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ORIGINAL

Macrobus and urban mobility: challenges and achievements in the ZMG

Macrobús y movilidad urbana: retos y logros en la ZMG

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ABSTRACT

Introduction: urban mobility represented a priority challenge for the Guadalajara Metropolitan Area (ZMG), due to its accelerated territorial growth and intensive automobile use. The implementation of the Bus Rapid Transit (BRT) system, known as Macrobús, emerged as a response to the need for efficient and sustainable public transportation, inspired by models such as Curitiba and Bogotá.
Development: the Government of Jalisco promoted the Macrobús during the period 2007-2012 as a low-cost alternative to the subway or light rail. The system was adapted to local conditions with exclusive lanes, prepaid stations and articulated units that reduced travel times and polluting emissions. The use of ultra-low sulfur diesel and automated fare collection improved efficiency. However, the model faced obstacles such as low urban density, politicization of technical decisions and limited citizen participation. Statistical analysis showed that, despite its benefits, BRT consolidation also depended on integration with other transport modes and coherent governance.
Conclusions: the BRT system positioned itself as a viable solution for the ZMG by offering concrete improvements in mobility, sustainability and accessibility. Although it did not completely replace other modes, it did represent a cost-efficient option adapted to local conditions. Its success, as in other Latin American cities, depended on comprehensive planning, political will and social acceptance. In short, the Macrobús strengthened the foundations for a more equitable and efficient transportation model in Guadalajara.

Keywords: Urban Mobility; Macrobus; Public Transportation; Sustainability; Guadalajara Metropolitan Area (ZMG).

RESUMEN

Introducción: la movilidad urbana representó un desafío prioritario para la Zona Metropolitana de Guadalajara (ZMG), debido a su crecimiento territorial acelerado y el uso intensivo del automóvil. La implementación del sistema Bus Rapid Transit (BRT), denominado Macrobús, surgió como respuesta ante la necesidad de un transporte público eficiente y sustentable, inspirado en modelos como Curitiba y Bogotá.
Desarrollo: el Gobierno de Jalisco promovió el Macrobús durante el periodo 2007-2012 como una alternativa de bajo costo frente al metro o tren ligero. El sistema se adaptó a las condiciones locales con carriles exclusivos, estaciones prepagadas y unidades articuladas que redujeron tiempos de traslado y emisiones contaminantes. El uso de diésel de ultra bajo azufre y la automatización del cobro mejoraron la eficiencia. No obstante, el modelo enfrentó obstáculos como la baja densidad urbana, la politización de decisiones técnicas y la escasa participación ciudadana. El análisis estadístico mostró que, a pesar de sus beneficios, la consolidación del BRT dependió también de la integración con otros modos de transporte y de una gobernanza coherente.

Conclusiones: el sistema BRT se posicionó como una solución viable para la ZMG al ofrecer mejoras concretas en movilidad, sustentabilidad y accesibilidad. Aunque no reemplazó completamente otros medios, sí representó una opción costo-eficiente adaptada a las condiciones locales. Su éxito, como en otras ciudades latinoamericanas, dependió de una planificación integral, voluntad política y aceptación social. En definitiva, el Macrobús fortaleció las bases para un modelo de transporte más equitativo y eficiente en Guadalajara.

Palabras clave: Movilidad Urbana; Macrobús; Transporte Público; Sustentabilidad; Zona Metropolitana de Guadalajara (ZMG).

INTRODUCTION

Urban mobility has become a determining factor in the quality of life of large city dwellers. In particular, the Guadalajara Metropolitan Area (GMA), as one of Mexico's most important urban agglomerations, has faced significant challenges for decades related to rapid growth, unorganized territorial expansion, and traffic congestion. With a population of over 8 million and urbanization that grew by more than 380 % between 1980 and 2010, the need for an efficient, safe, and sustainable transportation system has become urgent.

Against this backdrop, the Bus Rapid Transit (BRT) model has emerged as a viable alternative for improving urban connectivity without incurring the high infrastructure costs associated with underground or elevated rail systems. Inspired by successful cases such as Bogotá's Transmilenio or Curitiba's integrated system, BRT offers significant advantages in terms of energy efficiency, reduction of pollutant emissions, and better use of public space. In Guadalajara, the Macrobús system represents the most important attempt to adapt this solution to local needs.

However, the implementation of this type of system is not without challenges. The lack of comprehensive planning, scattered housing, and heavy dependence on private cars hinder the consolidation of a truly sustainable mobility model. Added to this is limited citizen participation in the design of public policies, as well as the politicization of technical decisions regarding transportation.

