Incidence of the Routes of the Public Transport System, Road and Pedestrian Infrastructure in Commune 10 in the Municipality of San Juan De Pasto - Nariño, Colombia

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Abstract

This article analyzes the impact of public transport system routes, road and pedestrian infrastructure on the accessibility of commune 10 of San Juan de Pasto, Nariño, Colombia. Through a geospatial approach and using quantitative data from the Geographic Information System (GIS), critical areas were identified in terms of accessibility and urban connectivity. The study evaluated the road infrastructure according to its degree of intervention, classified the platforms by their width and analyzed the public transport routes according to their frequency and coverage. The results reveal that more than 75% of the areas evaluated present critical conditions in road infrastructure, while more than 90% of the areas do not have adequate platforms to guarantee pedestrian accessibility. In addition, it was determined that more than 52% of the commune lacks access to public transport routes with sufficient frequencies. These deficiencies show inequalities in mobility that significantly affect the quality of life of the inhabitants. It is concluded that it is urgent to implement public policies aimed at strategic planning, prioritizing investments in road and pedestrian infrastructure, and optimizing the frequency and coverage of public transport. This study provides key tools for decision-making, facilitating the design of strategies that promote equity, sustainability and connectivity in intermediate urban contexts.

Keywords: Urban mobility, road infrastructure, public transport, geospatial analysis, GIS, sustainability, equity, intermediary cities.

Urban mobility has become an issue of increasing importance in Latin American cities, where demographic expansion and deficiencies in road infrastructure represent significant challenges for accessibility and sustainable development. San Juan de Pasto, capital of the department of Nariño, is no stranger to these problems. In particular, commune 10, located in the eastern corridor of the municipality of Pasto, is characterized by being home to 41 neighborhoods and being one of the largest recipients of displaced populations. This situation amplifies the difficulties related to the insufficient routes of the public transport system, as well as the lack of adequate road and pedestrian infrastructure, which limits the mobility of its inhabitants and negatively affects their quality of life.

Accessibility, understood from different academic perspectives, is a key concept to analyze this problem. Hansen (1959) defines it as the potential opportunities for interaction. Izquierdo and Mozón (1992) highlight that the structure and capacity of the transmission network directly affect the level of accessibility. Bath (2000) adds that it relates to the ease with which people can perform an activity in a land use, using a mode of transportation at a desired time. Geurs and Van Eck (2011) describe it as the ease with which people reach a land use by a transportation system, while Bertolini et al. (2005) emphasize the number and diversity of places achievable within a given travel cost. Finally, Rodríguez et al. (2009) highlight that accessibility implies the ability of a place to be reached or to connect different places through a transport system.

This study aims to analyze the impact of the routes of the public transport system, as well as the road and pedestrian infrastructure, on the accessibility of commune 10 of San Juan de Pasto. In addition, the Geographic Information System (GIS) will be used as a fundamental element to analyze the spatial distribution of transport routes, road infrastructure and its relationship with accessibility patterns in the commune.

The relevance of this work lies in its contribution to the understanding of local mobility problems in intermediate urban contexts such as Pasto, as well as in its potential to serve as a basis for the formulation of public policies aimed at improving accessibility and quality of life of its inhabitants. In the following sections, a review of the relevant literature, the methodology used, the findings of the study and the recommendations to overcome the limitations identified in commune 10 will be addressed.

General Objective

Analyze the impact of the routes of the public transport system, road and pedestrian infrastructure on the accessibility of commune 10 of San Juan de Pasto, using geospatial analysis tools to identify critical areas and propose improvement strategies that promote equity and sustainability in urban mobility.

Literature review

The literature review allows establishing a theoretical and contextual framework that supports the analysis of the impact of transport routes, road and pedestrian infrastructure on accessibility.

Urban mobility is defined as the ability of people to move around in a given geographical space, using various means of transport. Accessibility, as a component of mobility, is closely linked to the availability of opportunities, services and resources that can be reached efficiently. According to Geurs and Van Wee (2004), accessibility integrates four main dimensions: the transport component, the land use component, the temporal component, and the individual component.

