Analysis of the Influence of Road Infrastructure on Land Occupation Patterns. El Guamo, Colombia (2013-2024)

Daniel Camilo Manchola-Cardozo[1], Andrés Ernesto Francel-Delgado[2]

ABSTRACT

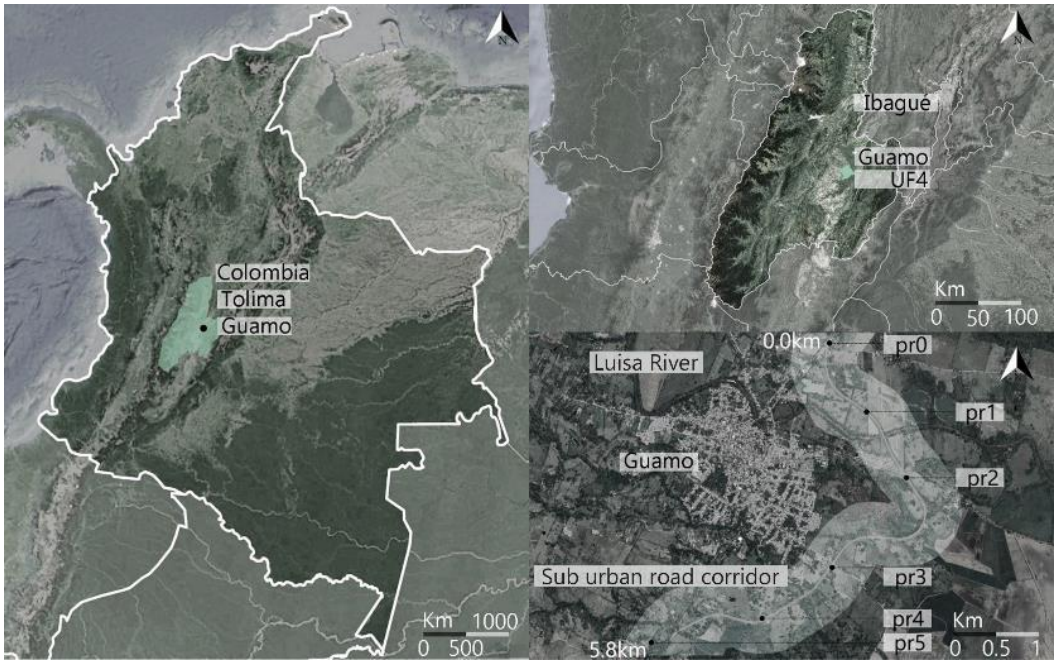
Over the past 15 years, the development of road infrastructure connecting major ports to the country's interior has been enhanced, fostering accessibility and market exchange with foreign markets. Therefore, this article highlights the actions resulting from the implementation of the dual carriageway connecting the municipalities of Girardot, and Neiva between the years 2013 and 2024, focusing on the Guamo – Tolima sector. The objective is to establish local capacities to mitigate negative effects and take advantage of the opportunities brought by such projects. To achieve this, we begin with a historical analysis of fourth-generation road implementation and the urban development and gentrification processes stemming from these interventions in Colombia. This includes data from the regional context prior to the completion of the dual carriageway and a subsequent evaluation of the project's implementation, aiming to generate questions and solutions for regional integration processes and economic, social, and environmental development.

Keywords: anthropic action; road infrastructure; suburban corridor; urban development; urban geography.

[1] Magister en Urbanismo (Universidad del Tolima, Colombia). Orcid: 0009-0006-8784-2105. E-mail: dcmancholac@ut.edu.co
[2] Doutor em História (Universidade Nacional de Tres de Febrero, Argentina). Professor de História da arquitetura na Universidade do Tolima. Orcid: 0000-0002-3249-3191. E-mail: aefranceld@ut.edu.co

Location The municipality of Guamo, with a population of 32,938 inhabitants[3], is located in the southeast of the Tolima department, in central Colombia, covering a total area of 18,751.09 square kilometers. Of this, 97.93% corresponds to rural areas, comprised of 47 hamlets, while 2.07% belongs to the urban area, consisting of nine neighborhoods. It is known as the Craft Capital of Colombia due to its tradition in crafting pieces from royal palm and clay. Due to its strategic location, it became the stage for one of the road connectivity projects for the development of the central-western and southwestern regions of the country since 2018 (Figure 1).

Figure 1. General Location.



Source: Own elaboration based on Google Maps.

This highway corridor has a total length of 196.85 kilometers, of which 58% is located in the Tolima department and the remaining 42% in the Huila department. It is divided into five functional units. Functional unit number four connects the municipalities of Saldaña and Espinal, with a length of 35.5 kilometers, and the municipality of Guamo lies between them (Figure 2).

[3] Departamento Administrativo Nacional de Estadística DANE. *Proyecciones de población* (2018).

Figure 2. Functional units of the Neiva–Girardot highway.

Source: Own elaboration based on Google Maps.

In this functional unit 4, the section of the Guamo road corridor begins at the Guamo north sector bypass route 4507 and ends at the Guamo south sector bypass, spanning a length of 11.9 kilometers, with no urban passage through the municipality. The purpose of the contract for this functional unit is the construction of a second lane and the rehabilitation of the existing one that forms the operational road corridor. Similarly, two overpasses and two perimeters return to the urban area were constructed. This zone, with a length of 5.8 kilometers, was the focus of the research (Figure 3).

Considering that road infrastructure projects impact local and regional dynamics[4], this study conducts a diagnosis of the adaptation process of the municipality of Guamo and how these interventions influence the development components of a territory. For this purpose, four main themes are defined: economic development, environmental component, social development, and territorial planning.

[4] Blandón López, Alexander., González Rubio, J., & Pedraza Vega, G. *¿Significa la doble calzada Bogotá – Girardot – Ibagué – Cajamarca la redención o el ocaso de los municipios tolimenses de área de influencia del corredor vial?*. Universidad del Tolima (2018).

Figure 3. Characterization of the Guamo suburban road corridor, Tolima.

Source: Own elaboration based on Google Maps.

Subsequently, during the period 2009-2010, a downturn in the trend of road infrastructure implementation index for Colombia was observed, a decline associated with the financial crisis with lesser impact on the Colombian economy. It is acknowledged that private sector funds can support the development of road infrastructure due to the state's inability to execute infrastructure projects of significant impact[5]. In this regard, the study is justified by the need to identify the opportunities and threats that road infrastructure projects bring to third-category municipalities like Guamo in the Tolima department, and the capacities it possesses to address this situation, as well as the route defined by the National Development Plan[6], which facilitates territorial planning, the implementation of organized urban development processes, economic strategies, and social integration aimed at fostering development for the municipality's inhabitants.

[5] Rojas-López, M.D., & Ramírez-Muriel, A.F. "Investment in Road Infrastructure and Its Impact on the Economic Development: An Analysis Approach to the Infrastructure Case in Colombia (1993-2014)". *Revista Ingenierías Universidad De Medellín,* vol. 17 Num. 32 (2018), pp. 109-128.
[6] Departamento Nacional de Planeación DNP. *Plan Nacional de Desarrollo 2022-2026*, (2023).

Materials and Methods

Initially, a normative analysis of territorial planning was addressed based on the National Development Plan[7] as the foundation for regional integration processes, along with public policies as a structuring element of development. Likewise, the associative scheme establishing the configuration of a new Administrative Region of Special Planning called the Central Region, expressed in the Neiva–Girardot road axis, was studied[8].

The benefits and negative impacts caused by the dual carriageway on the urban reconfiguration of the municipality of Guamo between 2013 and 2024 were analyzed to identify 'how development patterns follow transportation infrastructure investments, and these follow the economic, social, and urban dynamics of the municipality'[9]. Historical documentation from relevant public entities was collected for this purpose.

The analysis of environmental protection and conservation areas in Guamo was addressed. This includes the diagnosis of the delimitation areas for conservation, the protection of water sources, highlighting the water tributaries of the Luisa River, the Lemayá stream, and the four existing wetlands within the influence area of the bypass.

Construction Permit Processing To identify the impact of the Guamo bypass on land occupation patterns, urbanization and construction permits granted between 2017 and 2020 were analyzed. The aim was to determine the sectors experiencing urban expansion, their property characteristics, and their relationship with the infrastructure project (Table 1 and Table 2).

[7] Departamento Nacional de Planeación DNP. *Plan Nacional de Desarrollo 2022-2026*, (2023).
[8] González, Alba & Solorza, Jairo. *Región Administrativa y de Planeación Especial, Región Central (RAPE-RC)*. 1, (2017), pp. 1–12.
[9] Blandón López, Alexander; González Rubio, J. & Pedraza Vega, G. (2018). *Ibidem.*

Table 1. Issued Construction Permits.

