The Role of Small Green Initiatives and Socio-spatial Dynamics in Crime Prevention in Lower-income Neighbourhoods: A Case Study in Medellín

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Abstract

This study examines the role of small green interventions in enhancing neighbourhood safety and well-being within a lower-income community in Medellín, Colombia. By exploring the socio-spatial dynamics at play, we analyse how green infrastructure, together with community engagement, influences residents' perceptions of safety and fosters social cohesion. The contribution of the physical environment to crime control is explored by examining aspects derived from widely applied theories, such as Defensible Space and Busy Streets. This research employs a mixed-methods approach that includes interviews, surveys, spatial data, and ecological assessments. Findings suggest that small-scale green initiatives empower residents, strengthen communal bonds, and foster an emotional connection with nature, thereby contributing to crime prevention and improved community relations. Key contributions of this study provide insights into community-based environmental strategies that can serve as crime deterrents, relevant for urban planners and policymakers aiming to implement sustainable and inclusive green spaces in urban settings.

Keywords: Crime prevention, community-centric green interventions, sense of community, empowerment, environmental design, biodiverse green infrastructure, nature self-transcendence.

1. Introduction

Studies exploring the factors influencing neighbourhood violence have identified concentrated poverty, population density, and low social cohesion (Kondo et al., 2018)

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as significant determinants of criminal behaviour. The absence of social cohesion and a sense of community, in particular, is a crucial indicator of social disorder. Furthermore, a lack of collective efficacy and empowerment is recognised as a risk factor for violence (Sampson et al., 1997; Sampson, 2012), indicating that social control, such as resident monitoring, is a primary mechanism that helps against crime (Lanfear, 2022). Lower-income neighbourhoods in Latin American cities, such as Medellín, Colombia, offer valuable insights into the defensive mechanisms employed to foster social cohesion and collective efficacy (Eslava et al., 2015), which arise from prolonged processes of neighbourhood adaptation and reconstruction (Benjumea et al., 2024). These processes lead to the development of new social and spatial subjectivities used to counter systemic violence, as evidenced in Rio de Janeiro's favelas (Fahlberg, 2018) and Medellín's lower-income communities (Eslava et al., 2015).

The emerging collective ideas contribute to positive community values, often culminating in community-led initiatives that enhance residents' perceived safety from crime. These initiatives manifest in various forms, including artistic expressions that reflect contrasting ideologies, educational programmes (Faljberg, 2018), and environmental justice responses that address the depletion of natural spaces in neighbourhoods (Benjumea et al., 2024).

In recent years, the natural environment has been increasingly used to respond to environmental and social crises, such as those posed by the COVID-19 pandemic. Community gardening and greening vacant lots emerged as popular initiatives, actively engaging residents in environmental activities (Bieri et al., 2024; Bell-Williams et al., 2021). These green interventions also demonstrate a positive correlation with crime reduction (Shapley et al., 2019). In the context of Medellin, prevalent criminal behaviours in low-income neighbourhoods include homicide, assault, property crime (e.g., vandalism and theft), gang intimidation and territorial control, commonly known as invisible borders (Todtz, 2018). Kondo and colleagues (2018) suggest that introducing greening interventions into neighbourhoods with high crime rates could disrupt offenders' opportunistic processes to commit crimes. Integrating these initiatives adds a new protective layer, as community members who tend to gardens act as "capable

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guardians", thereby reducing opportunities for motivated offenders who may be deterred by the presence of vigilant community members (Brantingham, 1993; Aiyer et al., 2015; Heinze et al., 2018). Theories contributing to understanding the impact of the physical environment on crime control have helped identify specific features that might deter crime, for instance, the Defensible Space and Busy Streets (Newman, 1972; Aiyer et al., 2015). Nevertheless, while these theories and existing studies offer insights into crime behaviour following greening initiatives in Global North countries (Cozens & Love, 2015; Drawve & Barnum, 2018; Shepley et al., 2022; Schertz et al., 2021), the application of such features in the Global South, particularly South American cities, remains limited. The lack of exploration into the contributions of these interventions highlights the pressing need for more nuanced definitions of green space and its socio-spatial characteristics to deter criminal behaviour (Venter et al., 2022).

Most of the research in low-income neighbourhoods exploring interventionist approaches using urban green initiatives is heavily focused on communal gardens, as evidenced by studies conducted by Kondo et al. (2016) and Gong et al. (2023). This trend is similarly observed in programmes and interventions in South American cities. However, an area that has received less attention but holds potential for contributing to discussions on crime reduction in lower-income residential areas is the phenomenon of individual initiatives appearing spontaneously within neighbourhoods that help cultivate a sense of safety.

Existing literature has primarily emphasised the role of such spaces in enhancing users' overall health and well-being (Bell-Williams et al., 2021). Yet, an aspect worthy of exploration is their potential to deter criminal offenders, considering the spatial characteristics of green spaces and social factors that moderate peaceful interactions within crime-ridden contexts.

This study investigates how the nexus between small-scale green interventions, social dynamics, and spatial configuration, including the ecological contribution of natural green spaces in the neighbourhood, influences the perception of safety within a low-income neighbourhood in Comuna 13, Medellín. We contend that collectively, external alliances, a strong sense of community, and a clear neighbourhood layout with a

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balanced, well-maintained, biodiverse green infrastructure help maintain a positive neighbourhood image, which is crucial for sustaining a peaceful environment free from extreme violence. However, the sustainability of these dynamics relies heavily on community organisation and vigilant attention to their surroundings. Understanding the social dynamics, agents, and key actors involved is essential for adapting and shaping socio-spatial interventions to protect the neighbourhoods from criminal offenders.

Understanding the progression and diminishment of violence in Medellín

The city of Medellín has a long history of victimisation due to extreme crime in its urban areas. The 1990s were particularly violent, with the highest homicide rates in Latin America (Ruiz Vásquez et al., 2023). This violence was driven by a combination of historical and social factors, including the national armed conflict, the Medellín Cartels, the rural diaspora, the new neoliberal economic model, and the conflict involving various insurgent groups such as the EPL, ELN, FARC, and the United Self-Defense Forces of Colombia (AUC) (IBID). Many of these groups operated from the city's unregulated territories known as comunas, establishing enclaves dominated by illegal structures (Giraldo-Ramírez and Preciado-Restrepo, 2015).

The violence unleashed in these suburbs was exacerbated by the confrontations between insurgent groups vying for territorial control in the comunas. For years, these neighbourhoods were largely impenetrable to police forces. However, in the 2000s, significant changes occurred through military securitisation policies aimed at regaining control and restoring civil practices and peaceful interactions. These measures included violent confrontations with insurgent groups, with residents often caught in the crossfires (Abello Colak et al., 2023). Notable interventions included the October 2002 National intervention in Comuna 13, known as the "Orion Operation" (Giraldo-Ramírez and Preciado-Restrepo, 2015), negotiations with the AUC, and operations targeting high-value insurgent leaders (Dávila et al., 2016).

In addition to military strategies, the local government implemented a comprehensive plan to improve local infrastructure and address social inequality in the lowest-income neighbourhoods (Echeveri & Orsini, 2010; Giraldo & Fortou, 2012; Sotomayor, 2017). This approach, known as social urbanism, involves large-scale urban spatial interventions

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and a participatory democracy methodology, which has become one of the most recognised examples of community participatory processes (Sotomayor, 2017). Projects such as urban parks, cable cars, community centres, and libraries led to a 66% reduction in homicides in the affected neighbourhoods compared to areas that did not receive such interventions (Cerdá et al., 2012). At the core of these projects was the promotion of community conviviality and citizen culture, which contributed to reducing criminal acts (Vargas y García, 2008).

Despite these efforts and the resulting lower homicide rates, organised criminal youth gangs known as 'combos' continue to exert informal control in the neighbourhoods and act as warlords, engaging in sophisticated forms of crime such as extortion, drug dealing, illegal trafficking, and usury loans (Blattman et al., 2020). Residents have learnt to live with and cope with this ongoing violence.

The neighbourhood image and the perceived sense of safety's role in controlling criminal behaviours

Neighbourhoods that have benefited from effective crime control strategies often prioritise the perception of crime and safety, recognising its significant influence on social stereotypes and residents' life prospects (Butti, 2017). This emphasis is particularly relevant in Medellín's Comunas, where countering entrenched social stereotypes and stigma remains a pressing concern alongside reducing actual crime rates. The perception of crime and safety is not merely a reflection of factual occurrences but is deeply embedded in the collective imaginaries of residents (Guerrero Valdebenito, 2007). In South American cities, the perception of unsafety is socially constructed and shared, reinforcing stereotypes and prejudice (Cerda, 2001). Butti's study in lower-income neighbourhoods in Medellín found that feeling excluded or stigmatised by violence might lead youths to respond with violence, and those who face discrimination turn to crime as an automatic response (Butti, 2017). Additionally, the reinforcement of violence in the neighbourhood image naturalises the perception of crime, making high levels of crime and violence seem normal.

Vargas and Sanchez (2018) highlight how the naturalisation of urban violence perpetuates a cycle where violent actions are normalised through language and social

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representations, hindering critical examination and propagating societal acceptance of urban violence as a daily reality (Vargas & Sánchez, 2018); *"observing violence stimulates violence"* (Boxer et al., 2013). Nevertheless, instances of residents adapting positively and exhibiting high levels of resilience have been observed, where understanding the social and environmental context leads to positive social dynamics (Vargas & Sánchez, 2018; Heinze et al., 2017; Richardson, 2019). This adaptation can shift perceptions of unsafety into positive narratives that benefit social dynamics in the territories, transforming violent conflicts into self-protection strategies (Eslava et al., 2015).

The role of the communities in safeguarding the territories is ingrained in the actual dynamics of territories emerging from the extreme violence of the 1990s, where communities were initially responsible for sustaining basic safety (Ruiz Vásquez et al., 2023). Organised protective social responses and non-violent spatial subjectivities in the urban space represent the communities' mechanisms of social resistance (Davila et al., 2016; Falhberg, 2018). Examples include building sports facilities to forge collaboration, empathy, and respect (Davila et al., 2016). Environmental interventions, such as urban green spaces, promote communing dynamics (Colding & Barthel, 2013), a better sense of health and well-being (Arbuthnott, 2023), and reduce instances of crime (Shapley et al., 2019; Benjumea et al., 2024). The importance of such interventions lies in their effectiveness as violence-resistance and self-protection strategies. Several social factors have been associated with the formulation of these strategies, including strong collective efficacy (Sampson et al., 1989), leadership, resilience (Eslava et al., 2015), sense of community and social cohesion (Kuo et al., 1998; Sullivan et al., 2004; Olawole et al., 2022). The interplay of these factors influences the neighbourhood image and the likelihood of being targeted by criminal offenders (Taylor & Gottfredson, 1986).