Geurs and Van Wee (2004) propose a taxonomy that classifies accessibility measures into four categories: infrastructure-based, activity-based, human-based, and mixed-use. Scheurer and Curtis (2007) complement this classification by introducing spatial indicators that reflect the connectivity and efficiency of the transmission network. On the other hand, Bhat et al. (2000) highlight the importance of considering socioeconomic and cultural factors when assessing accessibility.

Relative accessibility refers to the comparison of the level of accessibility between different locations within a geographical area, while comprehensive accessibility considers the ability of a transport system to effectively connect all points within the network (Geurs & Van Wee, 2004).

Among the most commonly used accessibility indicators are:

Presence/absence: Assesses whether a resource or service is available in a given area.

Density indicator: Measures the amount of resources or services available per unit of area or per inhabitant.

Indicators based on travel times: They consider the temporal distance between origin and destination.

The quality of road and pedestrian infrastructure has a direct influence on accessibility. Jacobs (1993) points out that well-designed streets, with wide and safe sidewalks, encourage not only pedestrian mobility, but also the use of sustainable transport. In addition, studies conducted by UN-Habitat (2013) emphasize that adequate urban planning must prioritize the needs of pedestrians and vulnerable users, especially in densely populated urban contexts such as that of commune 10.

The Strategic Public Transport Systems (SETP) have been implemented in various intermediate cities in Colombia with the aim of optimizing urban mobility and promoting the use of public transport as the main means of transport. These systems are characterized by integrating trunk and complementary routes, adequate road infrastructure and centralized control systems. Studies carried out in cities such as Pereira and Armenia highlight how SETPs have improved the coverage and efficiency of public transport, reducing travel times and increasing user satisfaction (Pardo & Suárez, 2018).

In the Latin American context, cities such as Cuenca (Ecuador) and Arequipa (Peru) have implemented similar systems with positive results in accessibility and urban mobility, although facing challenges related to financing and user acceptance (Vasconcellos, 2019).

On a regional scale, research in Colombian cities such as Medellín and Bogotá has shown inequalities in the distribution of opportunities due to the disconnection between road infrastructure and public transport (López et al., 2018). At the national level, it has been identified that the lack of integration between transport systems limits urban competitiveness and affects social equity (Pardo & Gutiérrez, 2020).

In the context of Latin America, studies conducted in cities such as Mexico City and São Paulo highlight how deficiencies in public transport systems perpetuate socioeconomic inequalities (Vasconcellos, 2019). Finally, at the global level, research led by the OECD (2019) underlines the importance of sustainable transport systems to improve the quality of life in medium- and large-scale cities.

The use of Geographic Information Systems (GIS) has established itself as an indispensable tool for the analysis of spatial patterns in urban transport. According to Goodchild (2007), GIS allows the integration of spatial and non-spatial data to identify areas for improvement in infrastructure and plan more efficient transport routes. In similar studies conducted in Colombian cities, GIS has facilitated the visualization of gaps in accessibility and the formulation of strategies to overcome them (López et al., 2019).

The reviewed literature establishes a solid basis for analyzing accessibility conditions in commune 10, highlighting the importance of integrating technical tools and inclusive approaches to address mobility challenges in complex urban contexts.

Methodology

The methodology of this study is based on the use of quantitative data extracted from the Geographic Information System (GIS) of the municipality of Pasto. This approach allows for a detailed spatial analysis that integrates georeferenced information on transport routes, road and pedestrian infrastructure, as well as other relevant elements to assess accessibility in commune 10.

A conceptual model is proposed which considers three main aspects that interact to determine the level of accessibility in commune 10:

1. Road infrastructure developed by Avante:

Type I: Total intervention (geometric design and pavement).

Type II: Partial intervention (pavement only).

No intervention.

2. Platforms: Classified according to their width:

Platforms with a width greater than 4 meters.

Platforms 2.4 meters wide.

Platforms 0.2 meters wide.