Type	Complexity	Application Number	Property Registry
New Construction		73319-16-0050	360-35588
		73319-17-0006	360-26801
Adaptation	Low	73319-16-0057	360-19334
Demolition		73319-17-0008	360-249
New Construction		73319-16-0003	360-25963
		73319-17-0002	360-34042
		73319-15-0012	360-26009
	Media	73319-17-0023	360-29900 / 360-36016
		73319-16-0055	360-3705
		73319-17-0010	360-37204
		73319-17-0038	
		73319-17-0042	360-35547
	Low	73319-17-0053	360-11342
		73319-17-0043	
		73319-17-0019	360-36919
		73319-16-0048	360-34242
		73319-16-12	360-26804
		73319-17-063	360-19092
		73319-17-065	360-25927
		73319-17-49	360-35733

Source: Own elaboration based on information from the Municipal Planning Secretary (2017).

Table 2. Urban Licenses Issued.

License Type	Type	Complexity	Application Number	Property Registry
Development urbanization	New Construction			360-16208
Construction and urbanization		Low	73319-17-0053	360-35336 / 360-35337 / 360-35338 / 360-35339 / 360-35364 / 360-35365 / 360-35366 / 360-35367 / 360-35368 / 360-35369 / 360-35370 / 360-35371 / 360-35372 / 360-35374
Development urbanization				360-28673

				360-4483

Source: Own elaboration based on information from the Municipal Planning Secretary (2017).

Data registration cards were generated with relevant aspects of each property, including its location and basic data for population analysis, enriching the interaction between the physical and social characteristics of urban expansion. Refer to (Table 3).

Table 3. Property Data Collection.

Property Identification Form			
Analysis of construction permits issued in the suburban corridor of Guamo, Tolima			
Description		Research Entity	
Date		Property Information	
Adress		Type of Construction	Land Registry Number
Coordinates			
Location scheme		Construction Status	Total Number of Units
		Number of Units Built	Number of Units Not Built
		Sewer System	Water Supply System
		Who is in charge	Type of system
		Photographic record	
Observations			

Source: Own elaboration

FIELDWORK

Field surveys were conducted in the project's influence areas to identify points of interest, which were georeferenced. During the fieldwork, the wetlands were visited to verify the condition of their environmental structure, the actual identification of biotic components, and the true extent of their perimeter areas. The data were entered into the Epicollect tool, which allows georeferencing of these features through layers such as geographic location, photographic records, vegetation cover, land use, topography, and level of environmental impact. Based on this georeferencing, a

cartography was produced that delineates the wetland areas affected by the construction of the Guamo bypass, the definition of buffer zones, the road alignment, and critical points.

In the following image, we can observe a visit to the Las Garzas wetland while data is being entered into Epicollect, including its respective soil classification attributes and the resulting cartography showing the impact of the road corridor, which cuts through the wetlands and generates noise pollution. The third process involved the development of working sessions with urban developers and the local community (figure 4).

Sample Size

In non-probabilistic samples, the selection of elements depends on causes related to the characteristics of the research or the researcher's purposes. A survey was conducted using non-probabilistic sampling methodology in a quantitative process, taking a sample from a subgroup of the population of interest, defined within the 300-meter corridor of the road, supplemented with intentional sampling. Based on a total of 933 housing units, the survey was applied to 10% of the existing households, resulting in 93 surveys, of which 35 were conducted virtually and 58 in person. Techniques such as standard deviation, relative frequency, and linear regression were considered.

Survey

The survey was titled "Issues and Opportunities Arising from the Construction of the Guamo – Tolima Bypass" and divided into five parts, following parameters defined by Hernandez et al.[10]. Demographic characteristics comparison, representativeness analysis, and qualitative validation were taken into account.

[10] Hernández Sampieri, R., Fernandez R, & L Baptista. (2014). *Metodología de la investigación*. McGraw-Hill / Interamericana editores, S.A., México (2014).

1. Select your sex: female, male, non-binary

"This question is intended to identify the number of men and women living in this area and their behavioral characteristics".

2. Age: numeric

"This question is intended to identify age ranges and productive life stages of the inhabitants".

3. Are you a resident of the municipality of Guamo – Tolima? yes, no

"It is necessary to identify whether the inhabitants of the study area are native to the municipality or immigrants from other cities, as well as their length of residence."

4. Are you the owner of a plot of land or a dwelling in the area of the bypass? yes, no

"This question is intended to identify whether residents own or rent property and their intention to develop the lot or dwelling."

5. Number of people under your care: numeric

"This question is intended to identify the average number of people per housing unit in order to project future population growth."

6. Do you plan to make modifications or constructions on the property you own? If yes, please describe them. Open-ended

"This question is intended to identify the intention to develop the owned lot."

7. Is your source of income formal or informal? Please describe it.

"This question is intended to identify the main sources of household income of the people living in the study area."

8. Do you have access to a private vehicle? If yes, please specify which one.

"This question is intended to identify the means and type of transportation used by residents and their willingness to use the bypass."

9. How often do you use the Guamo bypass? (Options: daily, weekly, monthly, rarely, never)

"This question is intended to identify the period and frequency of use of the bypass and its usefulness for residents."

10. How satisfied are you with the quality of the Guamo bypass?

(Options: very satisfied, somewhat satisfied, neither satisfied nor dissatisfied, somewhat dissatisfied, very dissatisfied)

"This question is intended to understand residents' perceptions of the road infrastructure developed along the bypass."

11. How often do you visit the urban center of the municipality of Guamo?

(Options: very frequently, frequently, infrequently, never)

"This question is intended to identify the relationship between suburban residents and the urban center, as well as their level of connectivity."

12. Do you consider the construction of the Guamo bypass to be positive or negative? Why?

"This question is intended to identify residents' perceptions of the construction of the bypass and its implications for the social development of the area."

13. Do you think that more pedestrian crossings are needed along the Guamo bypass?

"This question is intended to identify the efficiency or deficiencies of the road infrastructure project for pedestrians."

The Link to the survey was active during the researching process.

Social Cartography

The geopolitical definition of territory, which refers to a fragment of land administered by a public body, overlooks the dynamics of the social structure of its inhabitants[11]. Therefore, a Social Management Plan was developed based on the

[11] Uribe-Lotero, C., Donoso-Figueiredo, D., & Ramírez, A. "De la cartografía social a la comprensión de los contextos socioeducativos". *Aletheia. Revista de Desarrollo Humano, Educativo y Social Contemporáneo*, 9:2, (2017), pp. 74–93.

methodology of 'Pedagogical Social Cartography' and the steps proposed[12] for conducting pedagogical social cartography. This approach involves selecting the type of issue, choosing the type of map, motivating participants, forming workgroups, agreeing on conventions, map development, map explanation, transformation agreements, map analysis, and map memory.

This way of thinking politically positions subaltern knowledge and provides a means to challenge the hierarchies of colonial epistemological difference, thus offering an opportunity to transcend the rigid boundaries of disciplines and, from our perspective[13].

The first component was defined as Initial Sensitization and Socialization, providing information about the research process and the methodology used to collect data from critical points in the project's influence area based on tools that aim to depict the intersubjective connections among territory stakeholders in a specific temporal context[14]. The second component was defined as Community Participation, involving the implementation of a workshop for dialogue with the community, which, due to its location or relationship with the project's sector or influence area, expresses interest in the issue.

