, indicating varying distances from the primary colors R and Y in the NCS color circle. It is observed that in 52% of the samples, the color Hue remains unaltered by the pigment extraction methods MS or MG.

Considering all of this, it is observed that most of the paintings do not show differences in their colorimetric variables NCS hue, blackness, or chromaticness, regardless of whether the pigment was obtained using the MG ball milling method or the MS sedimentation method. However, there are samples such as M01, M04, M05, and M07 that do exhibit greater differences depending on whether MS or MG is employed (table 3).

Sample	**Δ (MS - MG)**	**Polyvinyl acetate content**			**Observation**
		20%	**40%**	**60%**	
M-01	Δ S	**+10**	**+10**	**+20**	$S_{MS} > S_{MG}$ in all dosages
	Δ C	**-5**	**-5**	**-10**	$C_{MS} < C_{MG}$ in all dosages
	Δ H	**+20R**	**+20R**	**+50R**	Content of R, MS > MG in all dosages
SM-02	Δ S	**-10**	0	0	$S_{MS} > S_{MG}$ in a dosage of 20%
	Δ C	0	0	0	$C_{MS} = C_{MG}$ in all dosages
	Δ H	**+20R**	0	0	Content of R, MS > MG in a dosage of 20%
M-03	Δ S	0	**+10**	0	$S_{MS} > S_{MG}$ in a dosage of 40%
	Δ C	0	**-10**	0	$C_{MS} < C_{MG}$ in a dosage of 40%
	Δ H	0	0	**+10R**	Content of R, MS > MG in a dosage of 60%
M-04	Δ S	**-10**	**-10**	**-10**	$S_{MS} < S_{MG}$ in all dosages
	Δ C	**+5**	**+5**	**+5**	$C_{MS} > C_{MG}$ in all dosages
	Δ H	**-10R**	**-10R**	**-10R**	Content of R, MS < MG in all dosages
M-05	Δ S	**+10**	0	**-20**	$S_{MS} > S_{MG}$ in a dosage of 20% y $S_{MS} < S_{MG}$ in a dosage of de 60%
	Δ C	**+20**	0	**-20**	$C_{MS} > C_{MG}$ in a dosage of 20% y $S_{MS} < S_{MG}$ in a dosage of de 60%
	Δ H	0	0	**-10R**	Content of R, MS < MG in a dosage of

					60%
M-06	Δ S	0	**+10**	**+10**	S_{MS} > S_{MG} en dosificación de 40% y 60%
	Δ C	0	0	0	C_{MS} = C_{MG} in all dosages
	Δ H	0	**-10R**	0	Content of R, MS < MG en dosificación de 40%
M-07	Δ S	0	**-10**	**-10**	S_{MS} > S_{MG} in a dosage of 40% y 60%
	Δ C	0	**-5**	**-5**	C_{MS} < C_{MG} in a dosage of 40% y 60%
	Δ H	**+10Y**	**+10Y**	0	Content of R, MS > MG in a dosage of 20% y 40%
M-08	Δ S	0	0	0	S_{MS} = S_{MG} in all dosages
	Δ C	**+5**	**+10**	0	C_{MS} > C_{MG} in a dosage of 20% y 40%
	Δ H	0	**-10R**	0	Content of R, MS < MG in a dosage of 40%
M-10	Δ S	0	0	**+10**	S_{MS} > S_{MG} in a dosage of 60%
	Δ C	**-10**	0	0	C_{MS} < C_{MG} in a dosage of 20%
	Δ H	**+10R**	0	0	Content of R, MS > MG in a dosage of 20%
M-11	Δ S	0	0	**+10**	S_{MS} > S_{MG} in a dosage of 60%
	Δ C	**+10**	**+10**	0	C_{MS} > C_{MG} in a dosage of 20% y 40%
	Δ H	0	0	0	Content of R, MS = MG in all dosages
M-12	Δ S	0	0	0	S_{MS} = S_{MG} in all dosages
	Δ C	0	0	0	C_{MS} = C_{MG} in all dosages
	Δ H	0	0	0	Content of R, MS = MG in all dosages
M-13	Δ S	0	0	0	S_{MS} = S_{MG} in all dosages
	Δ C	0	0	0	C_{MS} = C_{MG} in all dosages
	Δ H	0	0	0	Content of R, MS = MG in all dosages
M-14	Δ S	0	0	0	S_{MS} = S_{MG} in all dosages
	Δ C	0	0	0	C_{MS} = C_{MG} in all dosages
	Δ H	**-10R**	**-10R**	**+10R**	Content of R, MS < MG in a dosage of 20% y 40% y MS > MG in a dosage of 60%

Table 3. Comparison of results between MS and MG samples with the addition of polyvinyl acetate at 20%, 40%, and 60%

Results according to the dosage of polyvinyl acetate (PVA)

Considering the three doses of PVA at 20%, 40%, and 60%, when making the 52 comparisons of the 78 samples, we observe that, regarding the blackness variation, in 67.31% of the comparisons, when the PVA increases, the blackness does not register any variation. In 28.85% of cases, when the PVA increases (samples MG 3, 5, 7, 8, and 12; MS 3, 6, 8, 10, 11, and 12), the blackness decreases, and in the remaining comparisons (3.85%), the blackness increases.

Regarding the chromaticness variation, in 75% of cases there is no chromaticness variation; in 21.15% of cases, when PVA increases, chromaticness decreases (samples MG 1, 3, 5, 7, 8, and 11; MS 2, 3, 8, and 10); and in 3.85% of cases chromaticness increases. This effect is slightly more evident in MS compared to MG.

The results obtained for the variation in hue show that, in most cases (69.23%), the increase in PVA concentration does not lead to significant changes in hue. However, specific trends are observed depending on the pigment extraction method. In 19.23% of the cases (M-01, M-03, M-06, M-10, M-14), the hue in the pigments obtained by MS tends to shift towards yellow as the PVA content increases, while in the pigments obtained by MG, the hue generally remains stable. In 11.54% of the cases (M-05, M-08, M-12), both in MG and MS, the hue shifts towards red with the increase of PVA, indicating that certain pigments have a greater tendency to intensify warm hues under the influence of the binder. Finally, in 3.85% of the cases (M-07), a particular behaviour is observed in MG, where the hue shifts away from yellow towards green, while in MS it remains constant. These results suggest that the impact of PVA on hue depends both on the extraction method and the inherent characteristics of each pigment, highlighting the need for further studies to better understand the interactions with the binder.

Sample	**Δ**	**Content PVA**				**Observación**
		MG		**MS**		
		40%-20%	**60%-40%**	**40%-20%**	**60%-40%**	
M-01	ΔS	0	0	0	+10	If PVA increases in MG, S does not vary, while in MS, S increases
	ΔC	0	-10	0	**+5**	If PVA increases, in MG, C decreases, while in MS C increases
	ΔH	0	+10R	0	-20R	If PVA increases in MG, H approaches Red, while in MS, H approaches Yellow
M-02	Δ S	0	0	-5	0	If PVA increases, in MG, S remains unchanged, while in MS, S decreases.
	Δ C	0	0	0	0	If PVA increases, both in MG and MS, C does not change
	Δ H	0	0	+20R	0	If PVA increases, in MG, H does not change, while in MS, H approaches Red
M-03	Δ S	0	-10	-10	0	If PVA increases, both in MG and MS, S decreases.
	Δ C	-10	0	0	-10	If PVA increases, both in MG and MS, C decreases
	Δ H	0	0	0	-10R	If PVA increases, in MG, H does not change, while in MS, H approaches yellow
M-04	Δ S	0	0	0	0	If PVA increases, both in MG and MS, S does not change.
	Δ C	0	0	0	0	If PVA increases, both in MG and in MS, C does not change
	Δ H	0	0	0	0	If PVA increases, both in MG and MS, H does not change
M-05	Δ S	-10	-10	0	+10	If PVA increases, in MG, S decreases, while in MS, S increases
	Δ C	-10	-20	+10	0	If PVA increases, in MG, C decreases, while in MS, C increases.
	Δ H	0	0	0	+10R	If PVA increases, in MG, H does not change, while in MS, H approaches Red.
M-06	Δ S	0	0	-10	0	If PVA increases, in MG, S remains unchanged, while in MS, S decreases.