3. Transport routes of the public system: Classified according to frequency:

Less than or equal to 6 minutes.

Between 6 and 10 minutes.

Greater than 10 minutes.

The study area corresponds to commune 10, delimited according to the administrative information of the municipality. Georeferenced data includes:

Geodata Folder: With shapes cut out for commune 10 that contain information on roads, transport routes, urban facilities and public spaces.

Indicators: Quantitative data obtained from the municipality's GIS to analyze accessibility and mobility patterns.

Main indicators

Road connectivity: Measures the density and efficiency of the road network.

Accessibility to public transport: Assesses the coverage of transport routes and stops.

Proximity to facilities: Calculates the average distance between homes and key services.

Quality of pedestrian infrastructure: Analyzes the state of sidewalks and pedestrian crossings.

Availability of public space: Quantifies the proportion of open spaces available per inhabitant.

Data analysis

The analysis will be carried out using GIS tools to generate thematic maps and graphs that visualize the spatial patterns of the variables considered. The results will allow identifying priority areas for interventions in commune 10, as well as evaluating the relationship between the components of the conceptual model.

This methodological approach ensures a rigorous and data-driven analysis that will contribute to the development of comprehensive strategies to improve accessibility in commune 10.

Results

5.1. Collection of Information

Commune 10 is located in the Eastern Corridor of the municipality of Pasto has 41 neighborhoods, It is characterized by being one of the largest recipients of population in a situation of displacement, the location is presented in the municipality of Pasto.

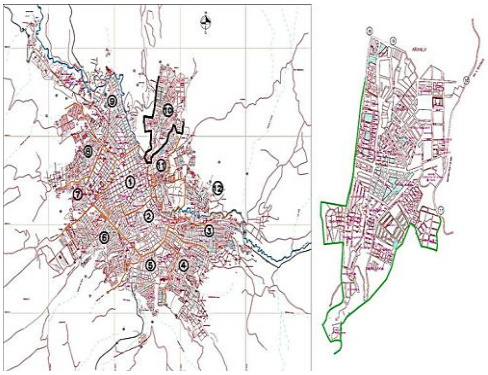
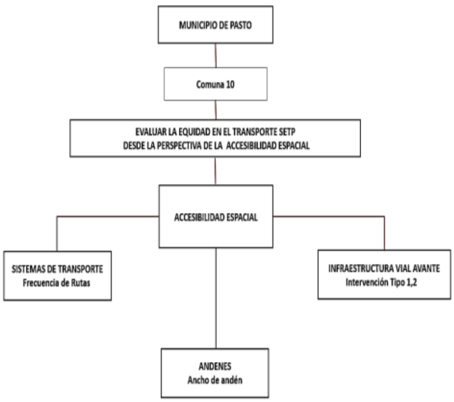


Figure 1. Location commune 10 in the city of Pasto. Source: this study

Information is organized through the conceptualization of the indicators

CONCEPTUALIZACIÓN DE INDICADORES							
INDICADOR	CRITERIO		CALIFICACIÓN INDICADOR				VARIABLE
		Shape	CRÍTICO	REGULAR	ÓPTIMO		
Infraestrutura Vial Avante	Se efectuaron acondionamientos e intervenciones que faciliten la	Infraestrutura Avante	Ninguna intervencion	Tipo 2. Intervencion Parcial	Tipo 1. Intervencion Total		Intervención Tipo
Andenes	Ancho de andenes existentes que faciliten la accesibilidad	Ancho de vias	Andenes 0.2 m	Andenes 2.4 m	Andenes ancho ≥ 4 m		Ancho de anden
Sistema de transporte Publico Buses	Frecuencias de las rutas existentes aporten a la accesibilidad	Rutas Transporte Publico	Frecuencia > 10 minutos	6 < Frecuencia ≤ 10 minutos	Frecuencia ≤ 6 minutos		Frecuencia de rutas

The conceptual model is approached, which is presented in the following diagram



For the logical model, the characteristics of each entity are defined, which are summarized below,