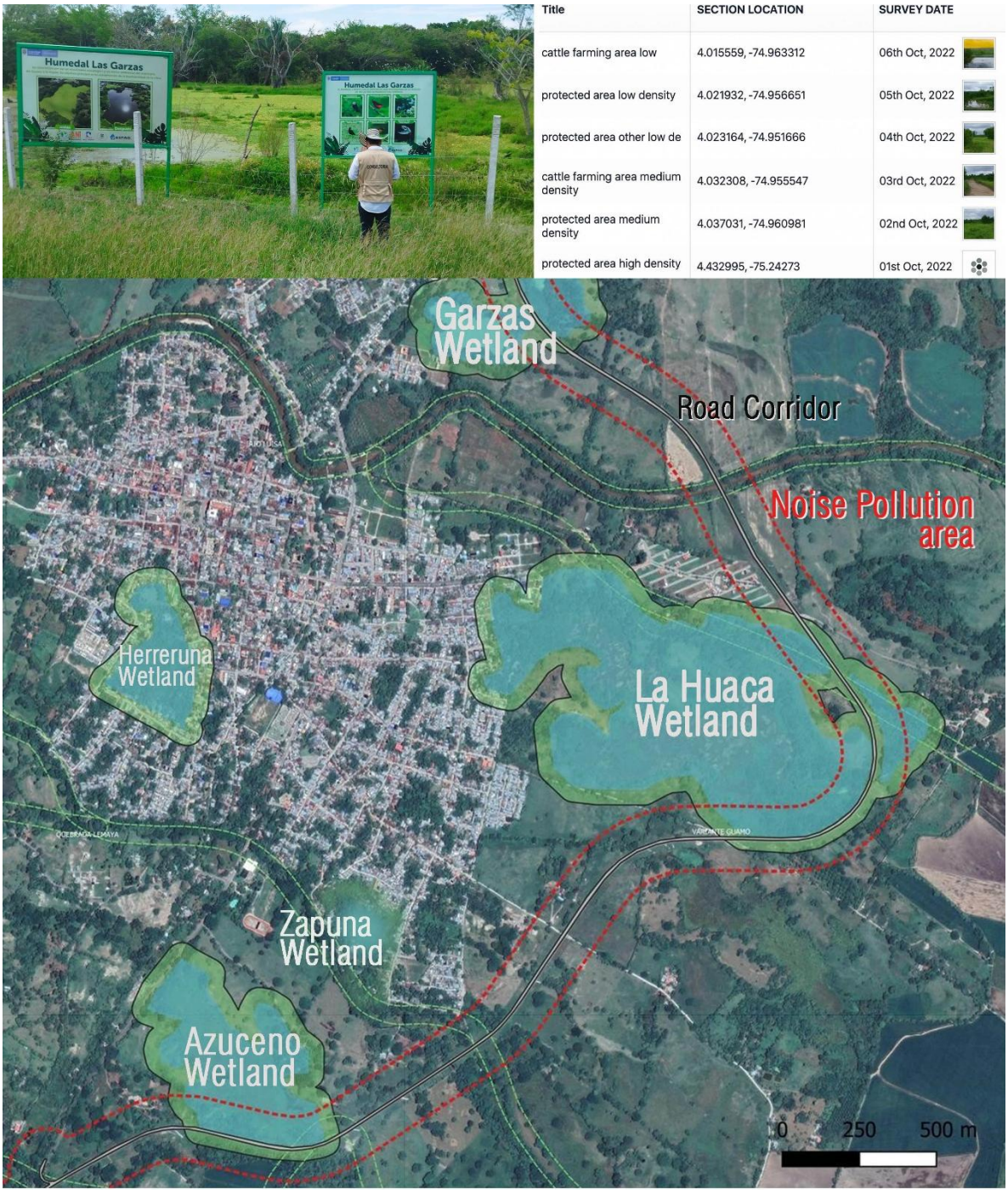
Table 4. Social Cartography Methodology

Type	Objective	Participants
Timeline Cartography	To represent and organize chronologically the events or occurrences before, during, and after the implementation of the road project.	Community representatives Municipal Ombudsman Research promoter
Problem Tree Cartography	To identify and analyze the root cause of a problem, possible solutions, and the outcomes of the solutions.	
Territorial Mapping Cartography	To visualize and analyze social relationships, community dynamics, and resources present in a specific geographical area.	

Source: Own elaboration based on participatory social cartography

[12] Barragan D, & Amador J. "La cartografía social- pedagógica: una oportunidad para producir conocimiento y repensar la educación". *Itinerario Educativo.* Vol.28, num.64 (2014), pp. 127–141.
[13] Montoya Arango, V., García Sánchez, A., & Ospina Mesa, C. A. Andar dibujando y dibujar andando: cartografía social y producción colectiva de conocimientos. Nómadas, 40, (2014), pp. 191-205.
[14] Uribe-Lotero et. Al. Ibidem.

Figure 4. Fieldwork and resulting cartography.



Source: Own elaboration based on Epicollect data.

RESULTS

FROM SECONDARY INFORMATION

The Basic Territorial Planning Plan[15] provides guidelines on the growth and urban expansion of Guamo, such as identifying priority growth areas for development and urban formation, defined by their technical feasibility for infrastructure construction, ease of public service provision, accelerated development of primary and secondary residential housing, and road infrastructure development.

In Colombian land-use regulations, prioritized expansion land refers to areas located outside the urban perimeter that, due to specific growth needs, are scheduled for immediate incorporation into the city, contingent upon the availability of public services and prior technical studies. Urban expansion land, in contrast, is also located outside the urban perimeter but is intended for medium- or long-term incorporation; these areas function as territorial reserves that may only be developed once the goals of the Land Use Plan (POT) are met and the necessary infrastructure capacities are in place. Finally, land with development treatment corresponds to urban or expansion areas already enabled for carrying out urban processes—such as subdivision, urbanization, and construction—according to the specific regulations of the applicable partial plan or planning instrument. Together, these three categories guide urban growth while ensuring sequence, carrying capacity, and sustainability[16].

It was observed that 80% of the areas proposed within the PBOT are within the influence area of the infrastructure project in question, defining a total of 171 hectares divided into 73 for urban expansion, 43 for prioritized urban expansion, and 55 for urban development treatment [Table 5 and Figure 5].

[15] Concejo Municipal del Guamo - Tolima. *Acuerdo N 014 de 2022 Revision y Ajuste Pbot Guamo Tolima. Mitigación del cambio climático*. (2022, September 30).
[16] Congreso de Colombia. *Ley 388 de 1997*. Diario Oficial No. 43.091, de 24 de julio de 1997.

Table 5. Urban Expansion Areas in Variant Influence Zone.

Type	Acres	Location
Prioritized Expansion	43	Southeastern Northeastern
Urban Expansion	73	Southeastern Southwestern
Development Treatment	55	Northeastern Southwestern
Total	171	

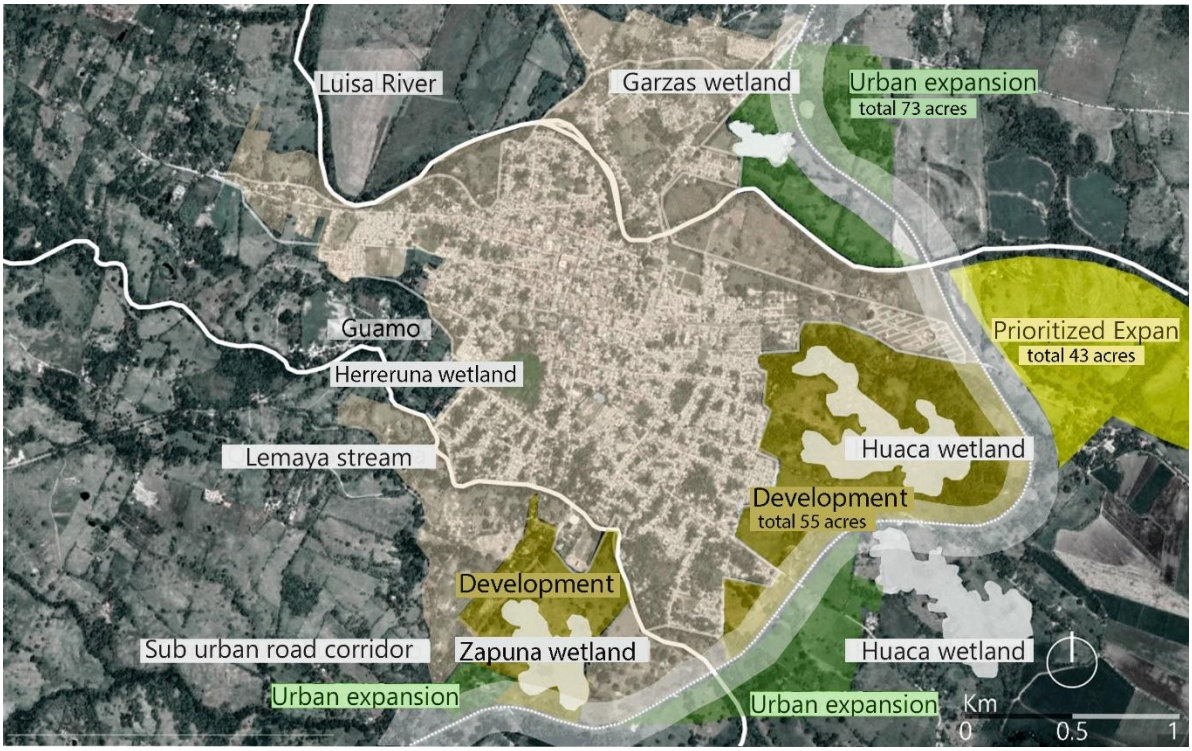
Source: Own elaboration based on the Sewer Master Plan

The identification of land uses in the influence zone of the road infrastructure project, on the eastern side of the municipality of Guamo, allows for determining how the territory is planned to be utilized and distributed primarily for residential purposes, covering an area of 94 hectares, equivalent to 54% of the land designated in the PBOT for new real estate developments. This shows a direct correlation between the layout of the road infrastructure and the promotion of urban expansion around it.

Primary residential use consists of one and two-story houses, inhabited by one or two families, with an average of four people per housing unit. Secondary residential use comprises vacation homes, such as second property acquisitions, totaling 870 units, where 70% of the owners do not reside in Guamo [Figure 6].