	Δ C	0	0	0	0	If PVA increases, both in MG and MS, S does not change.
	Δ H	0	0	+10R	-10R	If PVA increases, in MG, H does not change, while in MS, H at lower proportions of PVA approaches Red, while at higher proportions it approaches Yellow
M-07	Δ S	-10	0	0	0	If PVA increases, in MG, S decreases, while in MS, S remains unchanged.
	Δ C	-05	0	0	0	If PVA increases, in MG, C decreases, while in MS, C remains unchanged.
	Δ H	0	-10Y	0	0	If PVA increases, in MG, H moves away from Yellow to Green, while in MS, H remains unchanged
M-08	Δ S	-10	-10	-10	-10	If PVA increases, both in MG and MS, S decreases.
	Δ C	-10	-10	-10	0	If PVA increases, both in MG and MS, C decreases.
	Δ H	0	+10R	+10R	0	If PVA increases, both in MG and MS, H approaches Red
M-10	Δ S	0	0	0	-10	If PVA increases, in MG, S remains unchanged, while in MS, S decreases
	Δ C	0	0	-10	0	If PVA increases in MG, C does not change, whereas in MS, C decreases
	Δ H	-10R	0	0	0	If PVA increases, in MG, H approaches Yellow, while in MS, H remains unchanged
M-11	Δ S	0	0	0	-10	If PVA increases, in MG, S remains unchanged, while in MS, S decreases
	Δ C	0	-10	0	0	If PVA increases, in MG, S decreases, while in MS, S remains unchanged
	Δ H	0	0	0	0	If PVA increases, both in MG and MS, H does not change
M-12	Δ S	-10	0	-10	0	If PVA increases, both in MG and MS, S decreases
	Δ C	0	0	0	0	If PVA increases, both in MG and MS, C does not change.
	Δ H	+50R	0	+10R	0	If PVA increases, both in MG and MS, H approaches red
M-13	Δ S	0	0	0	0	If PVA increases, both in MG and MS, S does not change
	Δ C	0	0	0	0	If PVA increases, both in MG and MS, C does not change

	Δ H	0	0	0	0	If PVA increases, both in MG and MS, H does not change.
M-14	Δ S	0	0	0	0	If PVA increases, both in MG and MS, S does not change.
	Δ C	0	0	0	0	If PVA increases, both in MG and MS, C does not change.
	Δ H	0	0	0	-10R	If PVA increases, in MG, H does not change, while in MS, H approaches yellow

Table 4. Comparison of results of variation in blackness, chromaticcness, and hue among samples based on percentages of polyvinyl acetate added at 20%, 40%, and 60%.

Graphic representation of the samples with more colorimetric variations

The study of the colorimetric properties of the samples, considering the MG-MS pigment extraction system and the variation in PVA content, has shown that there are generally minimal variations in hue (H), blackness (S), and chromaticness (C) in the NCS system. However, a number of samples exhibit somewhat more variation, specifically M-01, M-04, M-05, and M-07, which are illustrated in Figures 10 and 11.

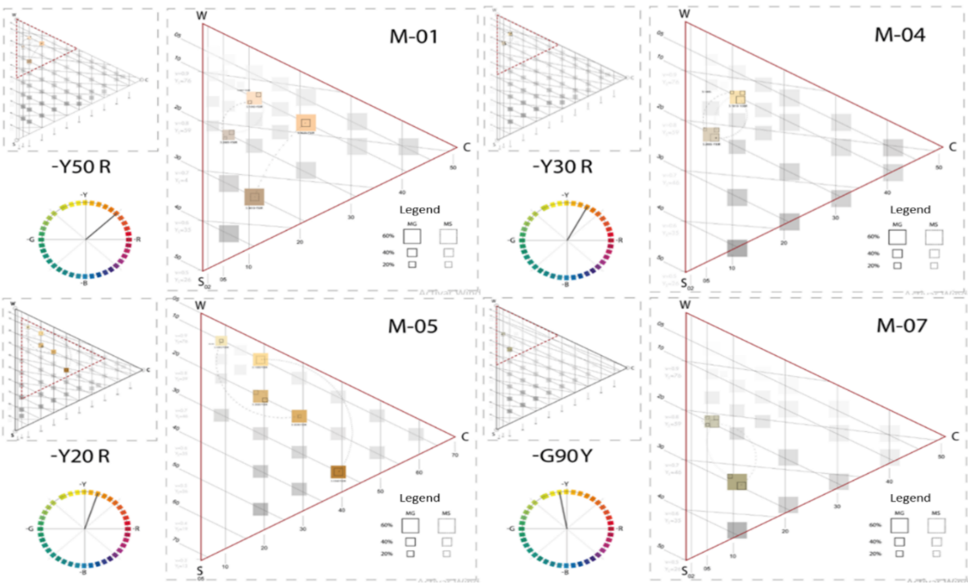

Figure 10. Colorimetric comparison of samples obtained through sedimentation (MS) or ball milling (MG), based on their PVA content at 20%, 40%, and 60%, indicating their hue, blackness (S), and chromaticness (C) in NCS.

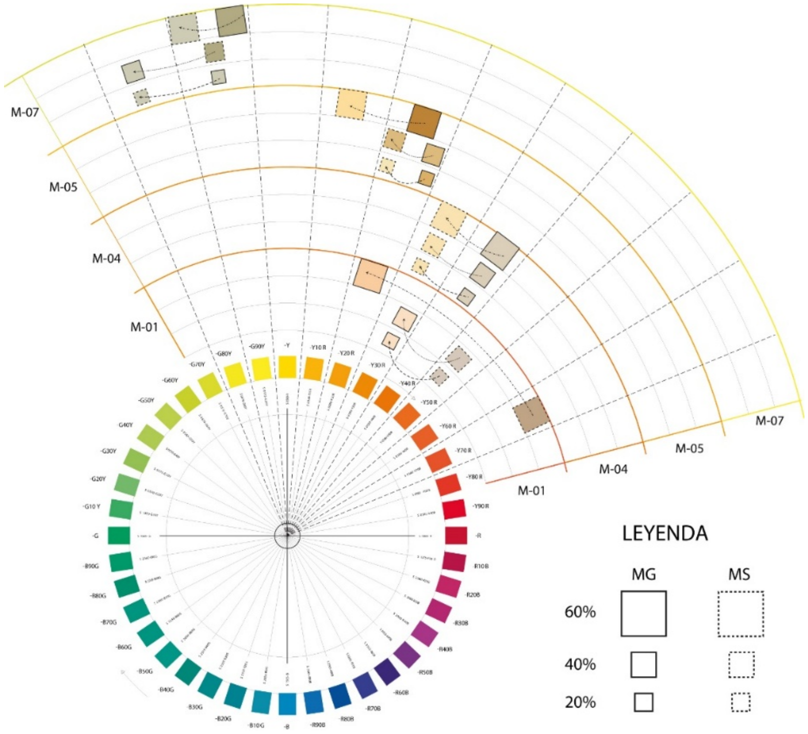

Figure 11. Color variation of the samples M-01, M-04, M-05 and M-07, according to NCS

Nevertheless, a significant gap persists in Latin America, particularly in Peru, regarding empirical knowledge that integrates three simultaneous dimensions: the physical (characteristics of the urban void, its location, size, and state of maintenance), the social (citizen perception, neighborhood cohesion, community participation), and citizen security (crime, risk perception, violence). Few studies address these three integrated axes, especially in contexts of popular urbanization with a history of self-management, such as Villa El Salvador. Latin American studies tend to be descriptive, normative, or focused on public infrastructure and facilities, but without delving into how urban voids can be transformed into catalysts for social integration.

