

ORIGINAL

## Types of roads and pollution in informal urban expansion in the AA.HH. Nadine Heredia, Banda de Shilcayo

### Tipos de vías y contaminación en la expansión urbana informal en el AA.HH. Nadine Heredia, Banda de Shilcayo

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#### ABSTRACT

**Introduction:** informal urban sprawl is a growing phenomenon in Latin America, characterized by unplanned land occupation and a lack of adequate basic services. In the case of the Nadine Heredia Human Settlement, located in the Banda de Shilcayo district, rapid urbanization has generated a pattern of disorderly growth reflected in the precariousness of access roads and increased environmental pollution.

**Method:** the current research uses quantitative methods. The study is descriptive, quantitative in approach, and non-experimental. Given the context of the study, the independent variable is informal urban sprawl. Within this variable, the dimensions of road infrastructure and environmental pollution are identified. Likewise, the dependent variable is living conditions in the Nadine Heredia Human Settlement, Banda de Shilcayo.

**Results:** 68 % of the roads are connected by a local street and 32 % are connected by a collector street. The percentage of road construction showed that 100 % are connected by compacted dirt roads and by roads in fair condition. The percentage of noise pollution showed that 100 % have urban pollution. The percentage of visual pollution showed that 48 % have graffiti and vandalism, 40 % have no visual pollution, 11 % have junk and garbage as pollution, 1 % have public services in poor condition, and 1 % have public spaces in poor condition.

**Conclusions:** the results discussed show that the road configuration and environmental conditions of the Nadine Heredia Public Housing Authority respond to a pattern of informal urbanization characterized by the predominance of local streets, compacted dirt roads, and a fair state of repair, which directly impacts mobility, accessibility, and the management of basic services. Added to this are environmental problems such as noise, visual, and water pollution, which not only deteriorate the urban environment but also affect the health and quality of life of its residents.

**Keywords:** Human Settlement; Living Conditions; Roads; Environmental Pollution.

#### RESUMEN

**Introducción:** la expansión urbana informal constituye un fenómeno creciente en América Latina, caracterizado por la ocupación no planificada del suelo y la carencia de servicios básicos adecuados. En el caso del Asentamiento Humano Nadine Heredia, ubicado en el distrito de Banda de Shilcayo, la rápida urbanización ha generado un patrón de crecimiento desordenado que se refleja en la precariedad de las vías de acceso y en el incremento de la contaminación ambiental.

**Método:** la investigación actual utiliza métodos cuantitativos. El estudio realizado es descriptivo, de enfoque cuantitativo, no experimental. Siguiendo la coyuntura del estudio, la variable independiente viene a ser la expansión urbana informal. Dentro de esta variable se identifican las dimensiones de; vialidad y contaminación ambiental. Así mismo se tiene en cuenta que la variable dependiente son las condiciones de habitabilidad en el Asentamiento Humano Nadine Heredia, Banda de Shilcayo.

**Resultados:** el 68 % de las vías están conectadas mediante una calle local y 32 % están conectadas por medio de una calle colectora. el porcentaje de materialización en vías mostró que el 100 % están conectadas mediante vías de tierra compacta y mediante vías en estado regular. El porcentaje del tipo de contaminación acústica arrojó que el 100 % tienen contaminación urbana. Mientras que el porcentaje del tipo de contaminación visual mostró que el 48 % tienen graffiti y vandalismo, 40 % no tienen ningún tipo de contaminación visual, 11 % tienen chatarra y basura como contaminación, 1 % tienen servicios públicos en mal estado y 1 % tienen los espacios públicos en mal estado.

**Conclusiones:** los resultados discutidos permiten evidenciar que la configuración vial y las condiciones ambientales del AA.HH. Nadine Heredia responden a un patrón de urbanización informal caracterizado por la predominancia de calles locales, vías de tierra compacta y un estado de conservación regular, lo que repercute directamente en la movilidad, la accesibilidad y la gestión de servicios básicos. A ello se suman problemáticas ambientales como la contaminación acústica, visual y del agua, que no solo deterioran el entorno urbano, sino que también afectan la salud y la calidad de vida de los habitantes.