ENTIDAD:	INFRAESTRUCTURA VIAL AVANTE		
NOMBRE	ID_OBJECT	INFRAEXTRU	LONGITUD
TIPO	number	Texto	number
LONGITUD MAXIMA	2	30	20
UNICIDAD	no único	no único	no único
OBLIGATORIEDAD	No nulo	Nulo	Nulo
EJEMPLO	1	TIPO 1	8.7449

TIPO 1. Intervención Total, diseño geométrico y pavimento	Óptima
TIPO 2. Intervención Parcial, pavimento	Regular
Ninguna intervención	Crítica

ENTIDAD:	ANDENES			
NOMBRE	ID_OBJECT	TIPO DE ANCHO	ANCHO ANDEN	LONGITUD
TIPO	number	String	number	number
LONGITUD MAXIMA	2	254	5	10
UNICIDAD	no único	no único	no único	no único
OBLIGATORIEDAD	No nulo	Nulo	Nulo	Nulo
EJEMPLO	15	ancho de andenes mayores a 4	0.2	95

Ancho anden mayor a 4	Optima
Ancho anden 2.4	Regular
Ancho anden 0.20	Crítica

ENTIDAD:	RUTAS TRANSPORTE - SISTEMA DE TRANSPORTE PÚBLICO				
NOMBRE	ID_OBJECT	Nombre Ruta	TIPO DE RUTA	LONGITUD	FRECUENCIA
TIPO	number	Texto	String	number	number
LONGITUD MAXIMA	2	256	50	10	2
UNICIDAD	no único	no único	no único	no único	no único
OBLIGATORIEDAD	No nulo	Nulo	Nulo	Nulo	Nulo
EJEMPLO	20	COMPLEMENTARIA 08 - INICIO	COMPLEMENTARIA	8232	10

Frecuencia ≤ 6 minutos	Optima
6<Frecuencia ≤ 10 minutos	Regular
Frecuencia ≥ 10 minutos	Crítica

5.2. Results

5.2.1. Road Infrastructure

INDICADOR	CRITERIO		CALIFICACIÓN INDICADOR			VARIABLE
		Shape	CRÍTICO	REGULAR	ÓPTIMO	
Infraestrutura Vial Avante	Se efectuaron acondionamientos e intervenciones que faciliten la accesibilidad	Infraestrutura Avante	Ninguna intervencion	Tipo 2. Intervencion Parcial	Tipo 1. Intervencion Total	Intervención Tipo

Interventions

Conditioning carried out by AVANTE on the road infrastructure used by SETP

- Type 1 Intervention. Total Intervention
- Type 2 Intervention. Partial Intervention
- No intervention

Category in numbering and color

No intervention	Critical	1
Type 2 Partial Intervention	Regular	2
Type 1 Total Intervention	Optimal	3

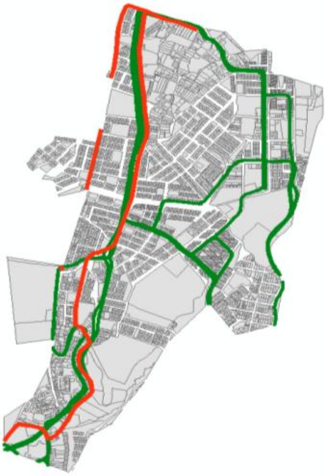


Figure 2 Public Transportation System Routes

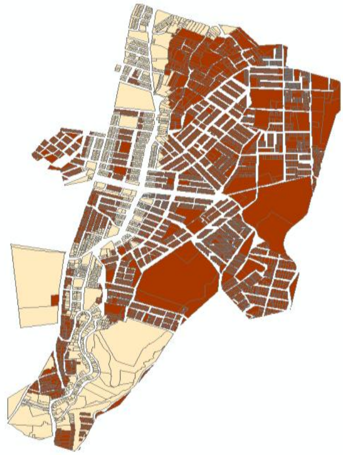


Figure 3 Public Transportation System Routes
Source: this study

Figure 3 presents the classification of the areas according to their level of influence after the road infrastructure interventions carried out by AVANTE, categorizing them as optimal, regular and critical. The results reveal that more than 75% of commune 10 corresponds to critical areas that do not benefit significantly from the existing routes, evidencing insufficient coverage in these areas