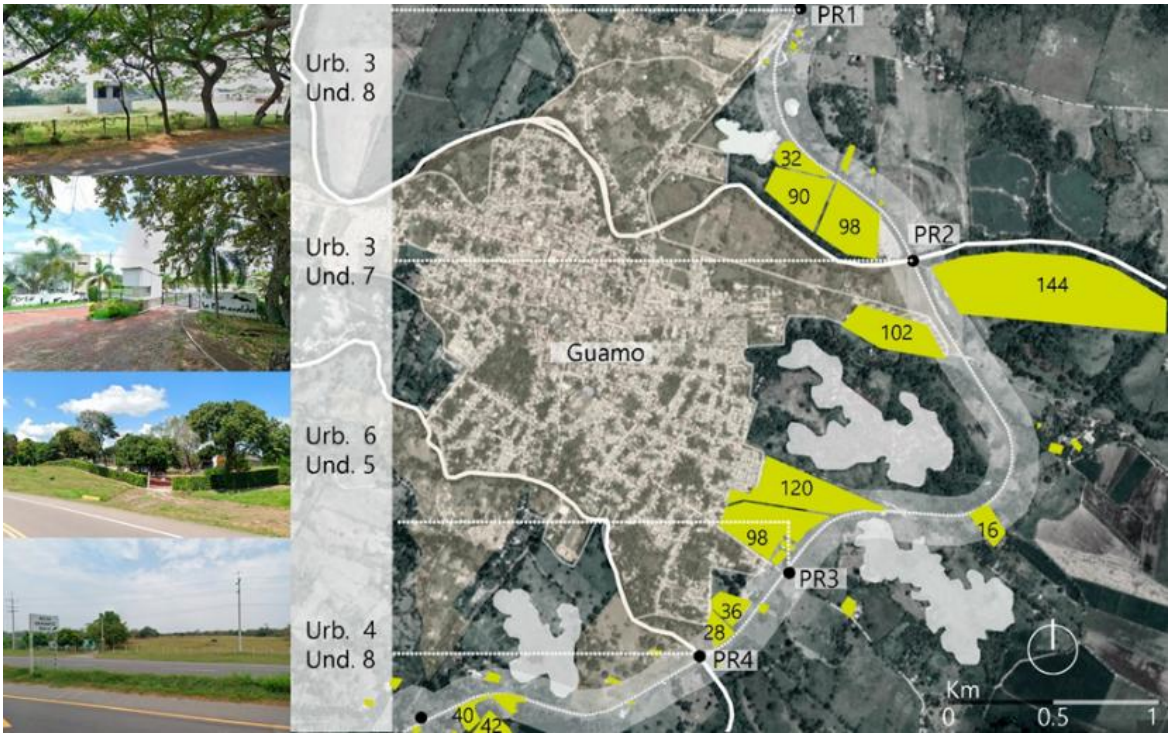
When overlaying cartography onto the implementation area, the composition and layout of the land were identified according to the development forecast contained in Guamo's PBOT. Primary and secondary residential areas were identified, along with collective equipment, consisting solely of a primary school, and protected areas, in accordance with the identification of water bodies, wetlands, and forested areas.

Figure 5. Urban Expansion in the Variant Influence Area.



Source: Own elaboration based on the Basic Territorial Planning Plan

Figure 6. Number of housing units under construction per lot.



Source: Own elaboration based on Urban Licenses Issued.

Environmental Protection

The areas of four wetlands were classified, including Las Garzas, La Huaca, and La Zapuna, la Herreruna, totaling 39.62 hectares, including environmental isolation areas, such as El Azuceno, which is located outside the urban boundary and is located in figure 4. Additionally, an area of influence on the Luisa River within the suburban corridor where the road project is implemented was identified, totaling 18 hectares on the northern side of the municipality, and an impact of eight hectares on the Lemaya stream on the southern side of the municipality [Table 6 and Figure 7].

Table 6. Areas of Environmental Impact.

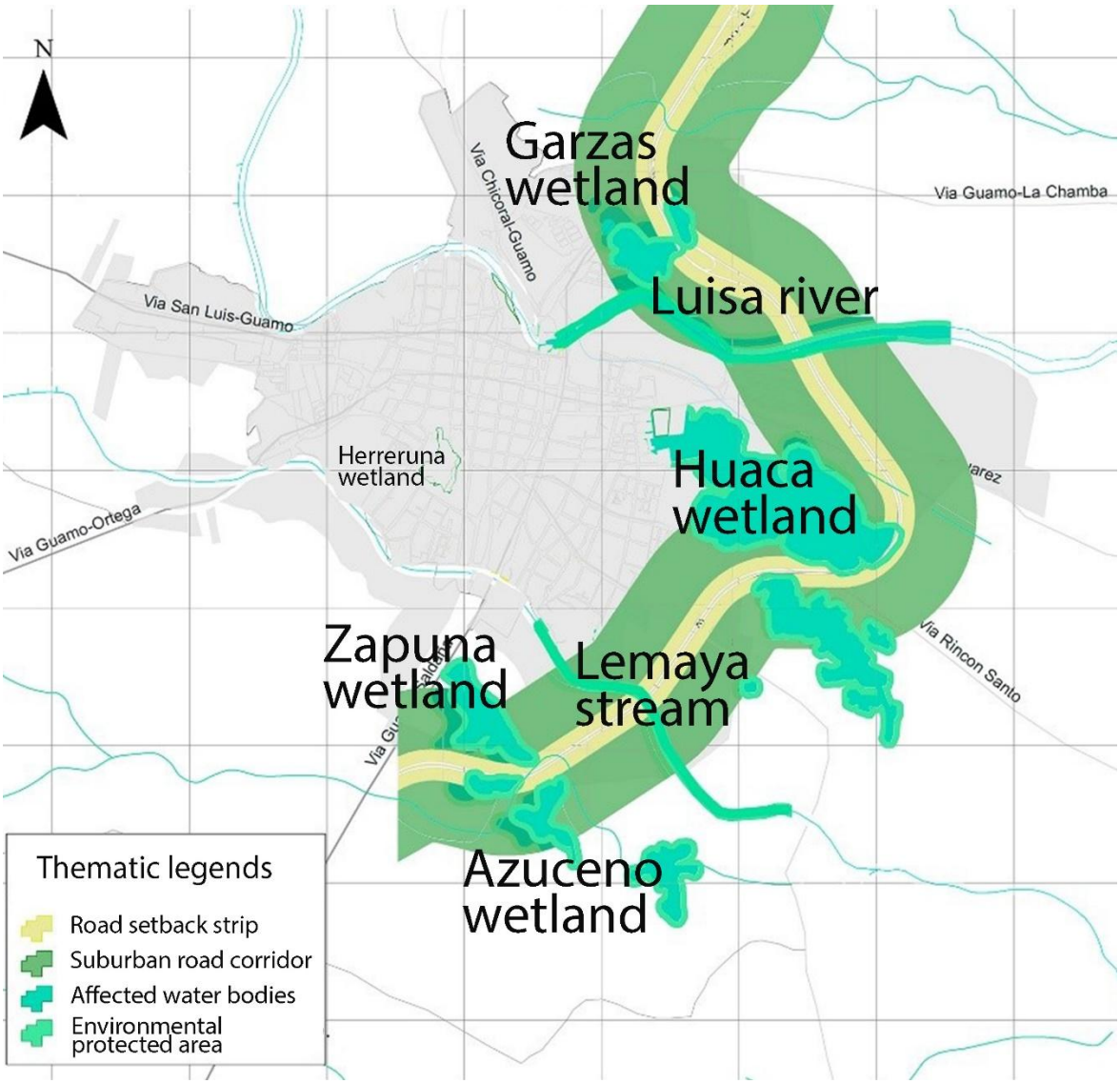
Area	Acres	Location
Luisa River	18,00	North
Azuceno wetland	16,77	Eastern
La Zapuna wetland	13,12	Eastern
Lemaya stream	8,00	South
Las Garzas wetland-Lake	7,13	Eastern
La Huaca	2,60	Western
Total Impact Areas	65,62	

Source: Own elaboration

From the Surveys

The initial analysis conducted within the survey application focused on the place of residence of landowners, aiming to identify migration dynamics and land purchases by residents of the sector or other municipalities, such as investors for the construction of housing units, thereby identifying land dynamics. Out of 93 respondents, 79 respondents, corresponding to 85%, are residents of the municipality or natives. The remaining 15% of property owners reside in other municipalities, mainly Bogotá, seeking vacation homes.

Figure 7. Areas of environment impact and Urban Expansion in Road Influence Area



Source: Own elaboration

Of the surveyed individuals, 86% (80 surveys) are owners of single-family or two-story houses and are residents of the area, while 13% are not property owners and act as caretakers of land or houses. In this regard, land ownership aligns with residency, indicating an increase in the real estate market. Specifically, 64% of respondents own agricultural land that is in the process of being sold to developers or urban developers, 35% are owners of single-family and two-family homes built in the last 10 years, and 1% are owners or developers of condominiums.

Of the surveyed individuals, 89% intend to make modifications or construction within their properties, while 11% anticipate land appreciation based on the growth of real estate projects. This condition of real estate speculation towards the peripheries or areas of urban expansion is reinforced by the fact that 69% of respondents do not own a vehicle, 29% commute by motorcycle, and 2% have a car. Given the dimensions of the urban area, the variant does not significantly impact transportation conditions, as only 31% use motorized means of transportation.