**Palabras clave:** Asentamiento Humano; Condiciones de Habitabilidad; Vías; Contaminación Ambiental.

## INTRODUCTION

Informal urban expansion is a growing phenomenon in Latin America, characterized by unplanned land occupation and a lack of adequate basic services. In the case of the Nadine Heredia Human Settlement, located in the district of Banda de Shilcayo, rapid urbanization has generated a pattern of disorderly growth that is reflected in the precariousness of access roads and increased environmental pollution. These processes not only affect urban mobility and connectivity, but also intensify the socio-environmental vulnerability of the resident population.<sup>(1,2)</sup>

Life in the city of Banda de Shilcayo has been significantly affected by the uncontrolled expansion of informal urbanization. According to recent research, there are multiple factors contributing to this situation. Socio-spatial segregation is one of the main factors, which has a detrimental effect on important areas such as education, employment, and housing. Poor urban planning and a lack of adequate infrastructure in these informal settlements have worsened the precarious living conditions in Peru. In addition, rapid population growth has increased pressure on basic services such as water, sanitation, and electricity.<sup>(3)</sup>

The types of roads found in informal settlements are usually dirt tracks, footpaths, and unpaved streets, which limits accessibility and makes it difficult to manage solid and liquid waste. The absence of adequate road infrastructure contributes to the accumulation of dust, vehicle emissions, and uncontrolled dumping, generating negative impacts on public health and environmental quality. Previous studies have shown that the lack of planning in the road network of informal settlements is closely linked to higher levels of air and soil pollution.<sup>(4,5)</sup>

The structure is disorganized and chaotic as a result of the lack of projects that promote improvements in the way of life and the situations surrounding housing through urban guidelines for sustainable growth. In addition, there are many factors that impact the growth of cities, and without these urban guidelines, the expansion of cities is carried out in an uncontrolled manner due to the lack of adequate control and planning in land use.<sup>(6)</sup>

Although there has been significant progress, considerable obstacles remain, such as the lack of collaboration between different levels of government, the lack of funds to implement urban design projects, and, above all, the continued neglect of marginalized groups.

In this context, it is essential to analyze the relationship between road types and pollution in the informal urban expansion of the Nadine Heredia neighborhood in order to understand how urban morphology and infrastructure condition environmental sustainability and the quality of life of its inhabitants. Scientific evidence shows that poor urban mobility planning in informal settlements not only perpetuates social exclusion but also increases environmental and health risks.<sup>(1,2,5)</sup>

In San Martín, particularly in the city of Banda de Shilcayo, informal urbanization in the Nadine Heredia Human Settlement has led to the proliferation of makeshift homes and inadequate building structures, which has increased vulnerability to potential flooding. This has led to the deterioration of urban infrastructure and has had detrimental effects on living conditions. Informality has an impact on the social and economic spheres.

The lack of skills and low productivity resulting from informality reduce tax collection, which in turn limits the formal economic growth of the district. Based on the above, the research question is posed: What are the conditions of the roads and environmental pollution in the informal urban expansion corresponding to the Nadine Heredia Human Settlement, Banda de Shilcayo?

Therefore, the general objective of the study is to determine the road conditions and environmental pollution in the informal urban expansion in the Nadine Heredia Human Settlement.

## METHOD

The current research uses quantitative methods. The study is descriptive, quantitative, and non-experimental.