The contribution of green initiatives in spatial design for crime prevention

The physical environment and its designed elements might either promote or deter criminal occurrences (Newman, 1972; Aiyer et al., 2015; Cozens & Love, 2015; Drawve & Barnum, 2018). Research on the influence of the physical environment on crime has led to the development of the well-known Defensible Space theory (Newman, 1972), which

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has subsequentially informed design concepts and frameworks implemented to reduce crime opportunities (Cozens & Love, 2015). This theory emphasises the role of spatial design and social markers in enhancing safety, highlighting location, geographical juxtaposition, territoriality, natural surveillance, and image and milieu as key to increasing neighbourhood safety (Donnelly, 2010). The application of this theory has evolved primarily in Global North countries, with some of its principles recently considered in Global South countries as well (Muhyi et al. 2019), where strategies based on 'territoriality' leverage the physical environment to create zones of influence to increase natural surveillance (Hatipoglu et al., 2022; Mshelia et al., 2024).

Critics, however, argue that the theory leans towards physical determinism, assuming that the physical environment alone determines human behaviour (Donnelly, 2010). Despite such claims and critique, decades of research indicate that specific built environment features can be indeed criminogenic or provide opportunities for crime (e.g., abandoned buildings, venues for alcohol sales, mixed land use, etc.) (Lanfear, 2022). Therefore, some of the design propositions of the Defensible Space could be explored in parallel with theories that consider social factors, including collective efficacy, sense of community, and empowerment – such as the Busy Streets theory (Aiyer et al., 2015).

The Busy Streets theory posits that revitalising neglected areas through community involvement could reduce crime by enhancing community connectedness and fostering vibrant neighbourhoods with lively environments - such as green spaces and thriving local businesses (Heinze et al., 2018). Research shows that communities that invest in maintaining and improving their neighbourhoods experience stronger social cohesion, which in turn can improve public safety and well-being (Gong et al., 2023). One example is repurposing vacant lots into community gardens or green spaces, which has been shown to restore feelings of hope and a sense of community while also signalling social control and improving neighbourhood perceptions (Burt et al., 2021).

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When considering green spaces in the context of crime prevention, aspects such as green space typology, greenery distribution, density, and vegetation condition are also relevant to consider. Recent studies have highlighted the role of green spaces in deterring uncivil behaviours. For instance, research has shown that areas with higher numbers of trees are frequented by more users, suggesting that the presence of greenery encourages pro-social behaviours (Sullivan et al., 2004). Additionally, studies by Ryan et al. (2023) found that increased greenspace accessibility and tree canopy cover are more beneficial than greenspace quantity for reducing both firearm and non-firearm crime compared to simply increasing the quantity of greenspace. The interplay of high vegetation density, appropriate lighting, and clear sightlines enhances natural surveillance, creating a buffer that helps define public and private spaces (Wolf, 2010; Branas et al., 2018). Furthermore, biodiverse green spaces, when coupled with engaged and vigilant communities, have been found to serve as a deterrent to criminal activity, further supporting the theory that natural elements, such as vegetation and community involvement, can play a key role in fostering safer environments (Schertz et al., 2021).

The role of green spaces in promoting pro-social behaviour and reducing criminal activity has been widely studied, with evidence suggesting that exposure to natural environments fosters a range of positive social outcomes. Individuals who regularly engage with green spaces are more likely to exhibit pro-social behaviours, such as increased civic engagement, community participation, and conservation actions that preserve natural habitats (Arbuthnott, 2023; Scannell & Gifford, 2010). These behaviours are often associated with a greater sense of community responsibility and a collective desire to improve common spaces, which can play a role in reducing crime rates (Schertz et al., 2021). For instance, studies have found that neighbourhoods with well-maintained green spaces tend to have lower crime rates, possibly because these spaces foster stronger social networks and greater collective efficacy, which in turn discourages criminal behaviour (Kuo et al., 1998).

However, it is important to acknowledge that the majority of research on the relationship between green spaces and social behaviour has been conducted in the Global North

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countries. This geographical disparity raises concerns about the generalisability of these findings and the applicability of theories such as the Defensible Space and Busy Streets to non-Western settings (Arbuthnott, 2023). For example, while these theories have provided valuable insights into crime prevention in cities like New York and London, their relevance in the Global South requires further investigation as these regions have distinct socio-cultural and economic contexts. Green spaces, in these contexts, may play an even more significant role in reducing crime by providing recreational spaces and opportunities for safe community spaces, or they could have the opposite effect.

Furthermore, although the core principles of the Defensible Space and Busy Streets theory remain influential in urban planning, certain foundational aspects may limit their applicability. For instance, the concept of 'green areas' fails to account for critical aspects that have gained recognition in contemporary urban analysis, such as green space typology, environmental contribution, and the density of greenery (Shepley et al., 2019; Wo & Rogers; 2024; Liang et al., 2025)

For example, studies highlight that green spaces that are carefully designed to incorporate a diversity of plant species and foster community interaction are more likely to reduce crime than large, open, and underutilised parks (Shepley et al., 2019). Additionally, the density of greenery can contribute to social cohesion and safety, as these spaces are conducive to natural surveillance while simultaneously offering privacy and security for residents (Branas et al., 2018). Nonetheless, it is important to highlight that the presence of green space alone is not enough to foster pro-social behaviours; the spatial configuration and management of these spaces, alongside community engagement, ultimately determines crime prevention and social cohesion.

In summary, we arrive at the conclusion that further research is needed to examine the influence of the physical environment on criminal behaviour, with particular attention to green spaces and the associated social factors – such as collective efficacy and a sense of community (Lanfear, 2022) – that may promote defensible behaviours in lower-income neighbourhoods in South America. These areas have unique urban development histories and distinct patterns of violence, as observed in Medellin (Davila et al., 2016). Furthermore, while community green interventions are widely recognised for their

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benefits (Richardson, 2019), small-scale individual interventions that appear in the physical environment remain underexplored as strategies for crime prevention. These interventions – including personal landscaping and gardening (Bell-Williams et al., 2021) – can collectively add an extra layer of guardianship by residents that eventually could help remove or prevent the development of criminal opportunities. Therefore, to better understand the relationship between crime and specific environmental features, it is necessary to move beyond broad land-use categories and conduct a more granular analysis of place and land-use types (Hodgen & Wuschke, 2023). Disaggregating these categories could reveal how different typologies of green space and urban form - such as individual small interventions, small parks, and community gardens and the quality of their natural elements (e.g., ecological contribution) - may impact criminal activity (Liang et al., 2025). The unintended consequences (Fernandez et al., 2019; Sukartini et al., 2021), such as potentially increasing crime risk by providing concealment opportunities if communities fail to oversee the green spaces (Delgado da Silva et al., 2024) need also to be explored.

In Medellin, known as the 'miracle city'[1] (Hart, 2021; Davila et al., 2016; Ruiz Vásquez et al., 2023), these approaches could foster unique forms of community coexistence and protect territories from anti-social and violent actors (Ortiz & Millan, 2022). Research should explore how communities that manifest a high sense of community use the physical environment to monitor safety, particularly small-scale green interventions. It is also crucial to examine whether well-maintained biodiverse natural elements serve as effective crime deterrents.

To address these gaps, this study conducts an in-depth longitudinal exploration conducted in Comuna 13, specifically in the Eduardo Santos neighbourhood. Over the past decade, this area has exhibited a noticeable decrease in violent crimes and features a high density of vegetation combined with an important number of small-scale

[1] The city of Medellín has been denoted by several authors as a miracle city due to its rapid shift from the most violent city in the world to the most innovative, intelligent, ecological, and resilient to crime, reaching the lowest homicide rates in Colombia by 2020 (Hart, 2021, Davila et al., 2016).

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individual green initiatives. Data collected from 2019 to 2023 include semi-structured interviews with community leaders and residents, surveys, historical crime data, government reports, videos, ethnographical fieldwork, remote sensing data, and spatial quantitative assessment of the green spaces' ecological contribution.

The following sections provide background information on Eduardo Santos in Comuna 13, detail the methodology and methods implemented, present the results and discuss the findings. The article concludes by synthesising the key insights and outlining contributions for future research.

1.2. Comuna 13: Eduardo Santos

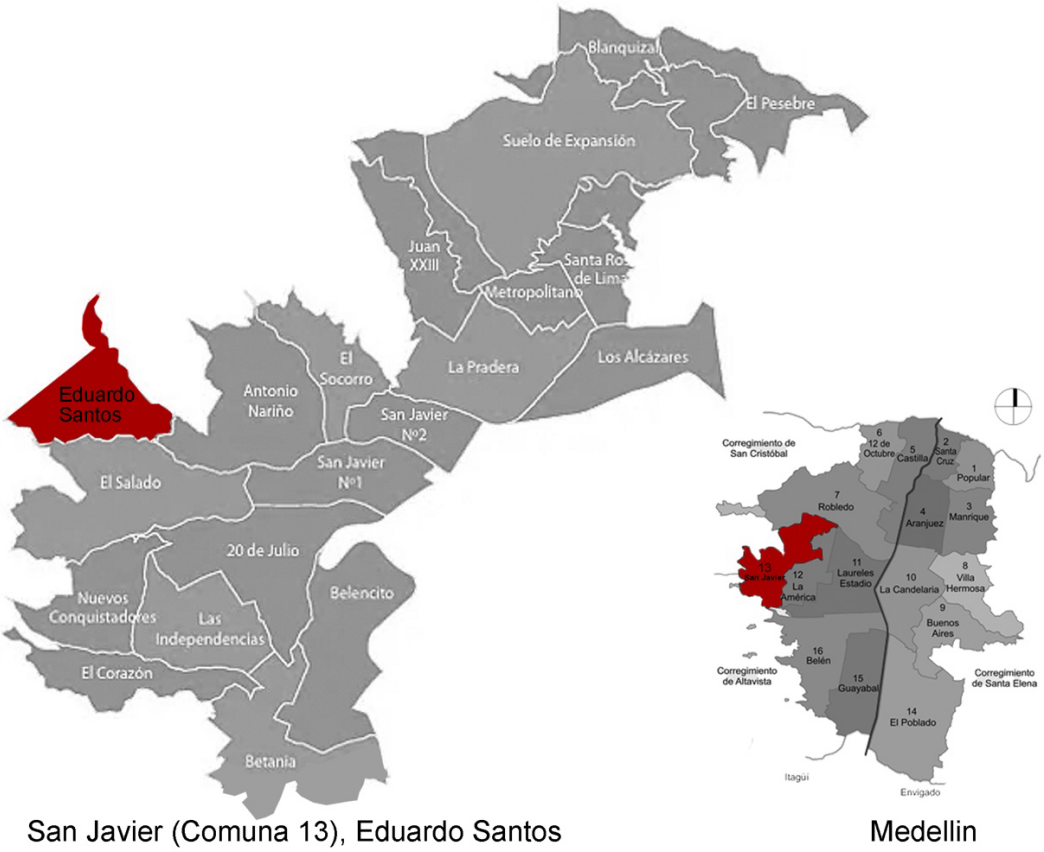

Figure 1. San Javier neighbourhoods (Comuna 13) and Eduardo Santos location.