Regarding the frequency of use of the variant, 25% of respondents use it daily, 20% weekly, 20% monthly, 19% rarely, and 16% never. Consequently, such projects do not facilitate mobility in the surrounding area, do not promote connectivity with the urban center, nor encourage social interactions and economic development processes, given their nature of national interconnection, where the impacts on municipalities are not relevant aspects and lead to indifferent designs in the affected areas. As a result, 75% of the sample population is dissatisfied with the project, 15% are very satisfied, and 10% are satisfied.

Regarding perceptions of the variant construction, 65% are negative, while 35% are positive, as they perceive a lack of ownership and utility for those living in the municipality's suburban road corridor.

From Social Cartography

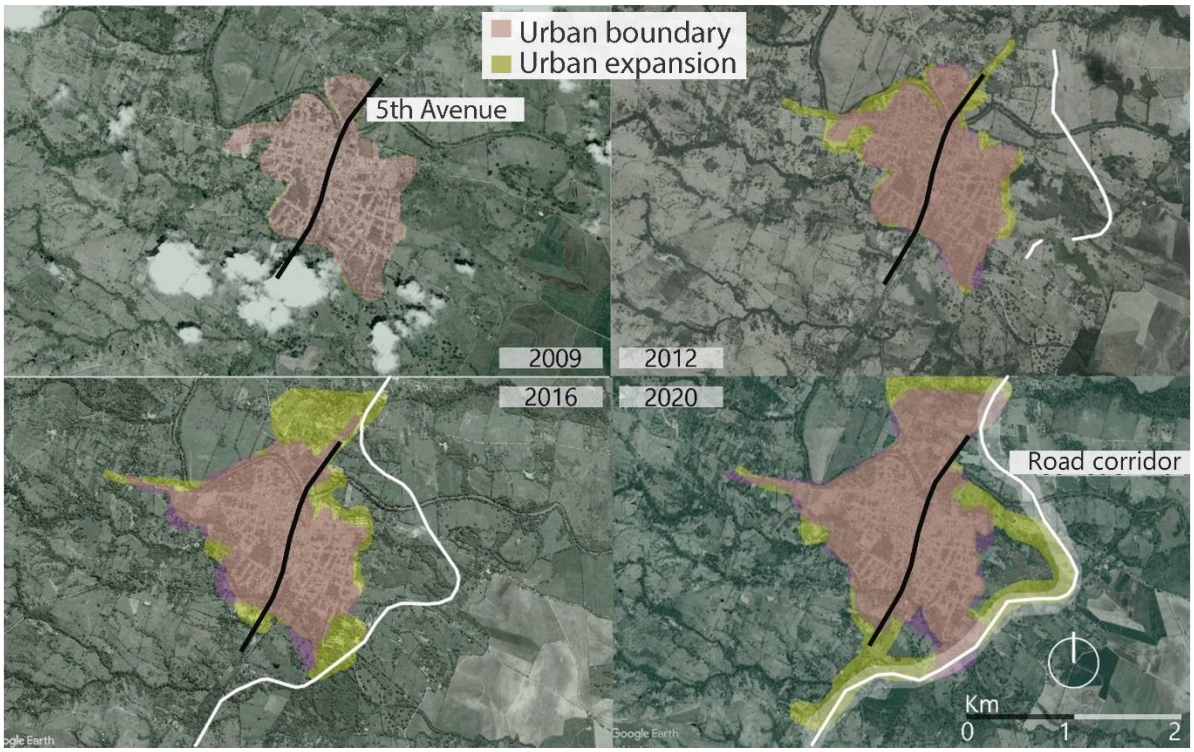
The timeline revealed a process of land ownership structure change between 2009 and 2020, With the change of 5th Avenue, which was the former road that connected El Guamo to the other municipalities, as a national road traversing the center of the municipality to connect Bogotá with the southwest of the country. In 2007, Law 1151 of 2007 was enacted, establishing investments in road infrastructure, leading to the implementation of the 4G roads in 2011, which included the Guamo road corridor. The National Development Plan[17] prioritized the construction of 4G highways,

[17] Departamento Nacional de Planeación DNP. *Plan nacional de desarrollo 2014-2018*, (2014).

which involved the demarcation of the Neiva-Girardot road corridor by the road concession Autovía N-G and the National Infrastructure Agency.

In 2020, the progress of the project reached 85%, overshadowing the importance of 5th Avenue, transforming the economic, commercial, and social conditions of the urban center and leading to the process of modifying the Territorial Ordering Plan, which proposed expansion areas of the municipality adjacent to the variant[18] (Figure 8).

Figure 8. Road Influence on the Territorial Occupation Process.



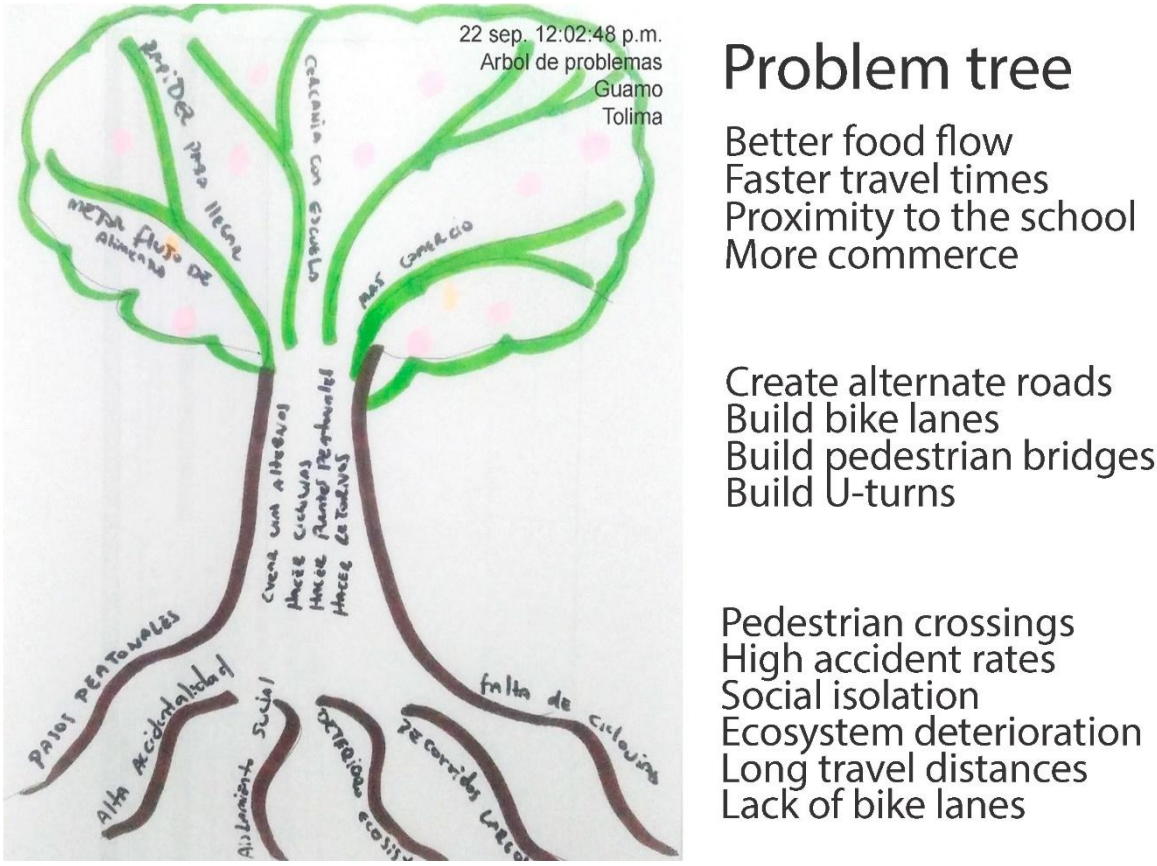
Source: Own elaboration based on aerial photographs from the Agustín Codazzi Geographic Institute.

The problem tree allowed us to identify the main issues such as the lack of safe pedestrian crossings, sidewalks, and bike lanes, as well as the deficiency of U-turns and overpasses to reduce travel times to the urban center and the widespread isolation of the suburban area from the municipality's urban center. Additionally, the barriers causing the isolation of the suburban corridor from the populated center were

[18] Concejo Municipal del Guamo – Tolima. (2022). Ibidem.

identified at several intersections to Guamo access, due to the deficient transversal connectivity infrastructure within the project (figure 9).

Figure 9. Problem tree during social cartography.



Source: Own elaboration during social cartography.

DISCUSSION

The road transport infrastructure in Colombia is one of the most important aspects influencing the country's internal and external competitiveness, significantly affecting economic growth and sustainable development[19]. In contrast to this, it has been determined that one of the main problems when planning is the sectorization

[19] Ordoñez-Cetina, K. S., & Parra-Velandia, V. J. *Infraestructura de transporte vial: un factor de atraso para la competitividad de Colombia en la Alianza Pacífico*. Universidad de La Salle. Facultad de Economía, Empresa y Desarrollo Sostenible – FEEDS, (2017).

involving a city (economic development, environment, land use, and roads)[20]. It can be said that in the formation of the imaginary, perception is transformed into representations through imagination to define the identity of a territory.