In line with the context of the study, the independent variable is informal urban expansion. Within this variable, the dimensions of road conditions and environmental pollution are identified. Likewise, it is taken into account that the dependent variable is the living conditions in the Nadine Heredia Human Settlement, Shilcayo Band. The universe of this study consists of people of both sexes living in the Nadine Heredia Human Settlement, Banda de Shilcayo. The population will be considered to be the Nadine Heredia Human Settlement in general, approximately 2 000 people. The inclusion criterion will be that participants are over 18 years of age, to ensure that they can give their informed consent and have an adequate understanding of the living conditions. All those under 18 years of age and residents who have lived in the area for less than 3 years will be excluded. For a population of approximately 2 000 people, a probabilistic sampling method will be used. This will result in a sample of 322 respondents. The following data collection techniques will be used: questionnaires and observation. The instrument used in this study will be the observation form, which will allow for the analysis and determination of living conditions in the informal urban expansion in the Nadine Heredia Human Settlement as a case study. Tabulation will be used for data analysis, as well as a resource for classifying and evaluating the information collected. In this way, we seek to simplify the distribution of the data and the findings obtained. The study will be conducted in accordance with all the ethical standards required for this type of research. Turnitin anti-plagiarism software was used to ensure that the research project was completely original. Another important ethical aspect is that any information obtained from previous sources, such as research, journals, theses, or other documents, was correctly cited and referenced in accordance with ISO standards.

## RESULTS

Tipos de vías	Cantidad	Porcentaje
Avenida	0	0%
Calle colectora	102	32%
Calle local	220	68%
Callejón	0	0%
Total	322	100%

**Fuente:** Elaboración propia

Figure 1. Types of roads in the Nadine Heredia neighborhood

Figure 1 shows the results obtained from the observation forms completed in the Nadine Heredia Human Settlement, 2024. It shows the percentage of road types that exist in this area, with 68 % connected by a local street and 32 % connected by a collector street.

Materialización en vías	Cantidad	Porcentaje
Asfalto	0	0%
Concreto	0	0%
Tierra compacta	322	100%
Piedra triturada	0	0%
Total	322	100%

**Fuente:** Elaboración propia

Figure 2. Materialization of roads in the Nadine Heredia Human Settlement

Figure 2 shows the results obtained from the observation forms completed in the Nadine Heredia Human Settlement, 2024. It shows the percentage of road construction, with 100 % connected by compacted dirt roads.

Estado de vías	Cantidad	Porcentaje
Bueno	0	0%
Regular	322	100%
Malo	0	0%
Muy malo	0	0%
Total	322	100%

Fuente: Elaboración propia

Figure 3. State of repair of roads in the Nadine Heredia Human Settlement

Figure 3 shows the results obtained from the observation forms completed in the Nadine Heredia Human Settlement, 2024. It shows the percentage of road maintenance status, with 100 % connected by roads in fair condition.