5.2.2. Platforms

INDICADOR	CRITERIO		CALIFICACIÓN INDICADOR			VARIABLE
		Shape	CRÍTICO	REGULAR	ÓPTIMO	
Andenes	Ancho de andenes existentes que faciliten la accesibilidad	Ancho de vias	Andenes 0.2 m	Andenes 2.4 m	Andenes ancho ≥ 4 m	Ancho de anden

The condition of existence of the Anden infrastructure is evaluated

Existence of platforms

- 0.2 m platforms
- 2.4 m platforms
- Andenes ≥ 4.0 m

Category in numbering and color

0.2 m platforms	Critical	
2.4 m platforms	Regular	2
Andenes ≥ 4.0 m	Optimal	3

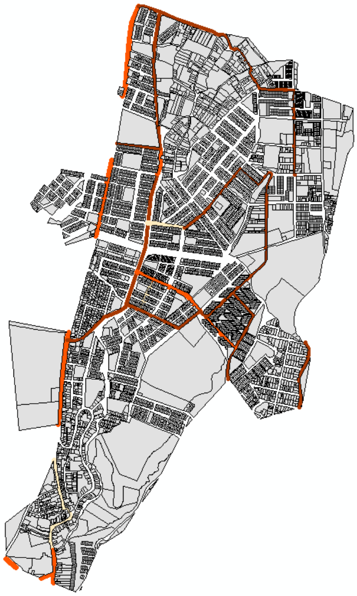


Figure 4 Public Transportation System Routes

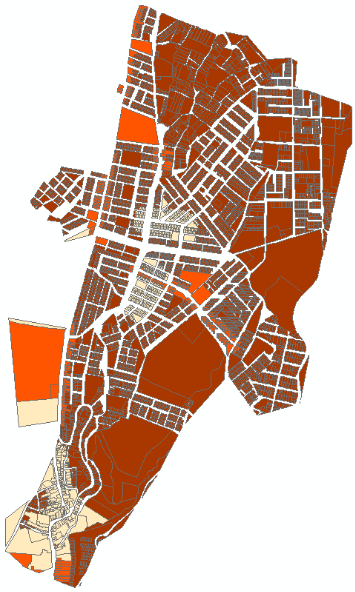


Figure 5 Public Transportation System Routes
Source: this study

Figure 5 presents the classification of the areas according to their level of influence of the existing platforms that facilitate accessibility, categorizing them as optimal, regular and critical. The results reveal that more than 90% of commune 10 corresponds to critical areas that do not have platforms of sufficient width to access and complement the existing public transport system.

5.2.3. Public Transportation System – Routes

INDICADOR	CRITERIO		CALIFICACIÓN INDICADOR			VARIABLE
		Shape	CRÍTICO	REGULAR	ÓPTIMO	
Sistema de transporte Publico Buses	Frecuencias de las rutas existentes aporten a la accesibilidad	Rutas Transporte Publico	Frecuencia > 10 minutos	6 < Frecuencia ≤ 10 minutos	Frecuencia ≤ 6 minutos	Frecuencia de rutas

The parameter that was taken is the frequency of the routes that provide the service to this commune, the frequencies of the existing complementary and strategic routes are taken

- Frequency ≤ 6 minutes
- 6 minutes < Frequency ≤ 10 minutes
- Frequency > 10 minutes

The category is presented in numbering and color

Frequency > 10 minutes	Critical	1	
6 m < Frequency ≤ 10 m	Regular	2	
Frequency ≤ 6 minutes	Optimal	3	