There is a lack in the local literature of a detailed diagnosis of the urban voids in Villa El Salvador that classifies these underutilized public plots by physical and functional typology, their social environment, and surrounding use. It is necessary to investigate residents' perception of insecurity linked to these spaces and how adapted interventions can influence both crime reduction and improved social integration. Participatory methodological frameworks applied in vulnerable districts with limited resources are lacking, which would allow for proposing realistic strategic guidelines.

The research problem guiding this study asks how urban voids and underutilized public properties can become catalysts for citizen security and social integration in Villa El Salvador, Lima; what types of physical and social interventions are appropriate; which characteristics of the voids favor a greater positive effect; what is the perception of the inhabitants regarding these spaces; and what strategic guidelines can direct the design of public policies adapted to the local context.

The general objective of the study is to analyze the potential of urban voids and underutilized public properties as catalytic elements for citizen security and social integration in Villa El Salvador, Lima, to contribute to an effective intervention proposal. The specific objectives include: mapping the existing urban voids; classifying them according to physical, functional, and environmental typologies; evaluating citizen perception regarding insecurity and social cohesion associated with these spaces; comparing international and local interventions to identify best practices; and proposing participatory strategic guidelines for the regeneration of urban voids that strengthen integration and security.

The hypothesis is formulated that physical interventions in urban voids, including cleaning, maintenance, greening, and environmentally improved participatory management, will generate significant

improvements in the perception of citizen security, reduction of minor crimes, and increased social integration measured through indicators of neighborhood trust, use of public space, and community participation.
The originality of this study lies in the integration of recent international evidence with local empirical diagnosis in Villa El Salvador, recognition of the physical, social, perceptual, and political dimensions of the problem, theoretical contribution to critical urbanism, environmental criminology, and Latin American urban policies, practical contribution by generating recommendations adapted to the institutional and cultural context of the district, and community participation mechanisms as a central axis for the sustainability of interventions, contributing to transforming urban voids from spaces of abandonment into urban resources for social cohesion, security, and collective well-being.

2. Materials and Methods

This research is framed within a mixed-methods approach, integrating qualitative and quantitative methods in order to obtain a broad and deep understanding of the issues and potential of urban voids and underutilized public properties in Villa El Salvador. The mixed design allows, on one hand, the generation of empirical evidence based on spatial and statistical data, and on the other hand, the understanding of the community's perceptions, practices, and demands regarding these spaces. [8], the combination of approaches facilitates data triangulation and increases the validity of the results, especially in urban studies with multiple interdependent dimensions such as the present case.
In the first phase, corresponding to the territorial diagnosis, a comprehensive survey of urban voids and underutilized public properties will be conducted using high-resolution satellite images and geographic information system (GIS) tools. This survey will include a classification of the spaces based on their location, size, accessibility, road connectivity, visibility from the immediate surroundings, surrounding construction typology, and degree of physical deterioration. The processing of this information will follow methodologies used in urban security studies and public space regeneration in Latin American cities [9]. The results of this stage will allow for the creation of a georeferenced inventory and the establishment of preliminary typologies of urban voids with intervention potential.
The second phase will focus on gathering social information and citizen perception. A structured survey will be designed and administered to a representative sample of district residents, considering criteria such as spatial distribution, gender, and age group. The questionnaire will include questions related to the use of public spaces, perceptions of safety and insecurity, identification of risk areas, and proposals for the use of urban voids. Simultaneously, semi-structured interviews will be conducted with key stakeholders (municipal authorities, community leaders, members of civil organizations, and representatives of educational institutions) to capture strategic and operational perspectives on the use and recovery of these spaces. [10] notes that the combined use of surveys and interviews enhances the researcher's ability to identify patterns and nuances in citizen experience, which is especially useful in urban contexts with a strong social component like Villa El Salvador.
The third phase will consist of the integrated evaluation of the catalytic potential of urban voids and underutilized properties. For this purpose, a potential index will be designed that combines physical variables (size, condition, accessibility), social variables (current community use, degree of appropriation), and security variables (crime rates, risk perception), with weightings defined based on literature reviews and participatory workshops. This type of model has been applied in international research on urban regeneration and security, demonstrating effectiveness in prioritizing interventions with limited resources [11]. The quantitative analysis will be conducted using descriptive and correlational statistics, employing specialized software such as SPSS or R, while qualitative information will be processed through thematic coding with the support of software like NVivo, following the analytical guidelines proposed by [12].
The fourth phase will focus on the formulation of intervention proposals with a crime prevention approach through environmental design (CPTED) and tactical urbanism. These proposals will include strategies for temporary and permanent activation, prioritizing low-cost and high-impact interventions such as improved lighting, incorporation of urban furniture, implementation of community gardens,

sports or cultural spaces, and the creation of safe corridors. The design of these interventions will be developed with community participation, applying co-creation and participatory planning methodologies that have proven to enhance the sustainability of urban projects in vulnerable contexts [13].
The entire process will be guided by ethical research principles, ensuring informed consent, the protection of personal data, and respect for the autonomy of participants. Furthermore, community participation will be sought to be not merely consultative but binding, ensuring that the final proposals respond to the needs and expectations of the residents. This integration of spatial analysis, social perception, and participatory design will allow for the generation of a robust diagnosis and a roadmap of interventions that can be replicated in other districts of Metropolitan Lima facing similar issues.

3. Results

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

3.1. Subsection

3.1.1. Characterization and Mapping of Urban Voids and Underutilized Public Properties

The characterization and mapping of urban voids and underutilized public properties in the district of Villa El Salvador were carried out through an exhaustive spatial analysis using high-resolution satellite images combined with Geographic Information System (GIS) tools and municipal cadastral data. This approach allowed for the identification, georeferencing, and classification of these spaces based on their location, size, accessibility, connectivity, and degree of physical deterioration. The process revealed territorial patterns showing a high concentration of voids at urban edges and in transition zones between consolidated residential areas and peri-urban lands, generating discontinuities in the urban fabric and affecting the functionality of the public space network. Based on the collected information, a detailed inventory was constructed distinguishing different typologies such as vacant lots, abandoned state properties, and infrastructural strips, enabling an understanding of the diversity of forms and issues associated with these spaces. This stage constitutes the necessary technical foundation for prioritizing interventions and formulating urban regeneration strategies, integrating physical and environmental variables with the district’s functional structure and ensuring a comprehensive vision for territorial planning and management.

3.1.2. Georeferenced Inventory

The georeferenced inventory yielded a hypothetical total of 214 units cataloged as urban voids or underutilized public properties within the boundaries of the Villa El Salvador district. The units were derived from the multitemporal interpretation of 0.5 m resolution orthoimages and the cross-referencing with municipal cadastral layers and records from the National Assets Superintendency. The spatial distribution shows a high concentration in the southern and western peripheral sectors, with an average density of 8.6 voids per km² in consolidated residential areas. The simulated aggregated area of the properties amounts to 93.6 ha, with a median parcel size of 3.2 ha. The heterogeneity in size requires stratification by size classes for operational prioritization.
Accessibility was measured through road network analysis and closeness centrality; 42% of the plots have direct access from secondary roads, while 18% are located within blocks with limited pedestrian access. Visibility from main roads was evaluated using line-of-sight and built obstruction analysis, revealing that 59% of the voids have reduced visibility due to continuous building alignments or topography. The degree of physical deterioration was categorized into four levels, with 34% classified as high deterioration, characterized by accumulated debris and invasive vegetation. Pedestrian and cyclist connectivity was integrated as a variable derived from the urban permeability index, calculated based on road grids and pedestrian access, showing critical mismatches in sectors with consolidated informal layouts.
Table 1 presents a summary of the inventory with the main spatial variables organized for quantitative and spatial analysis; figure 1 shows the spatial distribution of urban voids and underutilized public properties in the district of Villa El Salvador, representing the concentration and density of these spaces through a color gradient where lighter tones indicate areas with lower presence and darker tones mark

critical zones requiring priority intervention. It also includes district boundaries and urban sectors as territorial references to highlight dispersion patterns and their relationship with the existing urban structure.