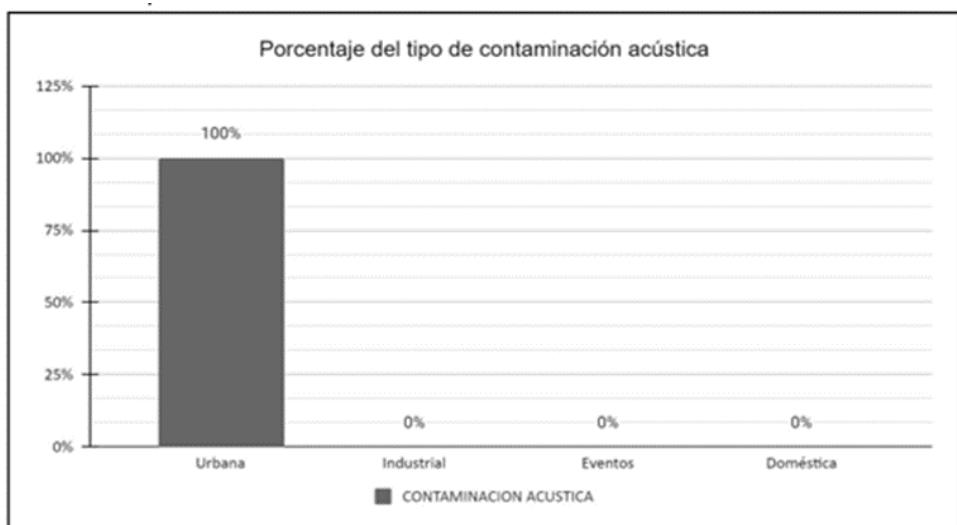


Figure 4. Type of noise pollution in the Nadine Heredia Human Settlement

Figure 4 shows the results obtained from the observation forms completed in the Nadine Heredia Human Settlement, 2024. It shows the percentage of noise pollution, with 100 % experiencing urban pollution.

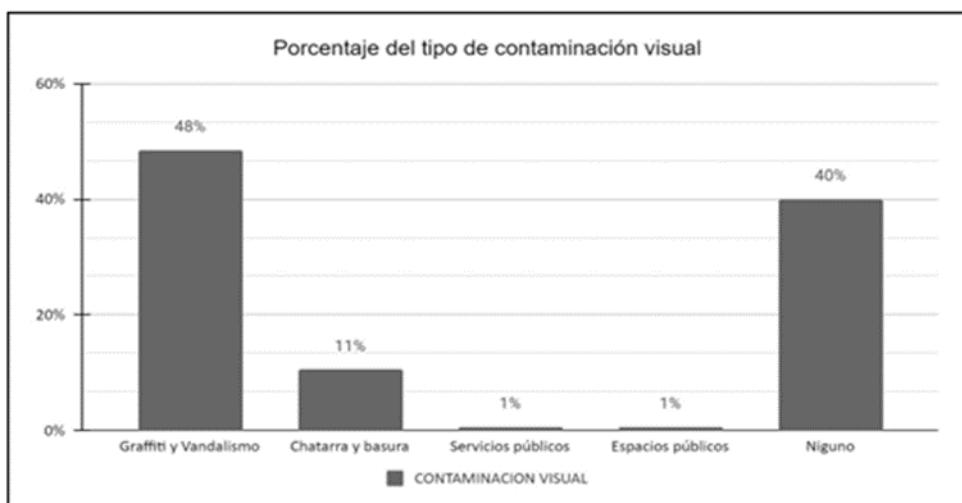


Figure 5. Type of visual pollution in the Nadine Heredia Human Settlement

Figure 5 shows the results obtained from the observation forms completed in the Nadine Heredia Human Settlement, 2024. It shows the percentage of each type of visual pollution: 48 % have graffiti and vandalism, 40 % have no visual pollution, 11 % have scrap metal and trash as pollution, 1 % have public services in poor condition, and 1 % have public spaces in poor condition.