During the 1950s and 1960s, a series of intra-urban displacements, driven by violence and the pursuit of a better quality of life, led rural families and impoverished urban dwellers to settle in Eduardo Santos and its surrounding areas. This settlement process

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was influenced by both intra-urban and rural migration flows. In response to escalating armed conflict in the northeastern and central-eastern areas of Medellín during the late 1980s and early 1990s, families began to occupy land illegally in what is now the Eduardo Santos neighbourhood, located in the central-western zone of Medellín's Comuna 13, San Javier. The neighbourhood was later legalised through the subdivision of an old estate, supported by urban regularisation and legalisation plans promoted by the mayor's office.

Eduardo Santos is bordered by two important streams, La Hueso and La Leonarda, which are vital water sources for the sectors of Comuna 13. To the North, there is a quarry managed by Agregados San Javier, a company that has acquired legal permissions from regional environmental authorities (Corantioquia) to extract construction materials. Residents have raised multiple complaints regarding an adjacent landfill, which has caused environmental pollution affecting both water streams and air quality. In the 1990s, insurgent groups began to afflict the area, using the landfill for disposing of victims' bodies (Monroy, 2008).

In 2007, a legal effort was launched by a local lawyer to secure the right to a healthy environment and better use of public space, involving the Área Metropolitana del Valle de Aburrá, Corantioquia, Agregados San Javier, Unión Temporal Pro Parque del Sol and Empresas Varias de Medellín to dismantle the landfill. This lengthy process, spanning over a decade, ultimately resulted in the immediate closure of the landfill, which was subsequently converted into an eco-park in 2019.

One of the largest military actions in 2002 unfolded in the city of Medellin, **Operation Orion**, which took place in several neighbourhoods in Comuna 13, including Eduardo Santos (Comision de la verdad). The operation, led by the Colombian armed forces, aimed at diminishing all insurgent groups operating in Comuna 13. Reports from the Truth Commission (Comision de la Verdad) describe weeks of gun confrontations and explosions. Several forms of violence were deployed, including arbitrary arrests, selective detentions, and subsequent disappearances (Zapata Gonzales, 2017; Radio Nacional Colombia, 2022). A local leader surviving the event described how she and

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family members had to remain hidden for over a week under their beds to avoid being accidentally shot during the confrontations that took place day and night.

More than two decades later, community leaders in Eduardo Santos report that the neighbourhood has finally experienced a return to prosperity and peace reminiscent of its early years. This process, however, necessitated intervention from external partnerships, including the government and private entities, often procured directly by residents. The quarry company played a role in consolidating the neighbourhood, providing financial support for social programs and infrastructural improvements. After Operation Orion, a consolidated community leadership structure launched educational programs for children, adults, and female groups and projects dedicated to enhancing green infrastructure.

Neighbourhood's socioeconomic profile

Eduardo Santos is located in the San Javier commune, also known as Comuna 13, and is constituted by 19 neighbourhoods (**see Figure 1**). Comuna 13 has a population of 140,758 residents, of whom 67,704 (48%) are men and 73,054 (52%) are women. The age distribution has an important concentration of residents aged 0-19, totalling 43,960 (31.23%). The age group between 20-34 years accounts for 35,094 (24.93%), followed by 35-54 years with 37,039 (26.31%). The 55-74 age group comprises 20,969 individuals (14.90%), while those aged 75 and older constitute only 3696 residents (2.63%).

Currently, detailed socio-economic data for individual neighbourhoods within San Javier is unavailable. However, municipal records provide a general profile of the commune, indicating that 38% of the population belongs to the lowest economic strata, with an additional 36% classified as extremely low-income. Approximately 21% of residents are part of the lower-middle strata, and only 4% belong to the middle strata.

According to the municipal indicators, the educational attainment in Commune 13 is reported to be low across primary and secondary education and has limited access to tertiary education. Economic activities are predominantly distributed into five sectors:

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food, crafts, clothing, trade, and services. A substantial portion occurs within residents' homes, showing the prevalence of informal economies and self-employment as the primary source of livelihood in the commune (Zapata Gonzales, 2017).

Today, a total of 3,471 inhabitants reside in Eduardo Santos neighbourhood, of which 1,672 (48.17%) are men and 1,799 (51.83%) are women. The neighbourhood's urban morphology features well-defined two-way roads mostly surrounded by natural green spaces. After 2002, several green initiatives emerged, dispersed across the neighbourhood; some take place in residual public green spaces with the government's permission (**Figure 2a**). Other interventions involve transforming individual 'private' spaces into gardening, farming, and gathering areas (**Figures 2b to d**). This study examined a total of 10 individual initiatives dispersed throughout the neighbourhood (**Figure 3**).

Figure 2. a) Interventions at the side of the road; b) Individual initiatives located at the side of the road; c) Individual initiatives with agricultural activities; d) Restricted access to the gardens.

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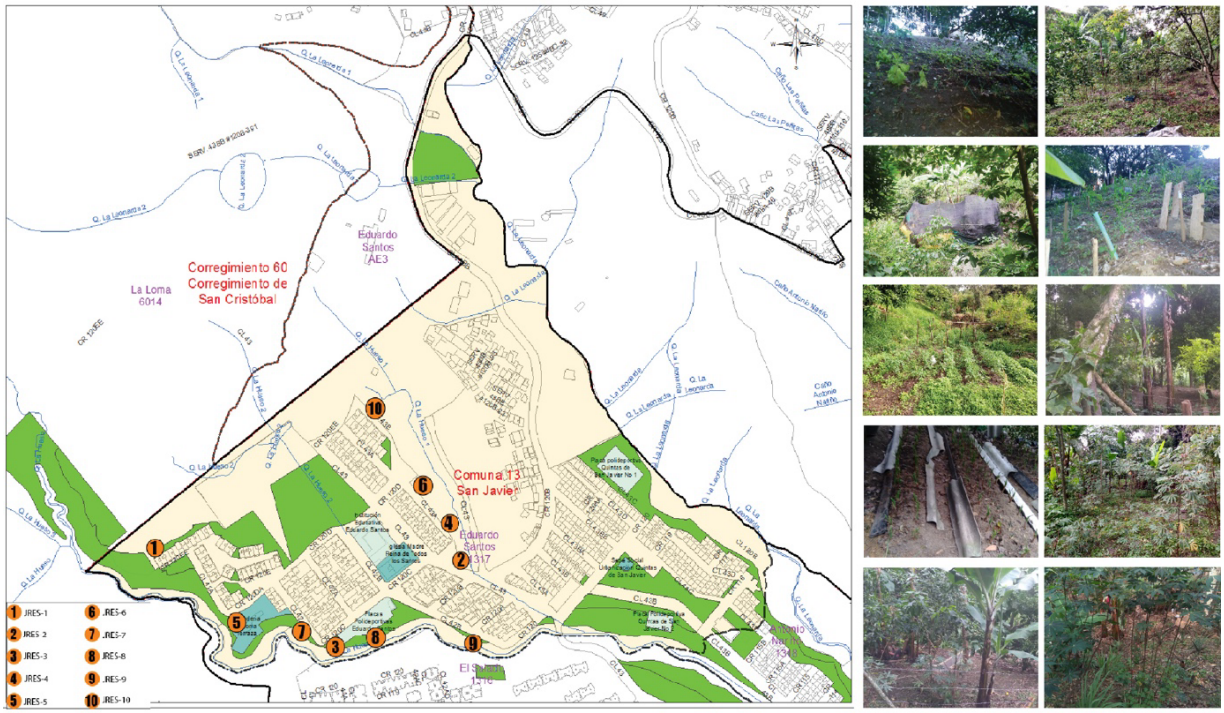

Figure 3. Individual interventions studied.

2. Methodology

The study adopted an exploratory sequential mixed-methods design, guiding an iterative process of longitudinal data collection and analysis conducted from December 2019 until December 2023. To gain a rich understanding of the lived experiences and roles of individual green initiatives, the first phase involved qualitative methods, including in-depth interviews and participant observation, to gather perspectives and contextual factors influencing perceptions of the neighbourhood and its gardens. This phase used purposive sampling to identify key participants, such as green initiative owners (n=10) (**Figure 3**) and community leaders (n=3) (**Table 2**). Ethnographic fieldwork was also conducted in December 2019. Additionally, secondary data sources, including online local media reports from newspapers and online platforms spanning from 1995 to 2020, were reviewed to reconstruct the neighbourhoods' development history (Hine, 2012).

Based on these qualitative findings, the second phase involved the use of quantitative methods, specifically designing a survey instrument administered from January to March 2022. The assumed population consisted of 3,471 residents, comprising 1,672 men (48%) and 1,799 women (52%).

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To help ensure equal participation by gender, we followed a stratified random sampling technique by gender. The target sample size was calculated to ensure a robust representation of the population while maintaining feasibility, given resource constraints.