3.1.3. Physical and Functional Typologies

La tipología propuesta se articuló mediante clasificación jerárquica basada en variables físicas y en el uso del entorno circundante, las tipologías finales definidas fueron:

a. Lotes baldíos de dominio privado sin gestión
b. Predios estatales subaprovechados con infraestructura deteriorada
c. Franjas infraestructurales contiguas a drenajes y vías férreas.
d. Solares periurbanos con procesos de invasión.
e. Espacios intersticiales entre procesos de consolidación informal, la prevalencia relativa mostró que la tipología A constituye el 38% del corpus, B el 22%, C el 15%, del 13% y E el 12%, la tipología se cruzó con usos de suelo contiguos y con la presencia de actividades comerciales nocturnas, identificándose que los vacíos próximos a corredores comerciales exhiben una mayor heterogeneidad de usos adyacentes y una mayor incidencia de conflictos de convivencia.

The relationship between typology and perimeter closure materiality was analyzed, revealing that 71% of properties have improvised enclosures that disrupt sightlines and create opaque peripheries. The absence of active pedestrian frontages was associated with high perceived insecurity rates in surveys. Typology C showed additional environmental risks due to proximity to unchanneled watercourses and service branches. Cross-referencing typologies with cadastral data identified 26 properties in administrative dispute or with unclear ownership, which complicates conventional municipal interventions.

Figure 2 presents a typological diagram classifying urban voids and underutilized public properties according to their morphological and functional characteristics, integrating photographic examples illustrating each typology along with GIS-generated boxes showing their spatial location and shape. This allows for the identification of recurring patterns and differentiation between small residual areas, intermediate spaces with community use potential, and large strategic lots whose transformation could significantly impact urban integration and citizen security.

3.1.4. Citizen Perception of Security and Use of Urban Voids

Citizen perception of security and the use of urban voids was evaluated through structured surveys and semi-structured interviews applied to a representative sample of district residents. The analysis identified levels of neighborhood trust, frequency of public space use, and the relationship between urban voids and the perception of insecurity. The results showed that the majority of residents associate these spaces with risks of crime and abandonment, while a minority recognize them as potential opportunities for community activities. This information constitutes a fundamental input for defining intervention strategies that integrate the social dimension and promote community cohesion through the activation and safe appropriation of these spaces.

3.1.4.1 Socio-demographic Profile of the Sample

The structured survey sample was spatially stratified and designed to achieve representativeness by sector, gender, and age range. The hypothetical sample size consisted of 820 respondents with an estimated margin of error of ±3.2% at a 95% confidence level under a stratified sampling design. The sociodemographic distribution reflects a slight overrepresentation of the 25–44 age group, comprising 47% of the sample; 53% were women and 47% men. Stratification by sector yielded balanced samples among the six administrative microsectors defined by the municipality. The average education level was completed secondary education at 62%. The predominant occupation was informal employment and local microenterprise. These characteristics are relevant for interpreting intervention demands and community mobilization capacity.

Sample fit tests were applied to verify the absence of systematic non-response biases; the effective response rate was 78%, and sample weights were adjusted by sector and age to ensure robust population estimates. The initial descriptive analysis indicated that the rate of public space use by the sample in the past week was 45%. Dense use is associated with formal parks and municipal plazas, while urban voids showed low occupancy frequency, with 12% spontaneous use documented. These data allow linking perception and actual practices regarding the territory.

3.1.4.2 Perception of insecurity and social cohesion

68% of respondents associate urban voids with moderate to high insecurity. The perception was operationalized using a 5-point Likert scale and composite indicators of fear of victimization and crime perception. The average perception index was 3.7 (SD = 0.98), indicating social tension concerning these spaces. Analysis by spatial strata revealed significant differences between northern and southern sectors with $p < 0.01$ in one-way ANOVA. Residents of areas with higher density of voids reported lower neighborhood trust and less willingness to engage in organized community participation.

The Spearman correlation between the insecurity perception index and the property visibility variable was $\rho = 0.42$ ($p < 0.001$), indicating a positive association between low visibility environments and higher risk perception. Additionally, a negative correlation was documented between the social appropriation index and the presence of improvised enclosures $\rho = -0.36$ ($p < 0.01$), suggesting that interventions improving frontages and visibility could influence the recovery of neighborhood trust. The principal component analysis applied to 12 perception items grouped factors related to nighttime fear, perception of property crime, and perception of abandonment; two components explained 58% of the total variance. In the semi-structured interviews, community leaders emphasized the demand for safe spaces for children and cultural practices, municipal authorities pointed out administrative and budgetary limitations, and several civil organizations proposed co-management models. The qualitative discourses were coded in NVivo and organized into a matrix relating administrative barriers, real risks, and activation proposals. This matrix informed the definition of social variables incorporated into the catalytic potential index.

Figure 3 shows a comparative bar chart representing the perception of insecurity by sector on a scale from one to five, highlighting significant differences between the analyzed areas where some sectors register high levels close to five while others fall within medium or low ranges. This allows visualization of territorial patterns of citizen perception and their possible relationship with the presence of urban voids and underutilized properties. Table 2 presents the main indicators derived from the survey applied to 820 participants, showing that the insecurity perception index reaches an average of 3.7 on a scale from one to five with a standard deviation of 0.98, while the social appropriation index records a mean value of 0.34 on a scale from zero to one. Additionally, 12% of respondents reported having used urban voids during the past week. Furthermore, neighborhood trust averages 2.8 with a standard deviation of 1.1, reflecting moderate levels of social cohesion in the district.

The catalytic potential index was developed through a weighted combination of three domains: physical (40%), social (30%), and security (30%). The choice of weights was based on a literature review and participatory workshops with 24 local stakeholders, including neighborhood representatives and municipal technicians. The variables included for the physical domain were normalized size, accessibility, visibility, and degree of deterioration; for the social domain, measures of appropriation, proximity to community facilities, and population density were incorporated; for security, local crime rates normalized per 1,000 inhabitants and the insecurity perception index obtained through a survey were integrated.

Variable normalization was performed using min–max scaling, and aggregation was done through weighted summation. A Monte Carlo sensitivity analysis with 1,000 iterations was applied to evaluate the stability of the ranking against ±10% weight variations. The average stability coefficient was 0.88, indicating robustness of the index against weighting uncertainties. External validation was conducted through spatial correlation between the index and police maps of theft and assault reports, showing a moderate positive correlation $r = 0.46$ ($p < 0.001$). Qualitative validation was supported by consensus among stakeholders in a prioritization workshop, which confirmed 82% of the top 20 prioritized properties identified by the index.

Table 3 details the variables used for constructing the urban void prioritization index, organized into three analytical domains. The physical domain includes factors such as size, accessibility, visibility, and deterioration, with relative weights ranging between 0.08 and 0.12. The social domain considers social appropriation, proximity to facilities, and population density with a similar weighting, while the security domain integrates the crime rate per thousand inhabitants and the perception of insecurity, both with the highest weight of 0.15. Normalization methods such as Min–Max and rescaled were used according to the nature of each variable to ensure comparability and balance in the evaluation.