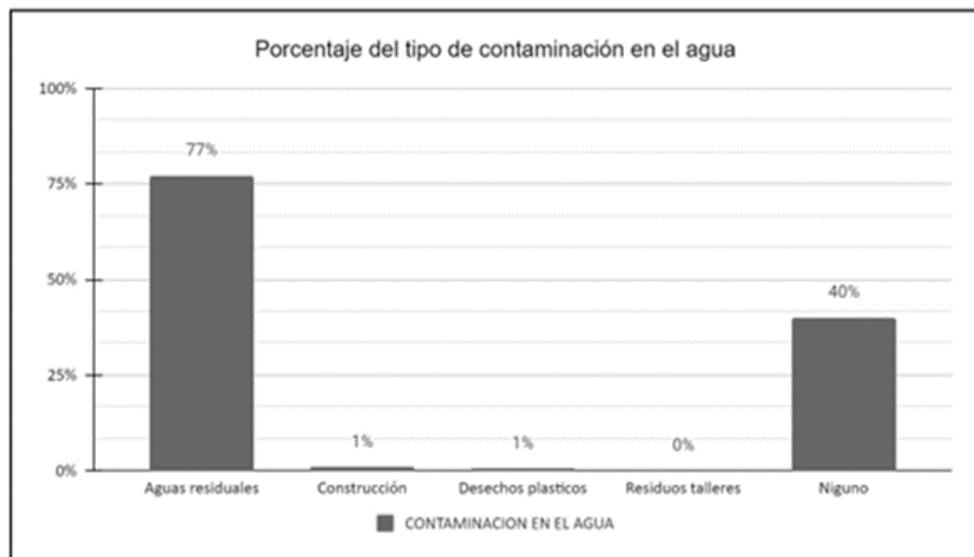


Figure 6. Type of water pollution in the Nadine Heredia neighborhood

Figure 6 shows the results obtained from the observation forms completed in the Nadine Heredia Human Settlement, 2024. The figure shows the percentage of water pollution types, with 77 % being wastewater pollution, 40 % having no pollution, 1 % being construction material pollution, and 1 % being plastic waste.

## DISCUSSION

The finding that 68 % of roads are local streets and only 32 % are collector roads reflects an urban configuration characteristic of informal settlements, where the road network develops spontaneously and with little planning. According to the classification of urban road infrastructure, local streets provide direct access to homes and have a low level of inter-neighborhood connectivity, while collector streets allow traffic flows to be directed to higher-level roads.<sup>(7)</sup> In this sense, the predominance of local streets in Nadine Heredia shows a fragmented urbanization pattern, which limits the integration of the settlement with the rest of the city and reinforces its status as an urban periphery.

Several studies<sup>(8)</sup> have pointed out that the prevalence of local streets in informal settlements is associated with self-construction and unregulated expansion processes, where the priority of residents is to ensure immediate access to their lots, without considering the functionality of the road network as a whole. This situation creates difficulties in urban mobility, as the few collector streets are unable to efficiently absorb public and vehicular traffic flows. As a result, congestion increases on the few existing collector roads, which leads to long travel times and the generation of sources of air and noise pollution, as warned by the Inter-American Development Bank in its analysis of deficient infrastructure in informal neighborhoods.<sup>(9)</sup>

Likewise, the unequal distribution between local and collector streets has direct implications for the environmental management of the settlement. The literature on informal settlements in Latin America points out that the lack of adequate collector roads hinders the implementation of basic services such as public transportation, solid waste collection, and access for emergency vehicles.<sup>(10)</sup> This not only increases the population's vulnerability to environmental and health risks, but also contributes to the accumulation of waste and the proliferation of micro-dumps in local streets that are difficult to access. In the case of Nadine Heredia, the predominance of local streets could be exacerbating these problems, reinforcing the need to rethink the road network as a key element in mitigating pollution and improving quality of life in contexts of informal urban expansion.

The fact that 100 % of the roads observed are made of compacted earth reflects the precarious condition of the settlement's road infrastructure. The absence of paving is a common feature of informal urbanization processes, where the consolidation of roads usually occurs after land occupation and depends on state intervention or urban improvement programs.<sup>(11)</sup> This situation limits accessibility, especially during the rainy season, when dirt roads deteriorate rapidly, causing mobility problems and partial isolation of the population. In addition, the lack of adequate road construction is an indicator of urban inequality, as it highlights the gap

between formal and informal settlements in terms of basic infrastructure.<sup>(12)</sup>

From an environmental perspective, compacted dirt roads contribute significantly to air pollution due to the emission of particulate matter (dust) generated by vehicular and pedestrian traffic. Studies on informal neighborhoods in Latin America<sup>(13)</sup> have shown that the lack of paving increases the population's exposure to respirable pollutants, which has an impact on public health, particularly in terms of chronic respiratory diseases. Likewise, soil erosion and the transport of sediments to nearby waterways intensify water pollution problems, affecting both the ecosystem and the quality of life of the inhabitants. In this sense, the construction of roads is not only a matter of mobility, but also a determining factor in the environmental sustainability of the settlement.