Residents' names and contact numbers were accessed through official records facilitated by community leaders, which helped ensure that stratified random sampling could be performed. Selected individuals were invited to participate in the online survey. Due to a lack of responses or incomplete entries, which might have been influenced by the aftermath of the COVID-19 pandemic, only 40 valid responses were obtained. The final sample obtained was approximately representative of the neighbourhood distribution by gender, comprising 18 men (45%) and 22 women (55%). The analysis presented in this paper is based solely on these 40 responses.

Various psychometric scales were implemented, including the International Positive and Negative Affect Scale short-form (IPANAS-SF) (Karim et al., 2011), the Brief Sense of Community Scale (BSCS) (Peterson et al., 2008), and measures of Environmental Actions. Additional questions assessed residents' perceptions of neighbourhood safety (VIOL) and the contribution of green spaces in reducing crime (ENV ACT) (see **Table 1**).

Table 1. Scales summary questions.

IPANAS-SF
Interval measure: Never 1 2 3 4 5 Always
Thinking about yourself and how you normally feel, to what extent do you generally feel:
Items in order:
Upset
Hostile
Alert
Ashamed
Inspired
Nervous
Determined
Attentive
Afraid
Active
BSCS
Interval measure: Strongly disagree 1 2 3 4 5 Strongly agree
I can get what I need in this neighborhood.
This neighborhood helps me fulfill my needs.
I feel like a member of this neighborhood.

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I belong in this neighborhood.
I have a say about what goes on in my neighborhood.
People in this neighborhood are good at influencing each another.
I feel connected to this neighborhood.
I have a good bond with others in this neighbourhood
ENV ACT
Interval measure: not at all 1 2 3 4 5 Very much
Participating in projects involving interaction with nature has helped me to:
Be more active in my local environment by participating in nature-related activities.
Be more aware of the natural environment and its importance.
Be more aware of nature and its contribution to my health and well-being.
Feel more motivated to integrate nature-related activities into my daily life.
Feel more connected with my neighbours.
VIOL
Interval measure: not at all 1 2 3 4 5 Very much
How violent do you think your neighborhood is?
How safe do you think your neighborhood is?
Do you think green spaces like gardens and parks have helped reduce violence in your neighborhood?

To explore the spatial configuration of the neighbourhood, the study comprehensively evaluated the spatial and biophysical properties of the area through fieldwork and spatial analysis using geospatial data from various sources, including satellite imagery and aerial photographs. Google Street View provided profile views of the urban landscape (Li et al., 2015). This information was combined with field surveys to conduct a spatial, quantitative assessment of ecological contributions, considering both natural and artificial structural aspects, such as lawns, hedges, water elements, ecological integrity, and habitats for plants and animals, as suggested in Daniels et al.'s (2018) ecological evaluation framework.

Interview Data Collection Procedure

The design of the semi-structured interview questionnaire adhered to the protocols and guidelines proposed by Scheele and Groeben (1988), emphasising the development of questions grounded in the reviewed literature. Consequently, all interview questions were formulated based on a conceptual typology to elicit residents' perceptions of their gardens and the relationships between these spaces and factors such as safety, health, and social cohesion. The general topics discussed included personal information and residential background, garden creation and maintenance (i.e., After moving to this

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neighbourhood, when did the idea of creating a garden or orchard project arise? Why did you decide to create the garden or orchard project?); community involvement and accessibility (i.e., Are there other community or neighbourhood members involved in maintaining the garden or orchard?); perceived safety (i.e., How safe do you feel when spending time in the garden or orchard? Do you think the presence of the garden or orchard has contributed to the safety of the neighbourhood? If so, how?); family and social connections (i.e., Do you think the garden or orchard has helped strengthen your connections with your neighbours? If so, how?); garden features and image (i.e., What trees, flowers, herbs, or vegetables can be found in your garden or orchard? How do you think the garden features might help to sustain the neighbourhood).

Recognising the importance of the interview setting (Knott et al., 2022), the decision was made to conduct the interviews in the gardens themselves to elicit vivid memories and feelings. Ten interviews were conducted with the garden owners, representing a diverse sample of respondents, and three interviews with community leaders were conducted by phone. Prior to each interview, a brief description of the research and the purpose of the interview were clearly explained. Participants were provided with a consent form, and the entire session adhered to the established ethical boundaries set beforehand. Respondent's answers were recorded verbatim using a digital recorder and transcribed onto interview answer sheets by the interviewer. To maintain the anonymity of interview respondents, pseudonyms have been assigned to the excerpts included in this paper.

Survey Data Collection Procedure

Google Forms™ was selected as the survey tool due to its user-friendly interface for both respondents and researchers, as well as its cost-effectiveness as a free platform. The survey participation request was disseminated via a link shared through the social media app WhatsApp and distributed across resident groups. WhatsApp has been identified as a convenient medium in studies, and it is widely used among the sample population (De Gruchy et al., 2021).

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Data Analysis

The qualitative data analysis processes were conducted iteratively, with findings from Phase One informing and guiding the subsequent data collection and analysis in Phase Two, specifically through surveys. This approach facilitated the identification of patterns, themes, and relationships. For instance, themes of community conviviality, emotional attachment to nature, and social strategies to sustain peace emerged from the interviews. The data were coded both deductively and inductively, resulting in an initial set of codes. These codes were categorised, leading to the emergence of four final themes.

The survey data were examined to determine the descriptive statistics for the sampled population (**Table 2**). The descriptive measures provided insights into responses and the scales and items measuring the Sense of Safety. A Spearman correlation test was performed on all the variables to explain the level of relationship between them, with the results presented in **Figure 4**.

The spatial characteristics and configuration were analysed by dividing the neighbourhood into seven polygons, which were defined based on their spatial layout and geographical features to facilitate the inspection of different areas (see **Figure 6**). For instance, natural edges such as water streams and roads were used as boundaries. These natural delimitations provided a consistent method for defining the spatial extent of each polygon. Additionally, the identification of different land use types was also considered. For instance, polygons representing areas primarily used for housing were categorised as residential, while those containing green spaces were classified as green spaces. An Indicator-based methodology was implemented to evaluate ecological conditions across urban and natural landscapes. We considered including an ecological assessment, following expert judgment, designed to assess habitat potentials for both plant and animal communities, and to measure key ecological processes, such as pollination and structural integrity.

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The assessment criteria were applied to each polygon, taking into account both its natural and artificial components, to ensure the evaluation was spatially and contextually specific. Each polygon was assessed as a whole, considering each item. For instance, a standardised range scoring criterion was implemented to evaluate the ecological quality of structural elements within each polygon, with scores ranging from 1.0, representing a theoretical worst-case scenario, to 5.0, reflecting the best-case scenario. The total percentage of green coverage was calculated using Google Street Maps (**Table 5**).

Table 2. Sample demographics.

Survey sample population					
Variable	Attribute	Freq	%	Mean	Standard deviation
Gender	Male	18	45		
	Female	22	55		
	Total	40	100		
Age	18-27	6	15	42	1.96
	28-37	10	25		
	38-47	7	17		
	48-57	6	15		
	58-67	7	17		
	68-78	4	10		
	Total	40	100		
Time of residence in the neighbourhood	Two to Five years	3	7.5	8.86	13.76
	Six to ten years	8	20		
	More than ten years	29	72		
	Total	40	100		
Ten gardens unstructured interviews sampled population					
Gender	Male	5	50		
	Female	5	50		
	Total	10	100		
Age	18-27	2	20	48	19
	28-37	1	10		
	38-47	1	10		
	48-57	1	10		
	58-67	3	30		
	68-78	2	20		
	Total	10	100		
Time of residence in the neighbourhood	Two to Five years	0		32	9.37
	Six to ten years	0			
	More than ten years	10	100		
	Total	10			

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3. Results

3.1 Qualitative exploration

Four themes identified in the qualitative exploration are presented in this section: 1) Conviviality and environmental practices fostered through gardening; 2) Emotional attachment towards nature and connection to plants; 3) Social strategies to sustain peace; and 4) Perception of Crime.

Conviviality and environmental practices fostered through gardening

Although the green initiatives have been maintained individually, the gardens serve as spaces where residents can talk to neighbours, share seeds, and engage in cordial behaviours to navigate differences. Nature was acknowledged as a good moderator for sustaining connections with others. However, even though the gardens are individually owned, established social norms are necessary to maintain peace. Grounded in respect, values are transferred and taught by families to younger generations; this includes respect for humans and more-than-human species":

> *“Other neighbours also have green areas, so for example, we share plants, share seeds, or help each other construct* ***spaces with materials and tools, i****t’s like all the activities start to make you connect with the community that also carries out these same activities".*
>
> *"I believe that the relationship with my neighbours is strengthened because I improved the appearance of the block, which enhanced my coexistence with them. Additionally, it helps me establish other relationships; we can hold various events in these gardens."*
>
> *"I have interacted with people whom I had never interacted with before, especially people who come to ask about plants or request to buy a fruit or a plant. I feel that this form of interaction also helps me to know people and resolve conflicts or differences if there are some.”*
>
> *"I believe that the most important thing is respect: respect for others, for all living beings, because we all feel. When there is respect for others, something very important has already been achieved because it acknowledges that I am not alone. I have to learn to respect those around me; this coexistence is essential for pacifying the sector. If I learn to coexist with others and nature, I learn to respect it. Someone will always approach another to say, 'Come on, why are you cutting down the tree? Why are you damaging it?' If I have good coexistence, I avoid inconveniences, problems, and clashes, just with how I speak and address others."*

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Emotional attachment towards nature and connection to plants

Eduardo Santos residents have developed a deep, transcendental connection to the natural environment. Through their engagement with gardening and farming initiatives, they have forged a profound bond with the land, as mentioned by Rosa: *"I love my garden very much; I admire it, and I take care of it. It's like a part of my life. Even now that I am ill, seeing the little plants become very ugly makes me very sad."* This connection is manifested in their reverence for the plants, their joy in witnessing growth and fruition, and their sense of responsibility in nurturing and sustaining the ecosystem:

> *"On a personal level, it is very satisfying to be able to see the flowers grow, observe their colours, and provide support when they are somewhat fallen by placing a little stick in them. One enjoys the garden a lot, so it is very satisfying" (Lina, Interview).*
>
> *"My favourite activity is harvesting the fruits and vegetables that I've planted. That is the greatest satisfaction: to see that a plant I sow begins to grow and bear fruit" (Jesus, Interview).*