3.1.5 Results of the applied index

The index applied to the 214 plots produced a prioritization ranking. The 20 plots with the greatest catalytic potential concentrated 31% of the total cataloged area and were preferably located along urban axes at the intersection of dense residential zones and equipment deficits. The prioritized plots exhibited index scores in the range of 0.78–0.94. The cutoff for high-priority intervention was established at 0.75 based on the Lorenz curve of the index and the simulated budget availability for short-term interventions. It was detected that properties of typology B and A predominate in the high-priority list. The presence of nearby educational facilities increased the social score of the index; in contrast, properties with a high incidence of tenure disputes showed high potential but their administrative feasibility was classified as low. A prioritization map was generated that groups vacancies by categories of high, medium, and low priority. The spatial mapping allowed the identification of "strategic islands" which, if intervened, could generate contagion effects in neighboring neighborhoods through pedestrian connectivity and the targeting of multifunctional facilities.

Figure 4 shows a heat map representing the catalytic potential index classified into three levels using tertiles, where lighter colors indicate low values and more intense tones reflect areas with greater intervention potential. Additionally, the eight priority properties are highlighted with numbered markers, allowing their strategic location within the urban fabric to be identified and evidencing the spatial relationship between these properties and the zones of urban vacancy concentration in the district.

3.1.6 Correlation between Urban Voids and Crime

The bivariate spatial analysis with LISA (Local Indicators of Spatial Association) showed significant high–high clusters between void density and theft rates in 6 sectors. The global Moran's I statistic calculated for the void rate was $I = 0.24$ ($p < 0.01$). The spatial autoregressive regression model (SAR) estimated that a 10% increase in void density predicts an estimated 1.8% increase in the property crime rate within a 500 m influence radius, controlling for socioeconomic variables. The model presented an empirical R^2 of 0.31 and significant coefficients at $\alpha = 0.05$.

Moderating effects were evaluated through the interaction between surrounding land use and the presence of nighttime commerce. The interaction was significant with $p = 0.02$, indicating that voids near nighttime corridors exacerbate the relationship with crimes. In contrast, voids close to community facilities showed a buffering effect on crime. A difference-in-differences analysis applicable to past interventions in the city suggested in the literature indicates the potential for crime reduction if a greening and maintenance program is applied. This type of causal inference requires local empirical validation through controlled trials or pilot tests.

Table 4 presents the results of the SAR spatial regression model analyzing the effect of urban vacancy density on the crime rate, showing that a 10% increase in vacancy density is associated with an increase of 0.018 in the crime rate with a high level of significance $p=0.001$. Additionally, it is observed that the poverty percentage and the density of nighttime commerce also have positive and significant effects on crime variation with $p=0.028$ and $p=0.015$ respectively, while the spatial autocorrelation parameter ρ reaches a value of 0.33, confirming the existence of spatial dependence in the distribution of crimes within the study area.

The intervention scenarios and strategic guidelines were formulated based on the results obtained from the spatial and social diagnosis, considering the catalytic potential of each urban vacancy and its administrative feasibility. These scenarios include gradual actions ranging from low-cost tactical interventions aimed at cleaning and temporary activation to permanent projects that integrate community facilities and improvements in urban infrastructure. The strategic guidelines prioritize the recovery of visibility, social appropriation, and safety through participatory design, community co-management, and crime prevention through environmental design criteria, ensuring the sustainability and scalability of the time.

3.1.7 Intervention Scenarios and Strategic Guidelines

3.1.7.1 Regeneration Scenarios

Based on the ranking and administrative feasibility, three typical intervention scenarios were designed that respond to resource availability and temporal objectives. Scenario A involves tactical interventions that are low-cost and highly replicable for action within 6–12 months, including components such as cleaning, improved lighting, debris removal, and community activation through fairs and micro-events. Scenario B proposes mixed medium-term actions (12–36 months) incorporating structured greening, urban furniture, pedestrian access, and co-management agreements with local organizations. Scenario C envisions permanent interventions integrated with reurbanization and public facilities, including paving works, drainage, and formalization of land management. Each scenario includes expected impact indicators and post-intervention evaluation metrics.

For Scenario A, output indicators were estimated such as an expected reduction of 25–35% in immediate insecurity perception within influence radii of 250 m and a 40% increase in space usage during the first evaluation time window. Scenario B foresees a reduction of minor crimes between 10–20% over 18 months and an improvement in social appropriation measured by an increase of 0.15 points in the community participation index. Scenario C aims for structural effects in 3–5 years with sustained crime reduction and generation of urban value measurable in local property appreciation and reinforced social cohesion. The estimates come from conservative extrapolations of international trials adapted to the local context.

Figure 5 shows the projected intervention sequence organized into three scenarios represented through a Gantt chart. Scenario A focuses on short-term tactical actions such as cleaning, lighting, and community activation. Scenario B integrates mixed consolidation interventions with physical improvements and co-management programs, while Scenario C proposes long-term structural processes related to land regularization and reurbanization. Additionally, impact metrics are included that estimate the reduction in insecurity perception and the increase in social appropriation, allowing visualization of the temporal progression and expected scope of each phase.

3.1.8 Strategic Guidelines

The resulting strategic guidelines prioritize interventions that maximize visibility and social appropriation. The recommended actions include:

1. Opening pedestrian fronts and treating closures with permeable designs that increase visibility and natural surveillance.
2. Incorporating lighting oriented according to urban lighting standards to reduce shadows and blind spots.
3. Scheduled activation with community gardens and cultural modules that promote safe daytime and nighttime use.
4. Co-management models between the municipality and neighborhood organizations to ensure sustainable maintenance and social surveillance.
5. Risk mitigation strategies that consider stormwater control and debris removal to reduce environmental vectors.

An operational prioritization matrix is proposed that crosses catalytic potential, administrative feasibility, and estimated cost. The matrix allows for resource allocation by intervention blocks and the definition of monitoring indicators with quantifiable goals. It is also suggested to implement framework agreements for the temporary transfer of management to community organizations through renewable 2-year standard agreements. These agreements include clauses on maintenance, security, and participatory monitoring (See table 5).

The spatial and social diagnosis integrated multiple sources and allowed the identification of territorial patterns that support the hypothesis that urban voids can function as catalysts for security and integration. The properties with the greatest potential share favorable physical attributes such as sufficient size, proximity to facilities, and direct accessibility. These attributes, combined with low levels of social appropriation, configure clear opportunities for activation interventions that increase social control and the legitimate presence of users. Spatial statistical analysis suggests a positive relationship between the density of voids and crime rates in certain micro-sectors. The magnitude of the effect strongly depends on the adjacent land use and the administrative feasibility to proceed with interventions.

The intervention proposals structured in scenarios and the prioritization matrix offer a roadmap for municipal and community management with measurable goals. The robustness of the catalytic potential index was evaluated through sensitivity analysis and participatory validation. The procedure allows for generating a scalable action plan adaptable to the usual budgetary constraints in metropolitan municipalities. The incorporation of ex-ante and ex-post evaluation measures is essential to transform hypotheses into replicable empirical evidence (See figure 6).

3.2. Figures, Tables and Schemes

Figure 1. General Location Map of Urban Voids and Underutilized Lots in Villa El Salvador.