On the other hand, the persistence of unpaved roads in informal settlements such as Nadine Heredia also has social and economic implications. The literature points out that the lack of adequate road infrastructure limits the arrival of public transportation, increases transportation costs, and restricts residents' opportunities for socioeconomic integration.<sup>(15)</sup> In addition, the absence of paved roads hinders the provision of basic services such as solid waste collection, which increases the accumulation of waste in public spaces and exacerbates local pollution problems.<sup>(16)</sup> Consequently, the condition of compacted dirt roads not only reflects a lack of infrastructure, but also perpetuates a cycle of urban and environmental exclusion that directly affects the inhabitants of the settlement.<sup>(17)</sup>

The fact that all the roads observed are in poor condition indicates a situation of progressive deterioration of the road infrastructure, typical of informal settlements where urbanization takes place without adequate planning or maintenance. According to studies, the fair condition of roads is usually associated with wear and tear from intensive use, lack of paving, and lack of systematic municipal intervention.<sup>(18)</sup> This scenario limits the functionality of the roads, affecting residents' accessibility and reducing the settlement's ability to integrate with the rest of the city.

From an environmental and health perspective, roads in poor condition have a negative impact on the quality of life of residents. Research in informal settlements has shown that road deterioration increases the generation of dust and particulate matter, which affects the respiratory health of the population.<sup>(19)</sup> Similarly, the poor condition of roads hinders the movement of emergency vehicles and public transportation, increasing residents' vulnerability to environmental and health risks.

On the other hand, the poor condition of roads also has socioeconomic implications. The literature indicates that the lack of adequate maintenance of road infrastructure in informal settlements limits the arrival of public and private investment, perpetuating a cycle of urban exclusion.<sup>(19)</sup> In addition, road deterioration increases transportation costs and hinders solid waste collection, contributing to the accumulation of waste and local pollution. In the case of the Nadine Heredia neighborhood, the evidence that 100 % of the roads are in poor condition suggests that the population faces structural barriers to improving their living conditions, reinforcing the need for comprehensive interventions that combine infrastructure, environmental management, and social inclusion policies.

The fact that all roads in the settlement suffer from urban noise pollution reflects a structural problem linked to a lack of territorial planning and the concentration of activities in confined spaces. In informal settlements, the proximity of homes to traffic routes, the absence of noise barriers, and the irregular layout of streets generate noise levels that exceed those recommended by the World Health Organization. According to Escartín-Gracia et al.<sup>(20)</sup> continuous exposure to high levels of urban noise is an environmental risk factor that directly affects the quality of life of residents. In this sense, the results obtained in Nadine Heredia are not an isolated case, but part of a common trend in informal urban areas in Latin America.

When these results are analyzed from a public health perspective, noise pollution is associated with multiple adverse effects. Recent research has shown that prolonged exposure to urban noise increases the prevalence of sleep disorders, chronic stress, high blood pressure, and cardiovascular problems.<sup>(21)</sup> In addition, constant noise affects the concentration and school performance of children and adolescents, which deepens social inequalities in vulnerable contexts. As Freire-Vinueza, Meneses, and Cuesta,<sup>(22)</sup> point out, environmental pollution in Latin America, including noise pollution, has become a determining factor in health inequality.<sup>(23)</sup> In the case of the Nadine Heredia neighborhood, the evidence of total noise pollution suggests that the population is exposed to cumulative risks that require priority attention.

Noise pollution also has urban and social implications. Excessive noise in informal settlements not only affects health but also undermines community cohesion by generating neighborhood conflicts and reducing spaces for social interaction. Studies in Latin American cities have shown that the lack of traffic regulation and the absence of adequate road infrastructure intensify noise pollution in peripheral neighborhoods.<sup>(4)</sup> In this regard, the situation observed in Nadine Heredia highlights the need for comprehensive public policies that include road paving, transportation regulation, and the implementation of community noise barriers. Only in this way can the impact of urban noise be reduced and the quality of life of residents in contexts of informal urban expansion be improved.