In some cases, plants were referred to as sentient beings with whom they could talk, implying that there was a form of communication between species to which plants seemed to reciprocate:

> *"When I don't have much or nothing to do, I entertain myself by going to my plants, caressing them, and talking to them. It helps me destress; talking to them is a beneficial relaxation technique for me. I also visit the garden to tend to the plants and ensure they always have good soil. I do this out of my own volition because I value my garden. This garden means a lot to me, especially because the flowers are beautiful and alive, and I believe they can hear me, too."*

Social strategies to sustain peace

To understand how residents overcame the extremely violent period unleashed in the 1990s, the role of community leaders in representing the neighbourhood, protecting it from crime, and channelling government resources for social development and education was recognised. Effective leadership can positively influence social dynamics and foster a positive neighbourhood image in the long term. For example, the gardens have evolved into educational spaces where children learn to appreciate and respect the natural environment. Additionally, strong family foundations have contributed to a sense of continuity and attachment within the neighbourhood, creating strong roots and a

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sense of belonging. According to participants, these factors might prevent young people from joining insurgent groups:

> *"For more than 40 years, this neighbourhood has been comprised of families. They help each other a lot, ensuring that young people have a strong family and academic structure, allowing them to grow up with a solid foundation. With a good education, family support, and a sense of belonging, it becomes difficult for insurgent groups to distract them."*

> *"The sense of community in this neighbourhood has been very strong. As community leaders, we have significantly influenced the preservation of the image of peace in this neighbourhood. I believe it plays a crucial role in the sector. Additionally, we have maintained good political management with government entities and always strive to benefit the community through social projects."*

Another aspect discussed was the physical characteristics of the neighbourhood. A key feature identified was the presence of dense natural borders, such as tree lines and water streams, rather than urban residential boundaries typically observed in lower-income areas. While the presence of these natural elements was not inherently associated with attracting criminal activity, the tendency to enclose the neighbourhood gardens suggests that residents fear uncivil behaviours and prefer to reduce opportunities for criminal occurrences.

Additionally, the neighbourhood's clear, lineal spatial layout – lacking alleys or concealed spaces – was highlighted as a physical feature that may contribute to crime prevention. Alleys are often recognised as attractive hiding places for criminals, and their absence can enhance safety.

> *"The thing is, we don't have neighbours. The neighbourhood starts from this street or that one. The only neighbours we have are nature, flora, and fauna. Ravines define our boundaries. We are situated between the ravines of La Hueso and La Leonarda. We don't have neighbours nearby, which has also significantly contributed to keeping the peace in Eduardo Santos. We don't have to deal with conflicts with residents from other neighbourhoods, at least not to the same extent. It eliminates problems with other people."* (Interview Ivan).

> *"If you walk through the entire neighbourhood, you'll notice well-defined roads. It's been a very well-planned neighbourhood from the beginning, which has been very beneficial. Groups operating outside the law often favour alleys for hiding and conducting illicit activities. However, in Eduardo Santos, they could never do that because we caught them precisely where they attempted to enter. So, it was never possible for them here."* (Interview Ivan)

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"We don't leave it open because there are people who have no sense of belonging, or sometimes we leave valuable things in the place and then return to find them missing. Situations have occurred where people, upon realising the space is organised and changed, attempt to gain entry. Previously, when the space was a dump, they didn't even pay attention to it. Since people started to show more interest in the space, we decided to close it for the same reason: it also invites unauthorised entry, especially at night. Due to its large size and darkness, it poses security concerns, which is why we close it."

Perception of crime

Residents reported that their perception of crime in the neighbourhood has improved dramatically since the Orion Operation in 2002. Following the removal of insurgent groups, a peaceful environment was restored and has been sustained over time. In interviews, respondents did not mention violent crimes; instead, they mentioned instances of uncivil behaviour occasionally observed in the gardens. However, one community leader noted that considerable efforts are made to keep criminal lords away from the area. As described by Ivan, one strategy involves maintaining a strong image of peace and harmony, supported by residents' vigilance and ensuring that the youth remain uninterested in joining criminal groups. This has been achieved through strong family support and educational opportunities. Consequently, while criminals may pass through the neighbourhood, they do not find a place to stay:

"As community leaders, we have played an important role in the neighbourhood. First, because we don't mess with those people. So, when they see that one doesn't mess with them, they don't mess with us either. Don't invade my space; I won't invade yours. And they don't encroach on our space for anything. And if there is a strange person in the neighbourhood, we keep an eye on them. We go and see who it is, what they're coming for, and if they intend to cause harm. We remain attentive, observing and alert to what will happen. It's especially for that reason that, here, criminal groups don't find the environment to stay. They can pass through here and maybe sit down in one of the shops to eat or have a beer, but they don't find a place to stay. Because they see a healthy neighbourhood where their misdeeds have no place. They will do their things in other sectors, but not here.

"And the other is our good political management with government entities. We do a lot to benefit the community."

3.2 Quantitative Results

Cronbach's alpha tests were conducted to assess the internal consistency and reliability of the measurement scales Sense of Well-being (IPANAS-SF), Sense of Community

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(BSCS), and Environmental Actions (ENV). The results indicated satisfactory alpha values, ranging from 0.72 to 0.77, which exceeded the recommended threshold of 0.7 and suggested adequate scale reliability**.** Error! Not a valid bookmark self-reference. presents the descriptive results. **Table 3** presents the descriptive statistics, including mean, median, standard deviation (in brackets), sample variance, and p-values, for the three psychometric scales employed in this study: IPANAS-SF, BSCS, and ENV. The central tendencies of participants' responses to each item are outlined. The inclusion of p-values facilitates the assessment of whether the participants' responses differ significantly from a neutral or expected midpoint (i.e., 3.0), indicating a tendency towards agreement or positive engagement with the scale constructs. All scales produced statistically significant results ($p < 0.000$), demonstrating that participant responses were neither random nor neutral, but rather inclined towards agreement or a positive affect or action.

The mean results report a fairly high sense of well-being, sense of community, and environmental actions, with statistically significant values ranging from 3.6 to 3.7, $p = 0.000$ (**Table 3**). According to the responses to the items measuring the sense of Safety (VIOL), residents do not perceive the neighbourhood as violent and manifest a high sense of safety. A moderate perception was reported that gardens help reduce violence (**Table 4**).

Table 3. Values distribution median and standard deviation (in brackets) for the items included IPANAS-SF, BSCS, ACTIONS, for all responses (N=40).

Scale	Mean	Median	Sample Variance	*P Value*
IPANAS-SF	3.69 (0.33)	3.70	0.11	0.000
BSCS	3.68 (0.59)	3.61	0.35	0.000
ENV	3.40 (0.66)	3.60	0.44	0.000

Where 1=Never; 5=Completely. Descriptive statistics for IPANAS-SF, BSCS, and ENV scales highlight participants' agreement tendencies. Statistically significant p-values ($p = 0.000$) indicate non-random, non-neutral responses across all scales.

Table 4. Values distribution median and standard deviation (in brackets) for the questions measuring perceived safety and violence for all responses (N=40).

Question	Median	Mode	Sample Variance
Perceived violence in the neighbourhood	1 (0.37)	1	0.14

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Perceived safety in the neighbourhood	4 (0.97)	5	0.94
Green spaces helped reduce violence	3.5 (1.39)	5	1.51

Where 1=Not at all; 5=Very much.

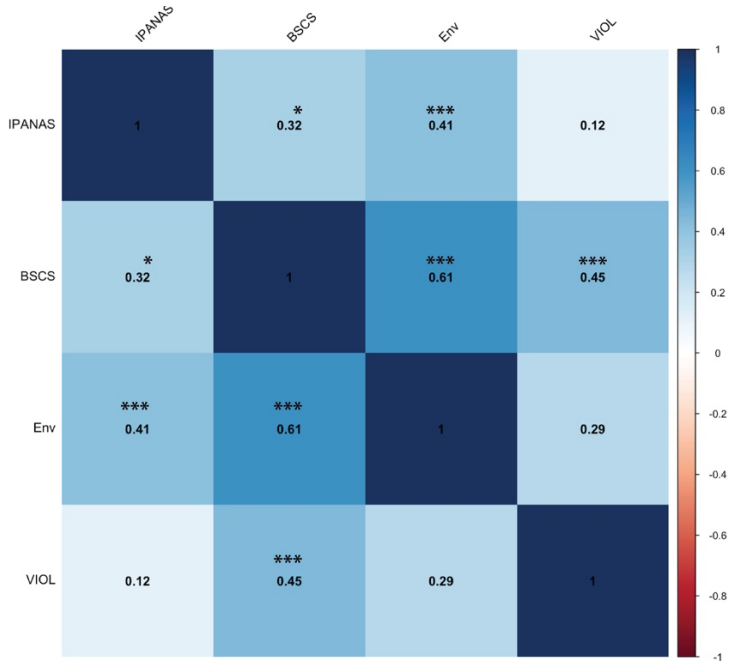

Figure 4. Correlation matrix for IPANAS-SF, BSCS, ENVI scales, and sense of safety. *p*-values are indicated as *p*=0.000 (***); *p*=0.00(**); *p*=0.05 (*).

The correlation matrix revealed significant relationships among the variables (**Figure 4**). As expected, a moderate positive correlation was found between IPANAS-SF and BSCS (r = 0.32, *p* = 0.04), indicating that higher levels of a sense of community are associated with better well-being. Interestingly, the correlation between IPANAS-SF and ENV was stronger (r = 0.41, *p* = 0.007), suggesting that greater environmental actions among residents are associated with an enhanced sense of well-being. Similarly, the correlation between BSCS and ENV was significant and positive (r = 0.61, *p* < *0.001*), indicating that a stronger sense of community is associated with a higher likelihood of engaging in or promoting environmental actions. Additionally, the variables BSCS and VIOL exhibited a significant relationship (r = 0.41, *p* = 0.003), suggesting that a strong sense of community is correlated with the perception of safety in the neighbourhood. No significant correlation was found between IPANAS-SF, VIO and ENVI.