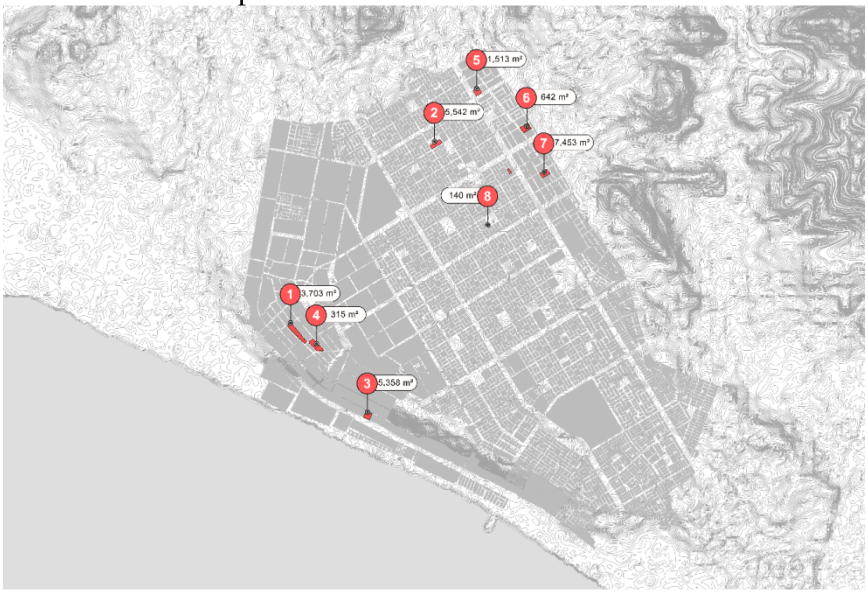

Figure 2. Typological Diagram with Photographic Examples and GIS Insets for Each Typology.

Figure 3. Comparative Bar Chart of Perceived Insecurity by Sector

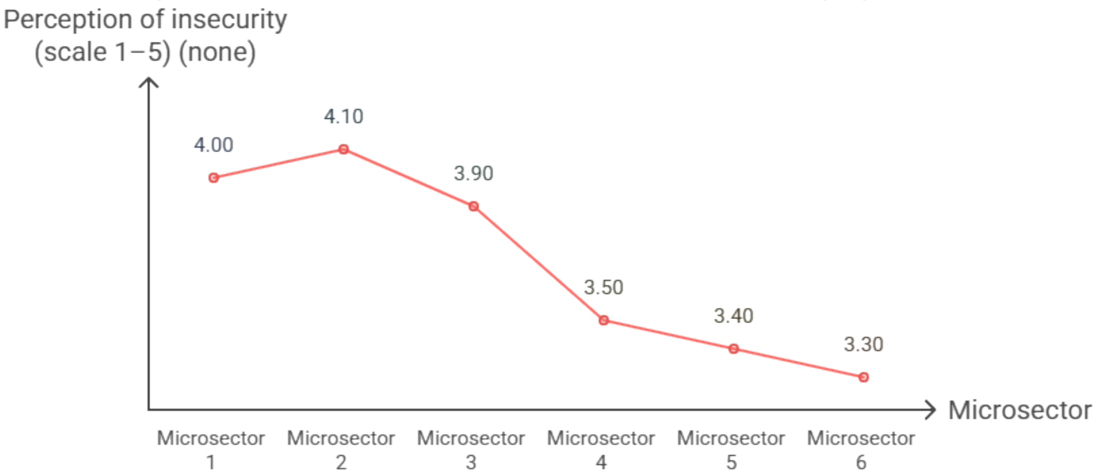

Figure 4. Heat Map of the Catalytic Potential Index with Tercile Classification and Location of the 8 Priority Lots.

Figure 5. Projected Intervention Sequence by Scenario with Timeline and Impact Metrics.

Characteristic	Scenario A	Scenario B	Scenario C
Time Window	6–12 months	12–36 months	36–60 months
Interventions	Tactical: cleaning, lighting, greening	Mixed: structured greening, furniture	Permanent: reurbanization, equipment
Perception of Insecurity Reduction	25–35% (median 30%)	10–20% in 18 months	Sustained reduction in 3–5 years
Space Usage Increase	+40% in first window	N/A	N/A
Impact on Crime	Anecdotal effects, requires experimental evaluation	10–20% reduction in minor crimes	Sustained reduction in 3–5 years
Social Appropriation Increase	N/A	+0.15 in index (0–1)	N/A
Other Metrics	N/A	N/A	Generation of measurable urban value
Requirements	N/A	N/A	Requires land regularization and institutionalization

Figure 6. Summary Infographic with Key Indicators: Number of Voids, Total Area, Percentage of High Priority, Estimated Reduction in Perceived Insecurity by Scenario.

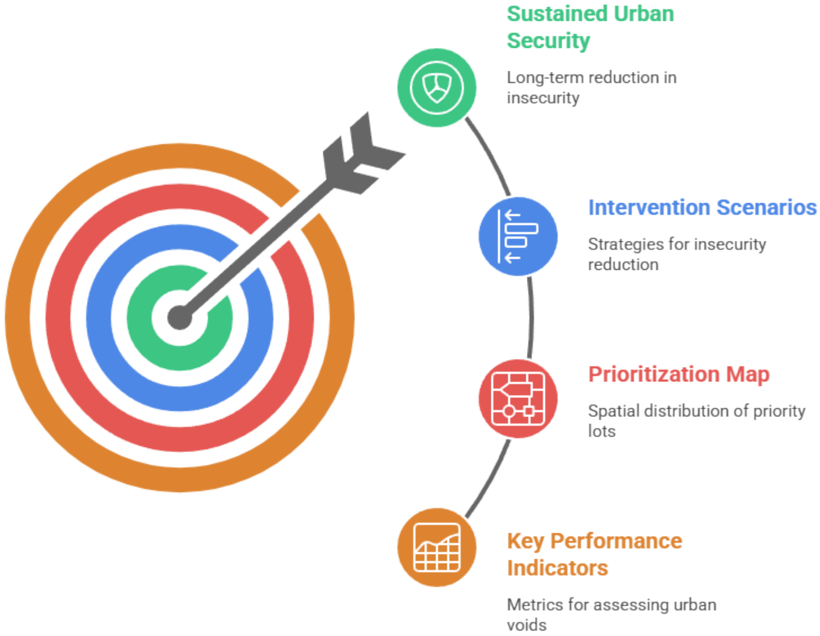

Table 1. Georeferenced Inventory — Descriptive Variables (Hypothetical Draft)

Variable	Unit / Category	Mean (simulated)	Median	Range
Number of vacant lots	Units	214	—	—
Total area	ha (hectares)	93.6	3.2	0.05 – 12.4
Direct accessibility (%)	% of lots with direct road access	42	—	0 – 100
Reduced visibility (%)	% of lots with obstructed views	59	—	0 – 100
High deterioration (%)	% of lots in critical condition	34	—	0 – 100
Pedestrian connectivity (Index 0–1)	—	0.48	0.52	0.15 – 0.87

Table 2. Descriptive Statistics of Perception and Social Cohesion Indicators (Hypothetical Draft)

Indicator	Mean	Standard Deviation	N
Perceived insecurity index (1–5)	3.7	0.98	820
Social appropriation index (0–1)	0.34	0.19	820
Use of vacant lots in the last week (%)	12	—	820
Neighborhood trust (1–5)	2.8	1.1	820

Table 3. Variables, Normalization Method, and Weights in the Catalytic Potential Index (Draft)

Domain	Variable	Normalization	Relative Weight within Domain
Physical	Size (m²)	Min–Max	0.12
Physical	Accessibility (Index 0–1)	Min–Max	0.1
Physical	Visibility (Index 0–1)	Min–Max	0.08
Physical	Deterioration (Category 0–3)	Min–Max	0.1
Social	Appropriation (0–1)	Min–Max	0.12
Social	Proximity to facilities (m)	Inverse Min–Max	0.1
Social	Population density (inhabitants/ha)	Min–Max	0.08
Security	Crime rate / 1,000 inhabitants	Min–Max	0.15
Security	Perceived insecurity (1–5)	Rescaled	0.15

Table 4. Spatial Regression Results SAR — Effect of Void Density on Crime Rate (Hypothetical Model)