This paper analyzes the empirical background and structural conditions that led to the implementation of the BRT system in the ZMG, evaluating its benefits and limitations in comparison with other modes of mass transportation. Through statistical data, technical studies, and international experiences, it seeks to understand how public transportation can become a cornerstone of sustainable urban development. It also examines the social, economic, and environmental implications of this model, highlighting its potential role in reducing pollutant emissions, improving travel times, and ensuring equitable access to urban goods and services.

DEVELOPMENT

Empirical background of the BRT transport system

According to the Jalisco Institute of Statistical and Geographic Information (IIEG) for 2015, Jalisco was considered the fourth largest state economy in Mexico. According to data from the National Population Council[1] in 2017, the state has a total population of nearly 8,1 million inhabitants, of which approximately 61 % (4,9 million inhabitants) are concentrated in the Guadalajara Metropolitan Area (ZMG). This is the second most populated metropolitan area in our country.

Table 1. Projected total population of the ZMG, 2010-2017

Name of town	2010	2011	20	2013	20	2015	2016	2017
Guadalajara	1 512 805	1 501 869	1 497 534	1 497 570	1 500 821	1 506 359	1 513 499	1 521 740
Ixtlahuacán de los Membrillos	41 594	44 822	47 574	49 903	51 883	53 577	55 043	56 328
Juanacatlán	13 375	13 562	13 744	13 917	14 085	14 248	14 407	14 563
El Salto	140 007	144 176	147 903	151 245	154 294	157 116	159 761	162 270
Tlajomulco de Zúñiga	421 952	453 653	480 785	503 869	523 620	540 659	555 527	568 683
Tlaquepaque	615 838	622 498	629 659	637 003	644 491	652 057	659 655	667 257
Tonalá	484 789	495 610	505 628	514 874	523 542	531 751	539 594	547 146
Zapopan	1 259 117	1 275 352	1 291 883	1 308 208	1 324 360	1 340 283	1 355 938	1 371 300

According to the National Population Council[(1)], what is known as the ZMG2 is made up of the municipalities of Guadalajara, Ixtlahuacán de los Membrillos, Juanacatlán, El Salto, Tlajomulco de Zúñiga, Tlaquepaque, Tonalá, and Zapopan.[(2)]

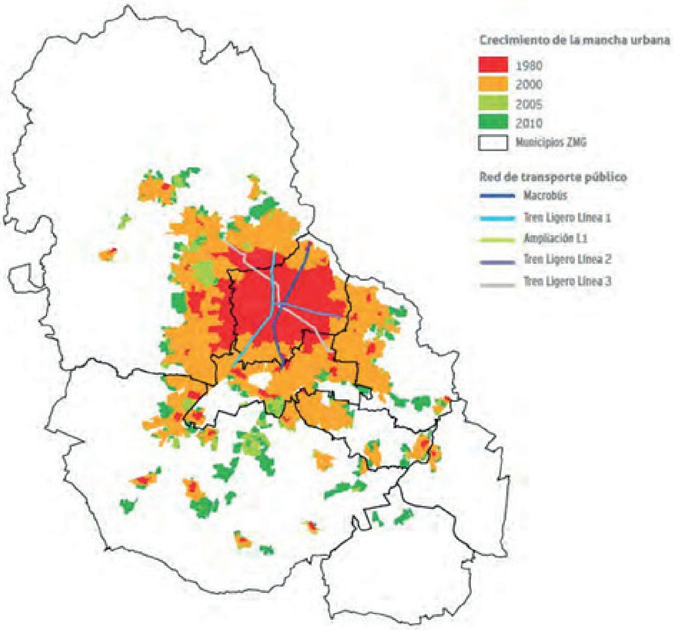

Figure 1. Guadalajara Metropolitan Area delimited by municipalities

According to SEDESOL projections urban sprawl in the ZMG between 1980 and 2010 was 381 %, increasing from 12 726 ha to 48 585 ha.

In this regard, various industrial, commercial, and cultural activities are carried out in the urban area of the ZMG, making this population center one of the most significant in the country. However, this phenomenon brings with it multiple mobility and sustainability problems, because the expansion has been far removed from the existing mass public transportation structure.