The finding that 48 % of roads have graffiti and vandalism as the main form of visual pollution, followed by 11 % with accumulation of scrap metal and garbage, reflects a pattern of deterioration of the urban landscape characteristic of informal settlements. Scientific literature has pointed out that visual pollution not only affects the aesthetics of the environment, but also influences the perception of insecurity and social cohesion in communities. According to Freire-Vinueza, Meneses, and Cuesta,<sup>(22)</sup> environmental degradation in Latin America, including visual degradation, is a factor that deepens urban inequality and has a negative psychological impact on residents. In this sense, the prevalence of graffiti and vandalism in Nadine Heredia can be interpreted as a manifestation of the absence of institutional control and the lack of adequate public spaces for cultural and social expression.

On the other hand, the fact that 40 % of the streets do not present any type of visual pollution suggests the existence of areas with greater community resilience or less pressure from disorderly urban activities. However, the presence of 1 % of public services and another 1 % of public spaces in poor condition shows that basic urban infrastructure also contributes to the perception of visual pollution. Research such as that by Zannin and Bunn,<sup>(23)</sup> has shown that the quality of the built environment directly influences residents' perception of livability and satisfaction with their neighborhood.<sup>(24,25)</sup> Thus, the situation in Nadine Heredia confirms that visual pollution is a multifactorial phenomenon, involving both social practices (graffiti, accumulation of garbage) and structural deficiencies (deteriorated infrastructure), which reinforces the need for comprehensive interventions that combine community management, urban policies, and public space improvement programs.

The finding that 77 % of roads are contaminated by sewage is critical, as it reflects the absence of adequate sewage and water treatment systems in the settlement, which increases the population's exposure to waterborne diseases. Scientific literature<sup>(23,25)</sup> has documented that the presence of sewage in informal urban environments is directly related to the proliferation of gastrointestinal diseases and the degradation of local ecosystems. Although 40 % of the areas show no apparent contamination, the coexistence of sewage sources with plastic waste (1 %) and construction materials (1 %) points to a scenario of multiple environmental vulnerabilities. As Brossard, Hernández, and Figueiredo,<sup>(25)</sup> point out, water pollution in contexts of urban precariousness not only affects public health but also limits equitable access to safe water resources, perpetuating social inequality. In this sense, the results obtained in Nadine Heredia confirm that inadequate water management in informal settlements is a structural problem that requires comprehensive interventions in infrastructure, sanitation, and environmental education.

## CONCLUSIONS

The results discussed show that the road layout and environmental conditions of the Nadine Heredia neighborhood follow a pattern of informal urbanization characterized by a predominance of local streets, compacted dirt roads, and poor maintenance, which directly affects mobility, accessibility, and the management of basic services. Added to this are environmental problems such as noise, visual, and water pollution, which not only deteriorate the urban environment but also affect the health and quality of life of residents. These findings show that the precariousness of road infrastructure and the presence of multiple forms of pollution are closely linked, reinforcing the need for comprehensive interventions that simultaneously address road network improvement, environmental management, and social inclusion in contexts of informal urban expansion.

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**CONFLICT OF INTEREST**

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*Conceptualization:* Betsabe Gonzales Cumapa, Milenka Danuzka Padilla Garcia.

*Data curation:* Betsabe Gonzales Cumapa, Milenka Danuzka Padilla Garcia.

*Formal analysis:* Betsabe Gonzales Cumapa.

*Research:* Milenka Danuzka Padilla Garcia.

*Methodology:* Betsabe Gonzales Cumapa.

*Project management:* Milenka Danuzka Padilla Garcia.

*Resources:* Betsabe Gonzales Cumapa, Katty Marilyn Alegria Lazo.

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*Visualization:* Milenka Danuzka Padilla Garcia.