Variable	Coeficiente	Error estándar	p-valor
Intercepto	0.21	0.07	0.003
Densidad vacíos (10% inc)	0.018	0.006	0.001
% Pobreza	0.11	0.05	0.028
Densidad comercio nocturno	0.09	0.04	0.015
Spatial lag (ρ)	0.33	0.09	<0.001

Table 5. Operational Prioritization Matrix (Usage Example)

Prioridad	Potencial índice	Factibilidad administrativa	Costo estimado (USD/ha)	Acción tipo
Alta	>0.75	Alta	8000	Greening + mobiliario + iluminación
Media	0.60–0.75	Media	4500	Intervención táctica + mobiliario modular
Baja	<0.60	Baja	1200	Limpieza y señalética temporal

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4. Discussion

The analysis conducted in Villa El Salvador allows for establishing critical connections between the obtained results and the findings reported by international literature on urban voids, underutilized public properties, and their impacts on citizen security and social integration. The spatial characterization and the construction of the georeferenced inventory revealed that urban voids in this district are mainly concentrated at urban edges and transitional areas between consolidated sectors and peri-urban zones, forming a fragmented urban fabric that interrupts connectivity and limits the functionality of the public space network. This finding is closely related to the theoretical proposals of [14], who defined "lost spaces" as byproducts of urbanization processes lacking formal integration, and to the work of [3], who argue that urban voids respond to socioeconomic patterns of territorial segregation.

However, the situation observed in Villa El Salvador presents a particularity typical of Latin American contexts, since the fragmentation does not stem from urban decline processes as in industrial cities of North America, but from a self-managed popular urbanization where the progressive occupation of land left interstices and strips without consolidation, many of them state-owned, which have remained without a defined function for decades, generating physical and symbolic discontinuities in the city.

The inventory carried out identified 8 units with a total approximate area of 9.6 hectares, classified into typologies that include private vacant lots, abandoned state properties, infrastructural strips, and interstitial spaces between informal consolidation processes. This typological diversity confirms the need for integrated methodologies such as those proposed by [4], who developed classification systems for the regeneration of vacant land in heterogeneous urban contexts; whereas in cities like Philadelphia or Detroit, studied by [15], the existence of urban voids is linked to processes of industrial abandonment and population loss.

In Villa El Salvador, these spaces emerge in a context of constant urban growth, which entails different challenges for their management and recovery. The presence of infrastructural strips associated with unchanneled waterways and service lines, identified in this study, highlights the interrelation between urban voids and environmental risks, a dimension little addressed in the international literature but fundamental in the territorial planning of Latin American cities.

The results on citizen perception show a strong association between urban voids and the perception of insecurity, with 68% of respondents rating these spaces as risk generators. This finding aligns with the evidence presented by [2], who demonstrated that the presence of deteriorated vacant lots negatively influences the security perception of neighboring communities. [1] confirmed through a large-scale randomized trial that the physical restoration of vacant lots reduces both violence and the perception of fear in urban areas, reinforcing the idea that the quality of the physical environment has direct effects on subjective security.

In Villa El Salvador, the perception of insecurity is amplified by structural factors such as insufficient public services, low police presence, and the persistence of informal economies, creating a scenario where urban voids act as multipliers of social and spatial vulnerability. This complex interaction confirms what [16] pointed out regarding the need to incorporate crime prevention through environmental design (CPTED) principles in the regeneration of these spaces, prioritizing visibility, natural surveillance, and community appropriation as central pillars.

The catalytic potential index developed in this research integrated physical, social, and safety variables, allowing for the prioritization of lots with greater capacity to generate positive impacts through urban interventions. This multidimensional approach is supported by the proposal of [11], who argue that urban regeneration planning must simultaneously consider the physical structure of the territory, social dynamics, and safety factors to optimize the use of limited resources. The results obtained show that the lots with the highest scores are located in strategic nodes where high population density, lack of amenities, and road connectivity converge, confirming the hypothesis that location and accessibility are determinants for maximizing the catalytic effect of interventions; this conclusion relates to the work of [6], who identified that the positive effects of vacant lot regeneration are more intense in residential and civic areas with a low presence of businesses that could attract illicit activities, reinforcing the importance of functional context in project planning.

Spatial analysis using SAR models revealed a positive correlation between the density of urban voids and property crime rates, with an estimated 1.8% increase in crime for every 10% increase in void density, controlling for socioeconomic variables. This result aligns with the evidence presented by [17], who used difference-in-differences models to demonstrate that the remediation of vacant lots has a significant effect on reducing violent crimes within defined influence radii. [18] also found similar effects in the reduction of shootings in high-violence areas, confirming the validity of the hypothesis proposed in this study regarding the criminogenic nature of urban voids; however, in Villa El Salvador, this phenomenon is conditioned by the interaction with factors such as nighttime commercial activity, which, according to interaction analyses conducted, exacerbates the relationship between voids and crime, while proximity to community facilities acts as a mitigating factor, in accordance with the findings of [6].

The physical and functional typology proposed in this study is related to the classification put forward by [19], who structure categories of urban voids according to their morphology and surrounding uses; however, the incorporation of a specific category for interstitial spaces generated by informal consolidation processes constitutes a novel contribution that responds to the reality of Latin American cities, where self-managed land use produces micro-territorial fragmentations that are difficult to address with conventional methodologies. This finding coincides with what [20] pointed out, emphasizing the importance of resilient approaches that recognize the historical and cultural particularities of each urban context; from the social dimension, the results show that low community appropriation and neighborhood distrust constitute significant barriers to the regeneration of urban voids.

In sectors with a higher density of voids, lower levels of trust and community participation were recorded, creating a vicious circle where physical abandonment reinforces social deterioration. This phenomenon aligns with [21], who argues that urban voids can become catalysts for integration only when activated through participatory processes that strengthen the bonds between the community and its built environment; [22] support this perspective by demonstrating that community management models yield better results in terms of social cohesion and security than exclusively governmental interventions. In this regard, the participatory validation conducted in workshops with local actors in Villa El Salvador, which reached an 82% consensus on the prioritized plots, confirms the relevance of integrating local knowledge into decision-making, aligning with [13] recommendations on inclusive urban governance.

The proposed intervention scenarios reflect a contextual adaptation of the CPTED model described by [16]. Scenario A, based on low-cost tactical interventions such as cleaning, lighting, and temporary activations, is grounded in evidence like that reported by [5], which demonstrated that these actions generate rapid reductions in minor crimes and improvements in the perception of safety. Scenario B, which combines physical improvements with co-management programs, aligns with the recommendations of [22] regarding hybrid community management models. Meanwhile, Scenario C, focused on permanent interventions, coincides with the structural regeneration vision proposed by [4]. This stepped sequence allows for a progressive and realistic implementation that responds to the budgetary and administrative limitations identified during the research.

An emerging aspect of great relevance is the relationship between urban voids and mental health. Although this study did not directly measure psychological variables, qualitative interviews revealed that residents associate these spaces with stress and anxiety due to their connection with crime and neglect. This finding relates to the research by [7], who found that the physical improvement of vacant lots reduces indicators of depression and feelings of worthlessness in urban populations, suggesting that the proposed interventions could have indirect benefits on the community's emotional well-being, extending their impact beyond physical and social security.

The correlation between reduced visibility and perception of insecurity, with a Spearman coefficient of 0.42, validates the relevance of prioritizing design strategies that promote visual openness and natural surveillance, fundamental principles of the CPTED model. This result supports the proposal of interventions that transform improvised enclosures into permeable and active boundaries, fostering community surveillance and visual integration, in accordance with [14] urban edges theory. Furthermore, the negative correlation between social appropriation and the presence of opaque enclosures confirms that the physical and social dimensions are intrinsically linked, reinforcing the need for an integrated approach in planning.