Likewise, the undertaking of large transport infrastructure projects requires, first of all, having enormous financial power willing to wait a long time for their profits for the development of a region[21]. This contributes a sense of meaning to representations and symbolic transformations as defined by Reyes-Guarnizo[22], leading to a balanced development structure coinciding with the perception outlined by Cosci & Mirra[23], which defines the process of unbalanced development among different regions, demonstrating the widening of the inequality gap since the 1970s in places where road infrastructures are provided, unbalancing the commercial and economic structure of the regions depending on their specific conditions, generating greater isolation and segregation or reactivation of new economies.

In relation to the concept of territory appropriation, it is based on the conceptualization of territory within its social construction, for which the themes of symbolic space, identity, and attachment to the place will also be addressed[24]. This is reinforced by the concept of panarchy and resilience[25], which allows for the evaluation of the effectiveness of territories to face adversity in social systems and the capacities of the population in the area of influence of road infrastructure projects to adapt and face the positive or negative effects of the dual carriageway.

Panarchy is understood as an integrative theory, so that the origin, types, and functions of changes that occur in the territory can be identified, and those that are susceptible to control and adaptation can be distinguished and appreciated[26]. In this

[20] Manrique-Bautista, J. A., Jiménez-Serpa, J. C., & Salas-Rondón, M. H. "Accesibilidad: elemento fundamental para la ejecución de infraestructura de transporte". *Infraestructura Vial*, *21*:37, (2019) pp.1–11.
[21] Flores-Rangel, Jorge Adrián. "Infraestructura carretera: construcción, financiamiento y resistencia en México y América Latina". *Revista Transporte y Territorio*, 13 (2015), pp.122-148.
[22] Reyes-Guarnizo, A. B. "Comprensión del territorio para la construcción de apropiación e identidad en el municipio de Soacha". *Revista de Arquitectura (Bogotá)*, *22*:1 (2020), pp. 44–57.
[23] Cosci, S., & Mirra, L. "A spatial analysis of growth and convergence in Italian provinces: the role of road infrastructure". *Regional Studies*, *52*:4, (2018), pp. 516–527.
[24] Reyes-Guarnizo. Ibidem.
[25] Prieto-Barboza, E. A. "Resiliencia y panarquía: claves para enfrentar la adversidad en sistemas sociales". *Multiciencias*, *13*, (2013), pp. 23–29.
[26] Blandón-López et al. Ibidem.

sense, four stages emerge that characterize an adaptive cycle resulting from the interaction between growth and accumulation on one hand, and novelty and renewal on the other. From this point of view, adaptive cycles are an excellent tool to understand how persistence and transformation processes coexist in the dynamics of a territory[27].

When comparing the study area with similar infrastructures such as the Bogotá-Girardot-Ibagué-Cajamarca dual carriageway, low performance is found in quality-of-life indicators and little economic and commercial development[28]. Consequently, poverty persists, as does an unemployment rate above the departmental average.

The concept of public value is related to the effectiveness and efficiency of state management[29]. However, conflicting positions arise regarding the benefits or impacts of this road project among inhabitants of the urban center, compared to those living in the area closest to the dual carriageway, because their economic and social dynamics are different, as demonstrated in the research by Cosci & Mirra[30], which shows the need to take into account the particular characteristics of each region, so as not to go against the potential or weaknesses they have[31].

From the secondary information collected, focusing on the Basic Territorial Ordering Plan (PBOT), the dynamics in the development of land occupation models, in relation to the implementation of road infrastructure, from a national context to a local one, demonstrate that inhabitants rarely participate in structuring this type of high-impact projects, nor do modifications to their territory often align with local regulations and institutional frameworks[32].

[27] Guderson, L.H; Holling, C.S. & Light, S.S. *Ciclos adaptativos y Panarquía.* (2002), pp.1–2.
[28] Blandón-López et al. Ibidem.
[29] Moreno-Parra, I. (2023). "Paradoja de los megaproyectos y gestión presupuestaria vial en Ecuador 2002-2006". *Infraestructura Vial*, *25*:44, (2023)57–74.
[30] Ibidem.
[31] Flores-Rangel (2015). *Ibidem.*
[32] Maya-Velásco, L. M. *Transformaciones urbanas pequeños centros poblados a partir de los proyectos de infraestructura vial 4G concesionados, estudio de caso pavas - Valle del cauca*. Universidad Piloto de Colombia, (2017).

With this, differences arise in the objectives of the regulations developed for the execution of municipal development plans, the administrative entities, and for the Concessionaire, which shows little interest in what happens to the territory[33]. Projects tend to become part of bureaucracy and economic power, as asserted by Cosci & Mirra[34], and do not solve local problems.

The property characteristics in the areas influenced by road corridors reflect territorial reconfigurations, such as subdivision or plotting, and changes in land prices[35]. In this regard, land valuation has been a central element for understanding the dynamics of development and growth of nations. Added to this is the high impact generated on the water components surrounding the road corridors. Thus, road infrastructure has generated significant changes in land use and city structure. Hence, the importance of studying the environmental impacts of cities involved, noting that these projects alter growth trends and their consequent demand for services, including water[36].

Currently, thanks to rural development policies based on strengthening land markets, interest in the determinants of rural land prices has intensified. However, aspects such as high informality in land property rights, outdated cadastral records, and speculation have created a significant obstacle to developing efficient land valuation methods in developing countries[37].

One of the major impacts within urban transformations in third-category municipalities, stemming from road infrastructure projects, is the generation of new urban geographies, including changes in land use, greater densification in the suburban road corridor, and a shift in land trends[38].

[33] Ibidem.
[34] Cosci & Mirra, ídem.
[35] Idem.
[36] Granados, R. & Villaseñor. F. "Entorno a la problemática del recurso agua ante los megaproyectos de transporte. Estudio de caso Zona Metropolitana de la Ciudad de Querétaro". *Boletín de La Sociedad Geológica Mexicana*, *59*:2, (2007), pp.163-169.
[37] Muñoz-Mora, J. C., & Jaramillo-Cardona, H. "El precio de la tierra: estado del arte de las metodologías de valoración de predios rurales y su aplicación en Colombia". *Suma de Negocios*, *4*:1, (2013), pp.21–31.
[38] Maya-Velásco, (2017), Ibidem.

Environmental Protection

Within this component, various factors affecting the ecosystem derived from the construction of fourth-generation (4G) roads were analyzed. In the case of the affected areas within the Guamo road corridor, it is observed that the impacts on biotic and abiotic factors are critical, reflected in 70% of the most common environmental impacts, such as loss of land use, loss of landscape[39], decreased water and air quality, loss of plant and animal species, and habitat fragmentation. This creates a growing edge effect leading to habitat quality deterioration, affecting the survival of populations inhabiting the fragments[40].

The implementation area of the Guamo municipality's road project is an area of high environmental richness directly affected by road construction processes, policies aimed at eliminating environmental isolation perimeters, and the change in land use towards development and urban expansion treatments. This goes against what is defined in environmental management and compensation plans, as a fundamental instrument of environmental management, whose main purpose is to ensure that environmental impacts related to economic development projects are addressed. The Manual for the Allocation of Compensation for Biodiversity Loss defines compensation as:

> Actions aimed at making amends to biodiversity for impacts or negative effects that cannot be avoided, corrected, mitigated, or substituted, and that result in biodiversity loss in natural terrestrial ecosystems and secondary vegetation; in such a way that the effective conservation of an ecologically equivalent area is guaranteed, where a new management category or permanent conservation strategy can be established"[41]. However, the execution of infrastructure projects evades the implementation of compensations with criteria of environmental, financial, and legal sustainability[42].

[39] Bannen-Lanata, P., Rosas-Vera, J., Hidalgo-Hermosilla, G., & Strabucchi-Chambers, W. (2022). La ocasión de imaginar un nuevo paisaje cultural para la modernización de una ciudad capital: Una relectura del Plan de Transformación de Santiago de Chile por Vicuña Mackenna (1872-1875). Identidades: Territorio, Cultura, Patrimonio, 11, 236–263.
[40] Santos, T., & Tellería, J. L. (2006). Pérdida y fragmentación del hábitat: efecto sobre la conservación de las especies. Ecosistemas, 15(2).
[41] Ministerio de Ambiente y Desarrollo Sostenible. *Resolución 1517. Por la cual se adopta el manual para la asignación de compensaciones por pérdida de biodiversidad*, (2012).
[42] Sarmiento, Mariana; Cardona, William; Victurine, Ray; López, Alexis; Carneiro, Andrea; Franco, Padu & Jiménez, Marcela. (2015). *Orientaciones para el Diseño de un Plan de Compensaciones por Pérdida de Biodiversidad.*

FROM THE SURVEYS

For the current scenario, there is evidence of a process of isolation for the community, promoting the disintegration of communities and increasing the gap of inequality between territories[43][44]. However, aspects such as high informality in land property rights, combined with the particularities of municipalities, 'make it impossible to assign price formation mechanisms within a traditional market'[45].