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3.3 Spatial Evaluation

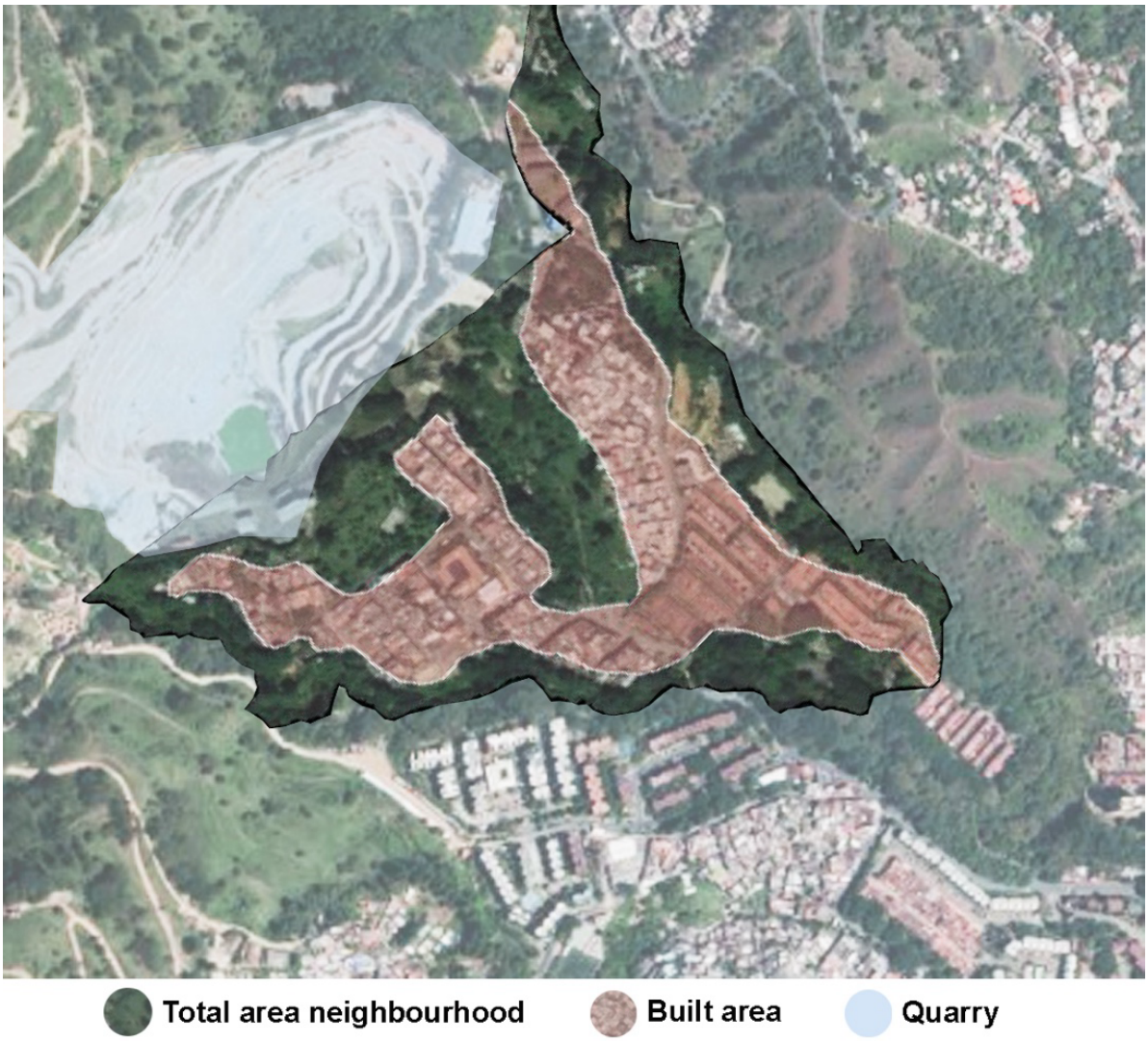

Figure 5. Eduardo Santos' total neighbourhood area and built area.

Eduardo Santos spans a total area of 247,287 sqm, with 41% (101,613 sqm) allocated to urbanised areas, 14% (33,230 sqm) corresponding to public space and green areas, and the remaining 45% (112,444 sqm) comprising green coverage, characterised by dense tree canopy and naturally protected sites (**Table 5**). Adjacent to its northwest boundary lies an active quarry (Figure 4), operating with legal authorisation from the Local Environmental Authorities. The neighbourhood exhibits a linear and straightforward morphology, centred around a lively main street hosting a variety of local mixed-use establishments, including commercial activities such as local shops, grocery stores, restaurant stalls, and bakeries. Institutional buildings, such as schools and community

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centres, are distributed throughout the area. The neighbourhood features well-defined two-way roads and lacks the maze-like layout typically found in lower-income neighbourhoods in Medellín (Coupé, 1993). Regarding public spaces, a limited number of government-maintained areas and green spaces were well-kept, alongside those maintained by residents. However, it was noted that artificially intervened green spaces reported a lower diversity and ecosystem contribution compared to natural green spaces (**Table 6** and **Table 7**).

Table 5. Green coverage, green spaces & built green spaces.

Total Area Eduardo Urbanised	**Urbanised area**	**Public space and green areas**	**Green coverage**	**Total green coverage areas**
247,287 m²	101,613 m²	33,230 m²	112,444 m²	145,674 m²
%	41%	14%	45%	

To perform the spatial evaluation, ecological indices were calculated according to various aspects, including spatial characteristics, structural elements (flower beds, hedges, lawns, margins, and water elements), ecological integrity, animal habitats, plant habitats, and pollination (Daniels et al., 2018). The neighbourhood was divided into seven polygons for easier evaluation, as shown in **Figure 6**.

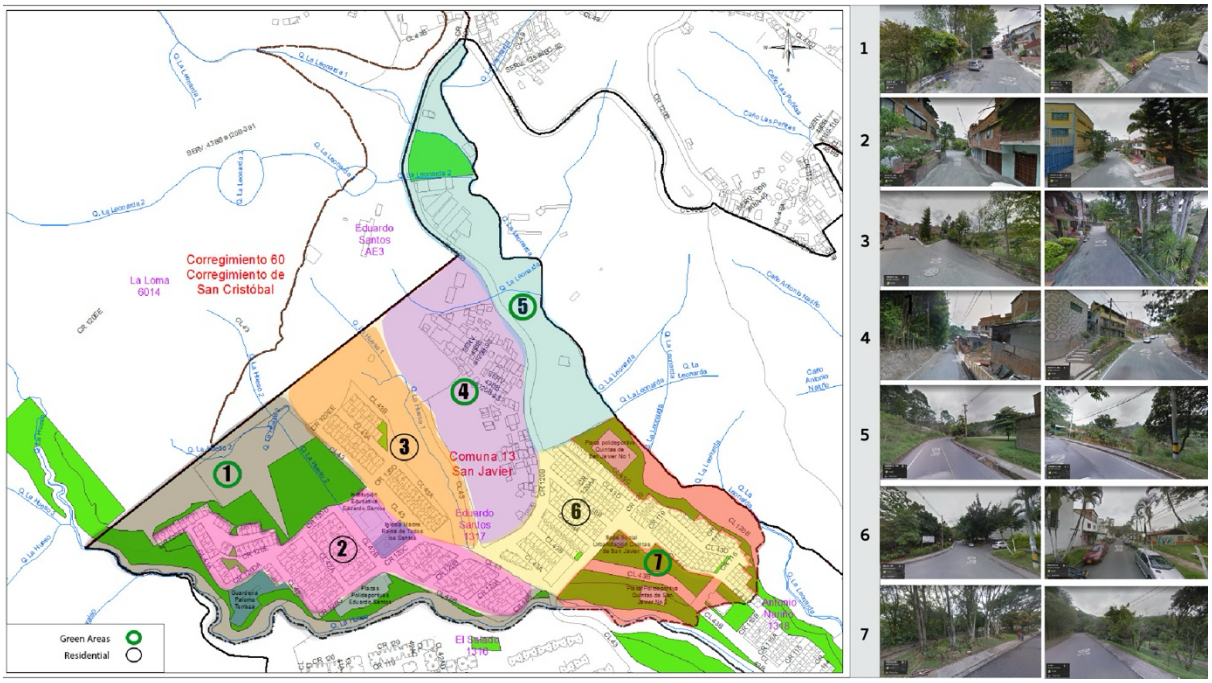

Figure 6. Polygons and Street Views.

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Table 6. Spatial characteristics.

Item	Polygon						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Number of public spaces in the polygon	1	3	1	0	1	2	4
The road is lined with trees	x		x	x	x	x	x
There are other trees intentionally planted	x	x	x			x	x
There is a view of the natural environment (field, mountain, river)	x		x	x	x	x	x
There is a view of a park/green area (man-made)	x	x	x	x	x	x	x

Table 7. Assigned indicator values for the ecological properties of structural elements (natural and artificial) of each respective polygon. (min=1; max= 5)

	Polygon (Expert judgment)													
Structural element	**1**		**2**		**3**		**4**		**5**		**6**		**7**	
	Nat	**Art**	**Nat**	**Art**	**Nat**	**Art**	**Nat**	**Art**	**Nat**	**Art**	**Nat**	**Art**	**Nat**	**Art**
Flower bed	3	2	1	3	3	2	2	3	4	1	1	3	5	3
Hedge	5	3	1	2	5	2	3	1	5	1	1	1	5	4
Lawn	1	3	1	0	4	2	2	0	4	0	1	4	4	3
Margin	4	3	1	2	3	1	3	1	5	1	3	2	5	3
Water element	5	1	0	0	5	0	2	0	2	0	0	0	0	0
Ecological integrity	4	3	2	0	4	2	4	1	5	1	3	1	4	4
Habitat animals	5	2	1	0	5	2	4	1	5	0	2	0	4	2
Habitat plants	3	2	2	2	4	1	4	1	5	0	3	1	5	4
Pollination	4	3	1	4	3	1	3	2	5	0	3	1	4	3