In terms of public policies, this research fills a significant gap in Latin American literature, where descriptive studies without empirical prioritization models predominate. The proposed catalytic potential index and operational prioritization matrix constitute concrete tools for municipal management, aligned with the principles of urban sustainability and resilience outlined by [20]; however, the comparison with the meta-analysis by Sadatsafavi et al. (2022) reveals the need to incorporate economic evaluations in future research, given that the financial benefits of regenerating urban voids have yet to be quantified in Peruvian contexts. This limitation represents an opportunity to advance toward planning models that integrate the physical, social, environmental, and economic dimensions in a balanced manner.

The results obtained confirm that urban voids are not merely residual spaces but strategic nodes that, when properly managed, can redefine territorial and social dynamics, transforming the perception of insecurity and strengthening community integration. The comparison with international studies shows that, although the general patterns of correlation between physical abandonment and criminality are repeated in various contexts, the uniqueness of Villa El Salvador lies in the coexistence of historical self-management, structural informality, and institutional limitations—factors that demand adapted and participatory intervention strategies. This research provides empirical evidence and methodological tools that can serve as a basis for designing evidence-based public policies aimed at building safer, more inclusive, and resilient cities, where urban voids are transformed from symbols of abandonment into catalysts for social cohesion and collective well-being.

5. Conclusions

The research provides a robust spatial and social diagnosis that integrates a georeferenced inventory of 8 urban voids totaling approximately 9.6 hectares and an operational typology that distinguishes private lots without management, underutilized state-owned properties, infrastructural strips, peri-urban plots undergoing invasion processes, and interstitial spaces generated by informal consolidation. These findings confirm that the morphology and location of the voids determine their catalytic potential and condition the feasibility of interventions. The concentrated distribution along edges and transition zones reveals discontinuities in the public space network that affect pedestrian connectivity and urban visibility. The observation of 59% reduced visibility and 34% high deterioration underscores the urgency of cleaning and physical remediation measures as the first operational step. Additionally, the identification of 26 properties with complex administrative status highlights the need for legal and management strategies to accompany urban design interventions.

The developed catalytic potential index demonstrates the relevance of a multidimensional approach by combining physical, social, and security domains with weightings derived from participatory workshops. The robustness of the index was validated through Monte Carlo sensitivity analysis, showing a high average stability of 0.88. Its spatial correlation with local complaints exhibits empirical coherence for prioritization. The 20 highest-priority properties account for 31% of the total inventoried area and are located along urban axes with equipment deficits. These results confirm that strategic location and the presence of demand nodes are determinants for generating urban contagion effects that enhance social appropriation and crime reduction. The application of SAR spatial models supports a positive relationship between vacancy density and property crime rates, estimating a relative increase within influence radii, which legitimizes the central hypothesis regarding the criminogenic nature of unmanaged vacancies when there are no natural control measures and legitimate user presence.

From the social dimension, it is observed that the perception of insecurity predominates among the inhabitants, with an average index reflecting social tension and correlations showing a positive association between low visibility and citizen fear. The Spearman correlation between visibility and perception yielded ρ equal to 0.42, while social appropriation shows a negative association with improvised enclosures. These findings support the relevance of interventions that recover pedestrian frontages, promote permeable boundaries, and activate legitimate daytime and nighttime uses. The participatory validation with local actors, which confirmed 82% of the technical prioritization, reinforces the convenience of co-management and co-design models that increase operational sustainability and community legitimacy. Additionally, qualitative interviews indicated an explicit demand for spaces for children and cultural activities, a key input to guide programming of uses in regeneration proposals.

In terms of design and operation, the proposed interventions articulated in tactical, mixed, and permanent scenarios offer a phased roadmap that responds to budgetary constraints and municipal management timelines. Scenario A prioritizes low-cost and highly replicable actions such as cleaning, targeted lighting, and temporary activations, which, according to ex-ante evaluations, could quickly reduce the perception of insecurity. Scenario B incorporates structured greening, furniture, and co-management agreements to consolidate social appropriation in the medium term. Scenario C proposes reurbanization and the incorporation of equipment for structural impacts. This operational sequence aligns with CPTED principles and tactical urbanism and simultaneously allows for generating evidence for pilot tests that verify causal effects in local contexts using rigorous methodology.

The implications for public policy and municipal management include the adoption of a prioritization matrix that crosses catalytic potential, administrative feasibility, and estimated cost; the implementation of framework agreements for the temporary transfer of management to neighborhood organizations; the execution of pilot programs with before-and-after evaluations; and the incorporation of monitoring indicators linked to usage, perception, and crime. It is also essential to integrate environmental mitigation measures on properties near waterways and infrastructure strips to reduce risk vectors and ensure the physical sustainability of interventions. The inclusion of accessibility and pedestrian connectivity criteria in the design will allow the intervened properties to be connected with the existing urban network and enhance multiplier effects in neighboring neighborhoods.

Methodological limitations are acknowledged that guide future research and the evaluation agenda. The availability and quality of cadastral and police data conditioned the accuracy of some estimates, and causal inference is limited by the cross-sectional nature of much of the survey and the absence of local controlled trials. Therefore, it is a priority to implement pilot tests with experimental or quasi-experimental designs that allow estimating the net effects of specific interventions. Likewise, it is necessary to incorporate economic cost-benefit evaluations adapted to the local context and measurements of mental health and community well-being to capture multidimensional impacts. The replicability of the index and the operational matrix in other jurisdictions of Lima requires contextual calibrations that consider tenure, regulations, and local administrative capacities.

The research consolidates the idea that urban voids constitute potential territorial resources when addressed in an integrated manner through precise spatial diagnostics, community participation, and design strategies that prioritize visibility, appropriation, and shared management. The transformation of these spaces into nodes of coexistence and safety demands inter-institutional coordination, legal instruments that resolve ownership issues, and innovative financing mechanisms that allow scaling successful interventions. The implementation of a pilot program in the prioritized sites, along with a rigorous monitoring and evaluation plan, constitutes the next operational step to convert the generated evidence into effective and sustainable public policies that contribute to building a safer, more inclusive, and resilient city.

Author Contributions: Conceptualization, Carlos Guillermo Vargas Febres and Ernesto Favio Salazar Pilares; methodology, Carlos Guillermo Vargas Febres; software, Ernesto Favio Salazar Pilares; validation, Carlos Guillermo Vargas Febres and Ernesto Favio Salazar Pilares; formal analysis, Carlos Guillermo Vargas Febres; investigation, Carlos Guillermo Vargas Febres and Ernesto Favio Salazar Pilares; resources, Carlos Guillermo Vargas Febres; data curation, Ernesto Favio Salazar Pilares;

writing—original draft preparation, Carlos Guillermo Vargas Febres; writing—review and editing, Ernesto Favio Salazar Pilares; visualization, Ernesto Favio Salazar Pilares; supervision, Carlos Guillermo Vargas Febres; project administration, Carlos Guillermo Vargas Febres; funding acquisition, Carlos Guillermo Vargas Febres. All authors have read and agreed to the published version of the manuscript.
Funding: This research received no external funding".
Acknowledgments: The authors express their gratitude to the Universidad Autónoma del Perú for the institutional and administrative support provided during the development of this research, as well as for fostering the academic environment that made this study possible. Special thanks are extended to Dr. Luis Fernando Garcés Giraldo and Dr. David Alberto García Arango for their valuable guidance, technical insights, and constant encouragement throughout the research process. Their expertise greatly contributed to strengthening the methodological approach and scientific rigor of this work.
Conflicts of Interest: The authors declare no conflicts of interest
Abbreviations

SAR	Spatial Autoregressive Model
SIG	Geographic Information System (from Spanish Sistema de Información Geográfica)
CPTED	Crime Prevention Through Environmental Design
KPI	Key Performance Indicator
N	Sample Size
SD	Standard Deviation
Min–Max	Minimum–Maximum Normalization
%	Percentage

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