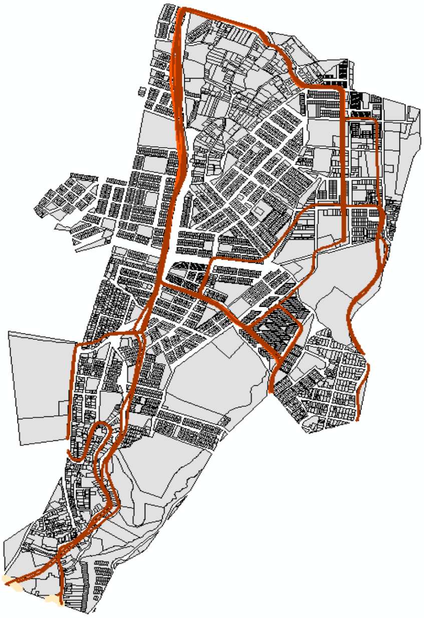


Figure 6 Public Transportation System Routes

Figure 7 Public transport system routes
Source: this study

Figure 7 presents the classification of the areas according to their level of influence of the frequencies of the existing routes that contribute to accessibility, categorizing them as optimal, regular and critical. The results reveal that more than 52% of commune 10 corresponds to critical areas that do not have access to the routes of the public transport system that provide their service in commune 10 of the city

Conclusions

The analysis of the road infrastructure interventions carried out by AVANTE shows an uneven coverage in the evaluated areas, highlighting that more than 75% of commune 10 faces critical conditions with limited access to existing routes. This result shows the need to rethink planning and execution strategies in road projects, prioritizing critical areas to ensure an equitable distribution of benefits and a comprehensive improvement in urban connectivity. In addition, it is suggested to implement continuous monitoring and evaluation mechanisms to optimize the effectiveness of future interventions.

The road infrastructure in commune 10 presents a significant deficit, especially in areas with type II and type III interventions, which limits connectivity and efficient mobility.

The analysis shows that more than 90% of commune 10 has critical conditions due to the lack of platforms with sufficient width to complement the public transport system. These findings underscore the need to prioritize the design and expansion of pedestrian infrastructure in the most affected areas, with the aim of improving accessibility and promoting the effective integration of different modes of transport. In addition, it is recommended to incorporate universal accessibility and sustainability criteria in future interventions, guaranteeing a positive impact on the mobility and quality of life of the inhabitants.

Public transport routes with frequencies of more than 10 minutes generate long waiting times, reducing the efficiency of the transport system.

The integration of the GIS made it possible to identify critical areas in terms of accessibility, evidencing areas with low road connectivity and deficient pedestrian infrastructure.

The analysis of the frequency and accessibility of the routes of the public transport system in commune 10 reveals that more than 52% of the classified areas present critical conditions, as they do not have adequate access to these routes. This result highlights the need to implement strategies that optimize the frequency and coverage of public transport, guaranteeing a more equitable and accessible service for all inhabitants. It also recommends the integration of data-driven planning tools to identify and prioritize the most affected areas, in order to improve connectivity and the quality of the urban transport system.

Public transport systems in intermediary cities, such as Pasto, require greater strategic planning to ensure sustainability and equity in urban mobility.

The lack of investment in road and pedestrian infrastructure perpetuates socioeconomic inequalities in commune 10.

The SETPs implemented in other intermediate cities offer models that could be adapted to improve public transport in Pasto.

The proximity to basic facilities is uneven in the commune, which negatively impacts the quality of life of its inhabitants.

Road connectivity is limited in peripheral sectors, which restricts opportunities for interaction and access to essential services.

The geospatial approach made it possible to generate thematic maps useful for urban planning and decision-making.

Public policies should prioritize intervention in areas with low accessibility to ensure an equitable distribution of resources and infrastructure.

The differences in the quality of the platforms reflect a lack of clear standards in the design and construction of pedestrian infrastructure.

The implementation of sustainable mobility strategies in Pasto could replicate the successes of other intermediary cities in Latin America.

Comprehensive accessibility should be considered as a key component in the planning of Pasto's urban development.

The findings of this study underscore the need for a multidimensional approach to address mobility issues in commune 10.

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