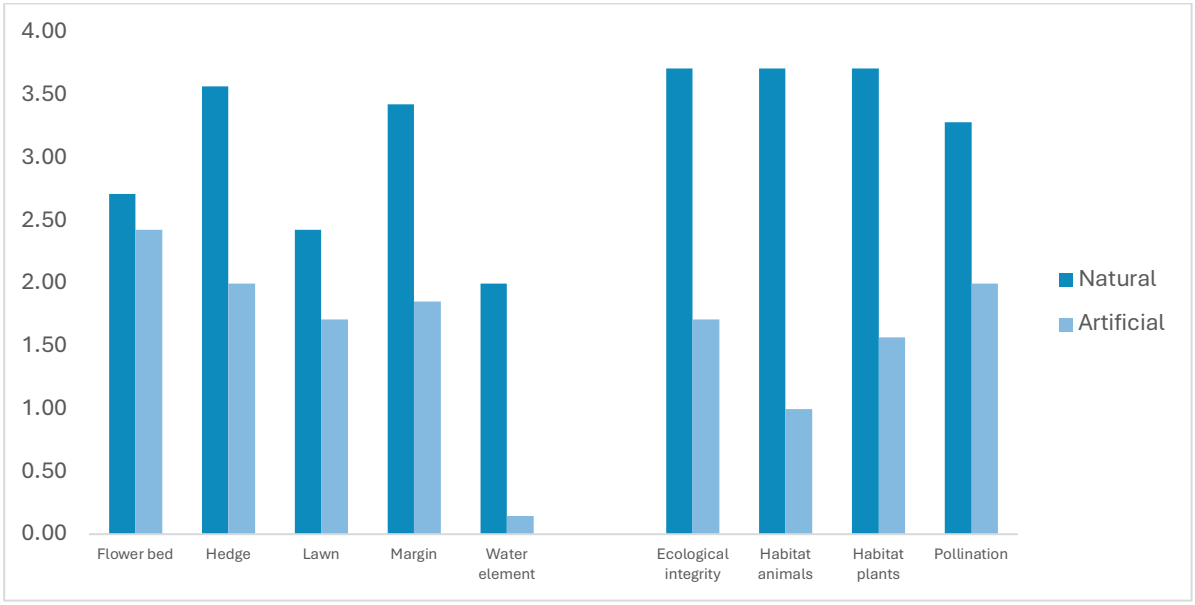

Figure 7. Evaluation summary for natural and artificial elements.

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Table 8. Means minimum and maximum of the indicator (min=1; max= 5).

Structural element	Natural (min/max)	Artificial (min/max)
Flower bed	2.71(1/5)	2.4(1/4)
Hedge	3.5 (1/5)	2 (1/4)
Lawn	2.4(1/4)	1.7(1/4)
Margin	3.4(0/5)	1.8(1/3)
Water element	2(0/5)	0.1 (0/1)
Ecological integrity	3.7(2/5)	1.7 (0/4)
Habitat animals	3.7(1/5)	1(0/2)
Habitat plants	3.7(2/5)	1.5(1/4)
Pollination	3.2(1/5)	2(0/4)
Average	**3.17**	**1.6**

The ecological assessment reveals differences in the design of structural elements for nearly every criterion (**Table 7**). Water elements were particularly absent from the artificial category (**Figure 7**). The biggest differences between the artificial and natural criteria were found in ecological integrity, habitat animals, and habitat plants, with values above 3.2 for natural elements and values not greater than 1.7 for artificial elements (**Table 8**). The natural elements overall performed better, indicating an important ecological contribution, as opposed to the artificial structural elements, which showed better indicators only for flower plants and hedges. This could be attributed to urbanisation and local intervention in green spaces. A high level of naturalness is evident throughout Eduardo Santos. Structural artificial elements could be better designed to enable higher levels of ecological contribution, supporting better habitats for animals such as birds, small vertebrates, insects, and soil communities.

4. Discussion

Collective neighbourhood interventions to prevent crime

In the years following the Orion Operation, the Eduardo Santos neighbourhood underwent significant renewal and social restoration. By harnessing available resources and external partnerships, the community redefined its trajectory and fostered strong social cohesion. Our findings indicate that green interventions played a crucial role in this process, serving as hubs for community interaction and promoting a sense of safety. These results align with broader socio-political and economic initiatives in Medellín, such as the implementation of Social Urbanism during the administrations of 2005-2015

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and subsequent developments that improved urban green infrastructure (i.e., The Green Belt; Ortiz & Millan, 2022). Programs promoting urban greenery in lower-income areas have enabled communities to remain active in their neighbourhoods and facilitate green interventions. This socio-political backdrop may contribute to the success of the green initiatives in Eduardo Santo in fostering social cohesion and enhancing perceptions of safety. This suggests that similar initiatives could benefit other lower-income neighbourhoods, highlighting the need for policies that support residents-led green projects and the maintenance of urban green spaces to enhance safety and well-being.

Discussions with leaders and residents unveiled contrasting ideologies, with residents expressing a strong affinity for nature as integral to community cohesion and well-being. Interestingly, the presence and environmental impact of a nearby quarry were seldom acknowledged in the interviews. Leaders, however, acknowledged the importance of financial support from the quarry company in the renewal process. While the study did not focus on the quarry's environmental impacts, its role in providing financial resources and additional surveillance of the neighbourhood was notable. Leveraging such allies constitutes a strategic approach to consolidating neighbourhood infrastructure and development. For instance, the quarry company funded public parks and educational projects, potentially overshadowing concerns about its environmental harm.

Strategically engaging external allies is a crucial first step in fostering development and deterring anti-social behaviours. Attention to the social benefits of such partnerships was integral to instilling social values through educational programmes. The process of social restoration following the Orion Operation entailed sustained efforts to redefine the neighbourhood's identity. Families have established strong social dynamics, evident in the maintenance of green spaces as hubs for community interaction and harmony, despite their designation as private property. Nevertheless, the decision to enclose these spaces to prevent uncivil behaviour reflects the neighbourhood's awareness of the volatile political challenges, albeit perceived as 'safe'.

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Despite this, a sense of community, social cohesion, and conviviality emerge as predominant factors shaping the neighbourhood's trajectory. Unsurprisingly, a sense of community stands out as the foundation for sustaining safety, promoting environmental actions, and overall well-being. This finding aligns with theories studying lower-income communities afflicted by crime trauma, where community cohesion and empowerment play pivotal roles in shaping positive futures (Benjumea et al., 2024; López, 2019; Anguelovski, 2013; Fullilove, 2020). Moreover, the notion of community is intricately intertwined with spatial dynamics, as social urban theorists have observed (Perkins et al., 1993; Rappaport, 1987; Tuan, 1977). This spatial dimension relates to **social and physical place attachment**, a psychological process involving affective, cognitive, and behavioural positive meanings held towards people and a place (Scannell & Gifford, 2010). In Eduardo Santos, the attachment to social and physical places could have been influenced by long-time residence. Participants in this study who have lived in the neighbourhood for over fifteen years, including the garden owners, expressed a strong sense of place attachment and community. Survey data indicates a similar trend, with most respondents having spent most of their lives in the area and only a small influx of new residents in recent years. This stability is significant, as factors such as land tenure and solid community ties have been documented as contributors to lower crime rates (Disney et al., 2023; Heinze et al., 2018).

Although the sample size of the interviews and surveys was modest, the participants represented a diverse age range, including younger, middle-aged, and elderly residents, with nearly equal participation across these groups. This was important, as the neighbourhood's current demographic profile shows a concentration of younger and middle-aged residents (18-45 years old). This finding suggests that small green initiatives may offer benefits across age groups, though motivations to sustain these initiatives vary by age. Younger interviewees, for instance, emphasised the economic potential of these spaces and their role as social gathering points. At the same time, middle-aged participants valued them as places for relaxation and for cultivating vegetables and flowers, often shared with neighbours. An interviewee involved in environmental education highlighted the potential of these spaces for promoting environmental

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awareness. In the case of elderly interviewees, they expressed feelings of attachment and nostalgia over the spaces, viewing the gardens as reminiscent of their rural childhoods.

Spatial contribution of small green initiatives in crime control

The **spatial configuration** and natural surroundings are crucial factors that, in conjunction with preceding elements, significantly contribute to the peaceful functioning of Eduardo Santos. The presence of nature plays a significant role in shaping daily interactions among residents, from casual conversations to fostering lasting friendships. Furthermore, a deep appreciation of nature might influence civil behaviours, as explained by the environmental self-transcendence theory (Castelo et al., 2021). This theory suggests that a deep, transcendental connection to nature could inspire altruistic behaviours towards all living beings and drive environmental initiatives (Arbuthnott, 2023). Both quantitative and qualitative findings suggest that feelings of respect and connection in nature form an integral part of the social fabric in Eduardo Santos, sustaining a cohesive and functional community. Furthermore, it was discerned that over forty per cent of the neighbourhood comprises natural spaces with high ecological contributions, potentially heightening residents' environmental awareness. Nevertheless, the ecological contribution of artificial green interventions was substantially lower than that of natural spaces. Therefore, while these spaces may deter criminal activities, there is a need to enhance their ecological function.

The **layout and distribution** of spaces within the neighbourhood have been configured to deter criminal behaviours. While its design may not have been conceived under the Defensible Space precepts, interestingly, some spatial aspects in Eduardo Santos' work overlap with this theory and are worth mentioning. For instance, 'territoriality' seemed to be reflected in the individual green spaces formed as zones of territorial influences to further enhance neighbourhood safety. These spaces, maintained and actively cared for by residents, not only enhance the neighbourhood aesthetic but also signal a sense of ownership and stewardship. This aligns with findings from studies suggesting that visible markers of territorial control, such as well-maintained gardens or defined property

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boundaries, can serve as deterrents to criminal activity (Hatipoglu et al., 2022; Mshelia et al., 2024).

Another feature was 'natural surveillance' or the capacity of the physical design to provide surveillance opportunities (Hatipoglu et al., 2022). In Eduardo Santos, natural surveillance is achieved through several interconnected spatial characteristics. First, the strategic distribution of the gardens, which their owners constantly protect. These spaces are actively used, further enhancing passive surveillance. Second, the neighbourhood's linear layout, devoid of alleys or concealed pathways, minimises potential hiding spots and facilitates clear sightlines. Third, public spaces are strategically positioned along natural edges to foster community interaction while enabling overlapping layers of surveillance by residents.

These spatial elements demonstrate a form of community-led urban design that integrates principles often associated with the Defensible Space theory without explicitly adhering to it. This organic adaptation is consistent with the agency of Medellín residents in shaping environments conducive to social cohesion. However, in the case of Eduardo Santos, such spaces are also conducive to safety. For instance, the absence of alleys and concealed areas not only contributes to physical safety but also aligns with the social dynamics of the neighbourhood. By eliminating spaces that could facilitate criminal activities, the community reinforces its collective efficacy to safety.