Another component that the survey application within this sample population highlighted is access to a personal vehicle as a mobility and connectivity element between rural and urban areas, resulting in 69% of the population not owning a vehicle, either a car or a motorcycle. Consequently, there is a high percentage of people for whom the construction of a 4G road does not imply any change in how they travel or connect with nearby population centers, becoming an obstacle and promoting segregation processes due to the lack of pedestrian infrastructure accompanying the road project design.

Concessioned urban highways constitute a new form of segregation because 'despite the governmental urban agenda considering toll urban highways as modernizations that will increase city connectivity, analysis indicates they intensify the socio-spatial segregation of the affected area'[46].

The survey shows that only 25% use this road corridor daily, and 40% are dissatisfied with the way it was designed and built because it segregates neighborhoods and hinders the interaction of integral urban space[47]. The goal of integrating the entire population through the development of efficient road infrastructure demonstrates that, almost 150 years after the proposal of the general theory of urbanization, the idea of

[43] Blandón López, Alexander., González Rubio, J., & Pedraza Vega, G. (2018). *¿significa la doble calzada Bogotá – Girardot – Ibagué – Cajamarca la redención o el ocaso de los municipios tolimenses de área de influencia del corredor vial?* (1st ed., Vol. 1).
[44] Cosci, S., & Mirra, L. Ibidem (2018).
[45] Muñoz-Mora, J. C., & Jaramillo-Cardona, H. (2013). El precio de la tierra: estado del arte de las metodologías de valoración de predios rurales y su aplicación en Colombia. *Suma de Negocios*, *4*(1), 21–31.
[46] Greene, M., & Mora, R. "Las autopistas urbanas concesionadas: Una nueva forma de segregación". *ARQ (Santiago)*, *60*, (2005), 56–58.
[47] Bannen et al. Ibidem, (2022).

the street as a dual space promoting social exchange is increasingly difficult to achieve[48].

In social cartography, there is a negative connotation regarding the outcomes of participatory experiences in Colombia concerning the implementation processes of road infrastructure, leading to multiple conflicts because concessionaires perceive the community as an obstacle hindering the fulfillment of contractual deadlines for execution. Consequently, these processes are deemed 'unnecessary for projects mostly already designed and ready to be implemented in unknown contexts'[49].

In cities like Bogotá, Medellín, Pasto, and Pereira, participatory methodologies have been implemented, resulting in positive effects in consolidating infrastructure projects through comprehensive community planning and the construction of inclusive territories using social cartography[50].

CONCLUSIONS

Infrastructure projects contribute to development, but during their structuring, they often overlook the territory as a social construction and become products of a commercial relationship between the state and particular economic interests. It is evident that the national government has restructured the institutions responsible for executing projects and territorial planning designs, but this does not transcend to solving the problems of its inhabitants; rather, it serves the particular interests of those managing these development models from positions of power.

The influence of implementing road infrastructure on territory occupation models, environmental impacts, urban expansion incentives, changes in economic and social dynamics, and the political-administrative intervention processes supporting these changes were observed. Physical and geographical changes in its organization are

[48] Greene, M., & Mora, R. "Las autopistas urbanas concesionadas: Una nueva forma de segregación". *ARQ (Santiago)*, *60*, (2005), 56–58.
[49] Martin Silva, V. B., Zabala, M. E., & Fabra, M. "Cartografía social como recurso metodológico para el análisis patrimonial. Experiencias de mapeo en Miramar (Córdoba, Argentina)". *Perspectiva Geográfica*, *24*(2), (2019), pp. 125–148.
[50] Martin Silva et al. Ibidem, (2019)

evident, defining a shift in territory, land use, increased densification, land tenure, and increased real estate speculation due to land use.

The infrastructure project evidently boosts the economy of Guamo municipality and connects it with the national goods system. However, the developmental rush affects natural wealth components, both through omission and by encouraging the colonization of its edges through new high-density settlements.

There is no adequate land control to calculate the capacity for urban expansion within the permitted limits, which highlights the land conditions in subdivisions or lots and their impact on the ecosystem structure, both in urban and rural areas. The disconnect from the edges of infrastructure, the generation of benefits for the wealthiest, and local administrative ineffectiveness are evident. It is crucial to review what pertains to infrastructure as primarily a national investment and what responsibilities local administrations have as a matter of social responsibility.

Regarding licenses that have compensation obligations, no compliance records were observed, suggesting a significant challenge for monitoring and oversight from the National Environmental Licensing Authority (ANLA), the Cortolima Autonomous Regional Corporation, the concessionaire, and local administrative entities, which establish conservation agreements involving direct payments between the license beneficiary and the landowner, without clarity on protection, conservation characteristics, and their implementation.

In light of these findings, it becomes imperative to strengthen local capacities so that municipalities can effectively anticipate, regulate, and channel the impacts generated by large-scale infrastructure projects. This requires consolidating technical, administrative, and participatory tools that allow local governments to exercise genuine territorial governance rather than functioning merely as passive recipients of national-level decisions. Achieving this also demands a clear articulation between local territorial planning instruments and national infrastructure initiatives, ensuring that planning advances coherently across scales and that local visions meaningfully shape the development agenda.

Central to this articulation is the establishment of a unified territorial planning structure that convenes municipal entities and aligns their decisions with national investments. Such a structure must be grounded in an environmental and hydric protection–based approach to territorial ordering, ensuring that ecological networks, water systems, and environmental services serve as the backbone of development decisions. This would enable municipalities to better mitigate negative externalities — such as uncontrolled urban expansion, ecosystem fragmentation, and real estate speculation— while fostering models of growth that reinforce ecological resilience and long-term wellbeing.

Moreover, the findings highlight the need to implement strategic actions that transform infrastructure corridors into platforms for equitable and sustainable regional development. Strengthening interinstitutional coordination among national authorities, regional environmental agencies, concessionaires, and municipal administrations is essential to ensure compliance with environmental compensation obligations and to develop transparent, verifiable conservation mechanisms. By aligning territorial planning instruments and adopting environmental protection as a structuring principle, infrastructure projects can shift from isolated, commercially driven interventions to catalysts for balanced economic growth and environmental stewardship.

The study underscores that community participation is essential for shaping a more inclusive and context-sensitive territorial model. The research process verified the willingness of diverse social and economic groups to participate actively in envisioning a new territorial future, demonstrating a collective interest in moving beyond top-down directives that traditionally guide national infrastructure interventions. This broad availability for engagement reveals the potential to construct a shared, democratically legitimized vision of territorial ordering: one that incorporates local knowledge, responds to heterogeneous needs, and strengthens the co-production of decisions that will define the territory in the long term.

In this context, a viable and immediate strategy to mitigate the adverse effects currently generated by the infrastructure project is the conciliation of a new characterization of urban expansion soils, aimed at ensuring the protection of the ecosystems connected to the road corridor. Reassessing these soils through updated environmental, hydric, and territorial criteria would allow the municipality to redefine the limits of expansion, restrict speculative urbanization, and establish conservation buffers that safeguard ecological connectivity. This approach provides a concrete and technically grounded pathway to align development dynamics with ecosystem preservation, reducing pressures on sensitive areas while reinforcing responsible territorial governance.

Such a strategy could be implemented in the short term through an adjustment to the municipal land-use planning scheme, representing both an institutional opportunity and a social mechanism to mobilize collective action. By incorporating this revision into the territorial planning framework, the municipality would not only respond to the urgent environmental challenges posed by the infrastructure project but also offer an exemplary case of popular participation in the defense of the territory. This process—anchored in community involvement, environmental responsibility, and administrative feasibility—demonstrates how locally driven planning adjustments can become powerful tools for protecting ecosystems, strengthening democratic legitimacy, and promoting a vision of development rooted in territorial justice.