These spatial configurations also complement other socio-cultural behaviours such as community gatherings and conviviality. Such dynamics align with the principles of the Busy Streets theory, which posits that vibrant, well-used neighbourhood spaces promote community cohesion and reduce opportunities for crime (Heinze et al., 2018). Contrary to the 'hot spots' hypothesis in which busy streets with commercial activity are potential hubs for criminal activity (Hodgen & Wuschke, 2023), in Eduardo Santos, a highly concurred main street comprises part of the surveillance strategy. Ensuring a clear view over the commercial area, constantly monitored by neighbours, could facilitate the identification of ill-intentioned, unfamiliar visitors that might affect the neighbourhood's safety. The willingness to exert vigilance and guardianship reveals that residents

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collectively function as a cohesive entity with two key aspects preventing anti-social behaviours: **a strong sense of community** and **capable spatial guardians**.

Small green interventions and the neighbourhood image

The importance of neighbourhood image and perceptions of crime aligns with the 'image and milieu' concept from the Defensible Space Theory. Although this theory focuses on physical properties, in the case of Eduardo Santos, the physical environment holds as much significance as the resident's predisposition to safeguard the neighbourhood from stigma or a negative reputation. This highlights a key point from this study: the physical environment cannot deter criminal behaviour without community effort to uphold positive images. The residents' active role in sustaining a positive image complements physical safety measures (Lanfear, 2022). In Eduardo Santos, residents actively work to counteract stigma and negative stereotypes. This effort complements physical safety measures and supports broader theories suggesting that community perceptions have a significant impact on crime prevention (IBID).

From a social standpoint, the contribution of small green interventions aligns with empowerment theory, emphasising the need to consider both structural context and social processes that empower residents to create positive changes in their neighbourhoods (Aiyer et al., 2015; Heinze et al., 2017; Gong et al., 2023). These interventions in Eduardo Santos also represent catalysts for social cohesion. Unlike the Busy Street paradigm, which often focuses on initiatives by external organisations to revitalise depleted or neglected areas (Shepley et al., 2019), the self-organised development observed in Medlin's low-income neighbourhoods demonstrates the importance of **organic, resident-led participation** in shaping safety and community identity (Benjumea et al., 2024). This distinction is particularly relevant in the context of Medellín, where historical marginalisation and inadequate institutional support have led to a tradition of grassroots community organisation.

Residents perceive these interventions as beneficial structural elements that yield individual and collective benefits by promoting health, well-being, and social interaction among neighbours, often facilitating conflict resolution. Such interventions are

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necessary for establishing control mechanisms to foster safe and functional environments (Heinze et al., 2017) and, to some extent, mediate internal conflicts essential for sustaining a positive neighbourhood image and deterring criminal activity (Taylor & Gottfredson, 1986; Cozens & Love, 2015).

Nevertheless, it is imperative to recognise that individual green interventions alone may not be sufficient to mitigate criminal activity. Instead, this study highlights the interplay of various components and strategies, including community educational programmes, external partnerships, a strong sense of community, spatial guardianship, biodiverse natural environments, and clear spatial layout. This comprehensive approach is compatible with the Ecological Networks concept, which posits a causal interplay between individuals, their environment, and multiple interventions that collectively influence violence reduction (Browning et al., 2017).

Practical and Policy Implications in Spatial Design

To enhance the study's applicability, we provide recommendations for urban planners and policymakers. These recommendations focus on developing community-centric green initiatives that foster social interaction, natural surveillance, and a positive neighbourhood image. Such initiatives are essential for reducing crime and promoting a safe environment, especially in vulnerable, low-income urban areas.

The local government of Medellín has been commended for its extensive interventions in lower-income neighbourhoods aimed at promoting peace and enhancing residents' quality of life. While these efforts have not fully addressed the historical debts accumulated over the decades, participatory agendas and physical infrastructure improvements have shown significant impacts, with violence decreasing by nearly 66% in areas receiving these interventions (Cerdá et al., 2012). Nevertheless, it is crucial to acknowledge the role of capable community leaders and residents (Vargas & Sánchez, 2018; Heinze et al., 2017). In the case of Eduardo Santos, for instance, government initiatives such as Operation Orion and investments in urban green spaces were strengthened by skilled community guardians who effectively utilised government support in educational programmes and established strategic partnerships with private

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entities. Furthermore, the presence of green infrastructure—characterised by dense vegetation and trees—has improved neighbourhood aesthetics, motivated individual green initiatives, and fostered prosocial behaviours. This finding is particularly relevant for similar neighbourhoods, as more greening initiatives can benefit from additional interventions – a priority for the Medellín government over the last decade, with the Green Belt project in lower-income neighbourhoods (Benjumea et al., 2024). Alongside large-scale government projects, small-scale individual green interventions can serve as buffers to prevent crime within green infrastructures. However, it is essential to integrate regulatory measures to ensure the health of the natural ecosystems. Policies involving community guardians, in partnership with the government, could support the protection and sustainability of these ecosystems.

Another contribution of this study is the design of urban green infrastructure that incorporates small-scale green interventions. Given the volatile and rapidly changing nature of these neighbourhoods, any intervention should include crime-preventative spatial measures. For example, individual and communal gardens can foster pro-social and pro-environmental behaviours while enhancing residents' well-being. The strategic placement of green spaces at the neighbourhood's edge further aids in crime prevention by supporting natural surveillance and reinforcing collective efficacy. Urban design strategies could amplify this protective effect by, for instance, positioning small green spaces along the outskirts of neighbourhoods, creating vibrant, accessible main streets with varied commercial activities, transforming certain alleys into green corridors, and expanding ecologically valuable green spaces. These measures collectively strengthen the neighbourhood's image, promote civic-minded behaviours, and encourage residents to participate in neighbourhood surveillance and protection.

Such insights are particularly relevant for neighbourhoods facing crime-related challenges similar to those in Medellín. Furthermore, while these interventions are small and dispersed, their impact can be scaled to form a secondary urban green network, which could be integrated into a broader Nature-based Solutions (NBS) framework.

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Urban planners and designers might consider these initiatives as a catalyst for enhancing urban green ecosystems and implementing NBS more effectively.

5. Conclusion

The findings of this study support the widely held view that green interventions have a positive influence on residents' perceived sense of well-being and safety in lower-income neighbourhoods. Notably, this study highlights the critical role of a strong sense of community in mediating these benefits. Our research emphasises the importance of integrating green spaces with community-building efforts to enhance neighbourhood safety and well-being.

In particular, the integration of small-scale green interventions, such as community gardens and green spaces, fosters community conviviality, enhances emotional connections with nature, and empowers residents to take active roles in maintaining their neighbourhoods. Collectively, these aspects contribute to upholding a positive neighbourhood image, which is fundamental for sustaining a peaceful environment devoid of extreme violence. Nonetheless, the sustainability of these dynamics relies heavily on community organisation and careful attention to their surroundings. Thus, understanding emergent dynamics, involved agents, and key actors is imperative for adapting and moulding socio-spatial interventions to safeguard the neighbourhood.

The research also highlights the interdependence of factors contributing to the sense of safety, wherein a strong sense of community, social cohesion, and collective efficacy serve as foundational elements. Equally significant are strategic partnerships that bolster interventions at both social and infrastructural levels. Additionally, the physical layout of urban space, coupled with the presence of nature, undeniably shapes social behaviour and diminishes criminal activity in these neighbourhoods. A well-defined layout complemented by well-maintained and biodiverse green infrastructure endows residents with all the benefits associated with exposure to natural environments.

The success of these initiatives is closely tied to the long process of adaptation that these communities have undergone, transitioning from self-building their neighbourhoods to developing safety strategies in response to limited governmental support. However,

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significant changes have taken place in Medellín over the past decades. Programs such as Social Urbanism, introduced during the 2005-2015 administrations, alongside subsequent initiatives, have played a pivotal role in transforming lower-income neighbourhoods. These efforts, promoting urban greenery and safety, have enabled communities to remain active in their neighbourhoods and advance small green interventions.

Individual small green interventions further foster collective empowerment, community conviviality, constant interaction and emotional affinity with nature. Policymakers and urban planners should consider incorporating community-centric green initiatives into broader crime prevention and urban development strategies to enhance the resilience and quality of life in vulnerable communities.

Study Limitations and Further Research

This study acknowledges limitations tied to Medellín's unique socio-political context, which may impact the generalisability of the findings. Future research should investigate similar green interventions in diverse urban settings to assess their broader applicability and identify factors that support or limit the effectiveness of these interventions.

Crime is a complex and evolving phenomenon in Latin American low-income neighbourhoods, shaped by a multitude of overlapping factors. Understanding this phenomenon requires examining not only the physical built environment and its green characteristics but also many social dynamics that can contribute to the development of crime. This study aimed to correlate some of the most prominent factors, identified through empirical analysis, although it is not exhaustive.

It is also essential to recognise the spatiotemporal heterogeneity of crime, as noted in several studies (Wen et al., 2024), which might impact how crime evolves and manifests in different spaces. Medellín, in particular, has experienced significant transformations since the civil war; however, it continues to grapple with criminal actors and the lingering effects of the drug trade conflict. Consequently, these ongoing challenges merit

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continued study to understand the evolution of crime within Medellín's unique social and historical context.

This study established a fundamental knowledge base and sought to explore a single case study showcasing responses to criminal activities and active involvement in the maintenance of green spaces, which are often used as deterrents of crime. While we employed a variety of research methods, it is essential to note that the results of this study must be interpreted within their own specific context. The small sample size should also be considered a potential limitation, especially the low response rate, which could introduce nonresponse bias.

While generalisation beyond this specific case was not the primary outcome of this research, it contributes to scholarly knowledge on underrepresented communities and their ability to shape their built and natural environments, employing a myriad of strategies for community adaptation to extreme circumstances to ensure safety and community cohesion. Examining these distinct responses enhances conversations about pluriversal ideologies, highlighting the significance of small-scale interventions and diverse lifestyles, and stressing the necessity of localised, culturally specific practices and solutions (Escobar, 2018).

Finally, although the modest sample size of this study may be considered a limitation, it provides valuable insights into social factors that can be further explored. For instance, examining the contributions of small green spaces across different age groups and their implications for urban design could yield meaningful strategies to support community cohesion and safety.

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