References

Bannen-Lanata, P., Rosas-Vera, J., Hidalgo-Hermosilla, G., & Strabucchi-Chambers, W. "La ocasión de imaginar un nuevo paisaje cultural para la modernización de una ciudad capital: Una relectura del Plan de Transformación de Santiago de Chile por Vicuña Mackenna (1872-1875)". Identidades: Territorio, Cultura, Patrimonio, 11, (2022), pp. 236–263. https://doi.org/10.5821/ID.12021

Barragan, Giraldo, Diego Fernando & Amador J. "La cartografía social- pedagógica: una oportunidad para producir conocimiento y repensar la educación". Revista Colombiana

De Educación, (70), (2014), *pp.* 247.285. *https://revistas.pedagogica.edu.co/index.php/RCE/article/view/3772*

Blandón López, Alexander., González Rubio, J., & Pedraza Vega, G. ¿significa la doble calzada Bogotá – Girardot – Ibagué – Cajamarca la redención o el ocaso de los municipios tolimenses de área de influencia del corredor vial? Ibagué: Sello Editorial Universidad del Tolima, (2018). *https://repository.ut.edu.co/handle/001/2882*

Concejo Municipal del Guamo - Tolima. Acuerdo N 014 de 2022 Revision y Ajuste Pbot Guamo Tolima, (2022, *September* 30). *https://es.scribd.com/document/624879563/14295-acuerdo-n-014-de-2022-revision-y-ajuste-pbot-guamo-tolima*

Congreso de Colombia. Ley 388 de 1997. Diario Oficial No. 43.091, *24 de julio* (1997). *https://www.funcionpublica.gov.co/eva/gestornormativo/norma.php?i=339*

Cosci, S., & Mirra, L. A spatial analysis of growth and convergence in Italian provinces: the role of road infrastructure. Regional Studies, 52(4), (2018), *pp.* 516–527. *https://doi.org/10.1080/00343404.2017.1334117*

Departamento Administrativo Nacional de Estadística DANE. *Proyecciones de población*, (2018). *https://www.dane.gov.co/index.php/estadisticas-por-tema/demografia-y-poblacion/proyecciones-de-poblacion*

Departamento Nacional de Planeación DNP. *Plan nacional de desarrollo* 2014-2018, (2014). *https://colaboracion.dnp.gov.co/cdt/pnd/pnd%202014-2018%20tomo%201%20internet.pdf*

Departamento Nacional de Planeación DNP. *Plan Nacional de Desarrollo* 2022-2026, (2023). *https://colaboracion.dnp.gov.co/CDT/portalDNP/PND-2023/2023-03-17-bases-plan-nacional-desarrollo-web.pdf*

Flores-Rangel, J. A. "Infraestructura carretera: construcción, financiamiento y resistencia en México y América Latina". Revista Transporte y Territorio (13), (2015), *pp.* 122-148. *https://www.redalyc.org/articulo.oa?id=333042522007*

González, Alba & Solorza, Jairo. Región Administrativa y de Planeación Especial, Región Central (RAPE-RC). Revista Ciudades, Estados y Política. 3 (3), (2016), *pp.* 122-148. *https://revistas.unal.edu.co/index.php/revcep/article/view/57329/59725*

Granados, Rebeca & Villaseñor, Alma. "Entorno a la problemática del recurso agua ante los megaproyectos de transporte. Estudio de caso Zona Metropolitana de la Ciudad de Querétaro". Boletín de La Sociedad Geológica Mexicana, 59(2), (2007), *pp.* 163-169. *https://www.scielo.org.mx/scielo.php?pid=S1405-33222007000200163&script=sci_arttext*

Greene, Margarita & Mora, Rodrigo. "Las autopistas urbanas concesionadas: Una nueva forma de segregación". ARQ (Santiago), 60, (2005), pp. 56–58. https://doi.org/10.4067/S0717-69962005006000009

Guderson, Lance & Holling C.S. Panarchy: Understanding Transformations in Human and Natural Systems. Island Press, (2022). https://saras-institute.org/wp-content/uploads/2019/06/SARASConceptos-CiclosAdaptativos-ES.pdf

Hernández Sampieri, R., Fernandez R, & L Baptista. Metodología de la investigación. McGraw-Hill / Interamericana editores, S.A., México (2014). https://apiperiodico.jalisco.gob.mx/api/sites/periodicooficial.jalisco.gob.mx/files/metodologia_de_la_investigacion_-_roberto_hernandez_sampieri.pdf

Manrique-Bautista, J. A., Jiménez-Serpa, J. C., & Salas-Rondón, M. H. "Accesibilidad: elemento fundamental para la ejecución de infraestructura de transporte". Infraestructura Vial, 21(37), (2019), pp. 1–11. https://doi.org/10.15517/IV.V21I37.32884

Martin Silva, V. B., Zabala, M. E., & Fabra, M. "Cartografía social como recurso metodológico para el análisis patrimonial. Experiencias de mapeo en Miramar (Córdoba, Argentina)". Perspectiva Geográfica, 24(2), (2019), pp. 125–148. https://revistas.uptc.edu.co/index.php/perspectiva/article/view/8631/8372

Maya-Velásco, L. M. Transformaciones urbanas en pequeños centros poblados a partir de los proyectos de infraestructura vial 4G concesionados, estudio de caso pavas - Valle del cauca. Universidad Piloto de Colombia, (2017). http://repository.unipiloto.edu.co/handle/20.500.12277/3298

Montoya Arango, V., García Sánchez, A., & Ospina Mesa, C. A. "Andar dibujando y dibujar andando: cartografía social y producción colectiva de conocimientos". Nómadas, (40), (2014), pp. 191-205. http://www.scielo.org.co/scielo.php?pid=s0121-75502014000100013&script=sci_arttext

Moreno-Parra, I. "Paradoja de los megaproyectos y gestión presupuestaria vial en Ecuador 2002-20062". Infraestructura Vial, 25(44), (2023), pp. 57–74. https://doi.org/10.15517/IV.V25I44.55544

Muñoz-Mora, J. C., & Jaramillo-Cardona, H. El precio de la tierra: estado del arte de las metodologías de valoración de predios rurales y su aplicación en Colombia. Suma de Negocios, 4(1), (2013), pp. 21–31. https://www.redalyc.org/journal/6099/609966988002/html/

Ordoñez-Cetina, K. S., & Parra-Velandia, V. J. Infraestructura de transporte vial: un factor de atraso para la competitividad de Colombia en la Alianza Pacífico. Universidad de La Salle. Facultad de Economía, Empresa y Desarrollo Sostenible – FEEDS, (2017). https://ciencia.lasalle.edu.co/server/api/core/bitstreams/f8bc3d2d-a17b-41db-83b8-00b5ea1e5529/content

Prieto-Barboza, E. A. "Resiliencia y panarquía: claves para enfrentar la adversidad en sistemas sociales". MULTICIENCIAS, 13, (2013), pp. 23–29. https://www.redalyc.org/pdf/904/90428348007.pdf

Ministerio de Ambiente y Desarrollo Sostenible. Resolución 1517. Por la cual se adopta el manual para la asignación de compensaciones por pérdida de biodiversidad, (2012). https://share.google/2unB74Km518wMDMP1

Reyes-Guarnizo, A. B. "Comprensión del territorio para la construcción de apropiación e identidad en el municipio de Soacha". Revista de Arquitectura (Bogotá), 22(1), (2020), pp. 44–57. https://doi.org/10.14718/REVARQ.2020.2651

Rojas-López, M.D., & Ramírez-Muriel, A.F. "Investment in Road Infrastructure and Its Impact on the Economic Development: An Analysis Approach to the Infrastructure Case in Colombia (1993-2014)". Revista Ingenierías Universidad De Medellín, 17(32), (2018), pp. 109-128. https://doi.org/10.22395/rium.v17n32a6

Santos, T., & Tellería, J. L. "Pérdida y fragmentación del hábitat: efecto sobre la conservación de las especies". Ecosistemas, 15(2), (2006), pp. 3-12. https://www.revistaecosistemas.net/index.php/ecosistemas/article/view/180

Sarmiento, Mariana; Cardona, William; Victurine, Ray; López, Alexis; Carneiro, Andrea; Franco, Padu & Jiménez, Marcela. Orientaciones para el Diseño de un Plan de Compensaciones por Pérdida de Biodiversidad. Fundepúblico (2015). https://colombia.wcs.org/Portals/113/Orientaciones%20para%20Plan%20de%20Compensaciones%20V1.0.pdf

Uribe-Lotero, C., Donoso-Figueiredo, D., & Ramírez, A. "De la cartografía social a la comprensión de los contextos socioeducativos". Aletheia. Revista de Desarrollo Humano, Educativo y Social Contemporáneo, 9(2), (2017), pp. 74–93. http://www.scielo.org.co/scielo.php?pid=S2145-03662017000200074&script=sci_arttext

Análisis de la influencia de la infraestructura vial en los patrones de ocupación del suelo. El Guamo, Colombia (2013-2024)

Resumen

Durante los últimos 15 años, se ha fortalecido el desarrollo de infraestructura vial que conecta los principales puertos con el interior del país, mejorando la accesibilidad y el intercambio comercial con mercados internacionales. En este contexto, este artículo analiza las acciones derivadas de la implementación de la doble calzada que conecta los municipios de Girardot y Neiva entre los años 2013 y 2024, con énfasis en el sector Guamo–Tolima. El objetivo es identificar las capacidades locales para mitigar los efectos negativos y aprovechar las oportunidades que generan este tipo de proyectos. Para ello, se inicia con un análisis histórico de la implementación de las vías de cuarta generación y de los procesos de desarrollo urbano y gentrificación asociados a estas intervenciones en Colombia. Esto incluye información del contexto regional previo a la finalización de la doble calzada y una evaluación posterior a su puesta en funcionamiento, con el fin de plantear preguntas y soluciones sobre los procesos de integración regional y el desarrollo económico, social y ambiental.

Palabras clave: Acción antrópica; infraestructura vial; corredor suburbano; desarrollo urbano; geografía urbana

Received: 06/03/2025
Approved: 09/12/2025