Clave	Municipio	Población			Tasa de crecimiento medio anual (%)		Superficie[1] (km²)	DMU (hab/ha)
		1990	2000	2010	1990-2000	2000-2010		
21. Zona metropolitana de Guadalajara		3 003 868	3 699 136	4 434 878	2.1	1.8	2 727.5	124.4
14039	Guadalajara	1 650 205	1 646 319	1 495 189	0.0	-0.9	151.2	149.5
14044	Ixtlahuacán de los Membrillos	16 674	21 605	41 060	2.6	6.4	201.8	60.6
14051	Juanacatlán	10 068	11 792	13 218	1.6	1.1	138.1	44.1
14070	El Salto	38 281	83 453	138 226	8.2	5.0	81.8	72.0
14097	Tlajomulco de Zúñiga	68 428	123 619	416 626	6.1	12.5	714.0	95.0
14098	Tlaquepaque	339 649	474 178	608 114	3.4	2.4	118.2	122.4
14101	Tonalá	168 555	337 149	478 689	7.2	3.5	166.3	127.9
14120	Zapopan	712 008	1 001 021	1 243 756	3.5	2.1	1 156.3	110.2

Figure 2. Population and spatial growth of Guadalajara 1990-2010

The data on surface area was obtained from the Municipal Geostatistical Areas (AGEM) of the 2010 National Geostatistical Framework. Average Urban Density: the surface area data used to calculate the AUD was obtained from the Basic Geostatistical Areas (AGEB) of the Urban Geostatistical Cartography of the 2010 Population and Housing Census. State and municipal boundaries were compiled from the INEGI geostatistical framework, which consists of the delimitation of the national territory into coded area units, called State Geostatistical Areas (AGEE) and Municipal Geostatistical Areas (AGEM), in order to reference statistical information from censuses and surveys. The boundaries adhere as closely as possible to political and administrative boundaries.

The mobility problems that have accumulated since the 1970s have not been overcome. Although it can be said that the Jalisco government has never neglected this area, its decisions have been overtaken by urban growth and, above all, the intensive use of cars (figure 3). In the first scenario, these trends generate what are known as urban mobility externalities, i.e., traffic congestion, high accident rates, environmental and noise pollution, and the deterioration of public spaces. In turn, urban mobility problems have also had a direct impact on a society's ability to access work, education, culture, and recreation, which are essential activities for promoting the comprehensive development of citizens.(3)

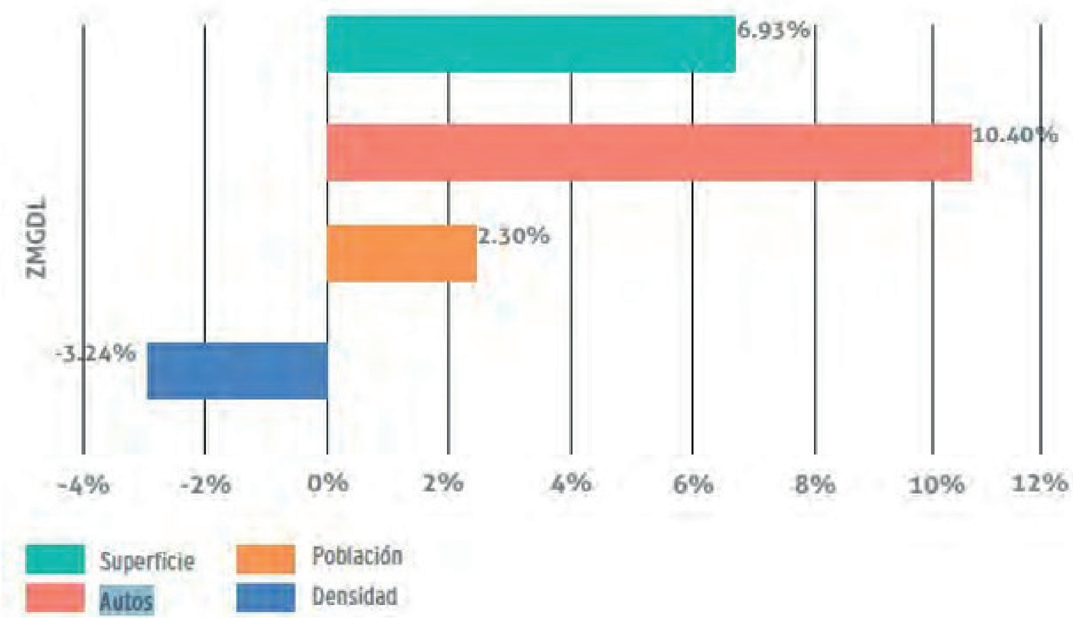

Figure 3. Average annual growth rate of land area, population density, cars, and population in the ZMG, 1990-2010 (percentages)

According to the Study of Multimodal Travel Demand in the ZMG there were 9 752 652 trips made daily and 3 042 719 inhabitants made trips, generating 2,48 trips per capita. In this regard, mobility in the ZMG in 2007 was as follows: 37,4 % of trips were made on foot, 28,3 % by public transport, 27,2 % by private transport, 2,2 % by bicycle, 1,1 % by staff transport, 0,9 % by taxi, 0,5 % by school transport, 0,5 % by motorcycle, and 1,7 % unspecified (figures 5 and 7).

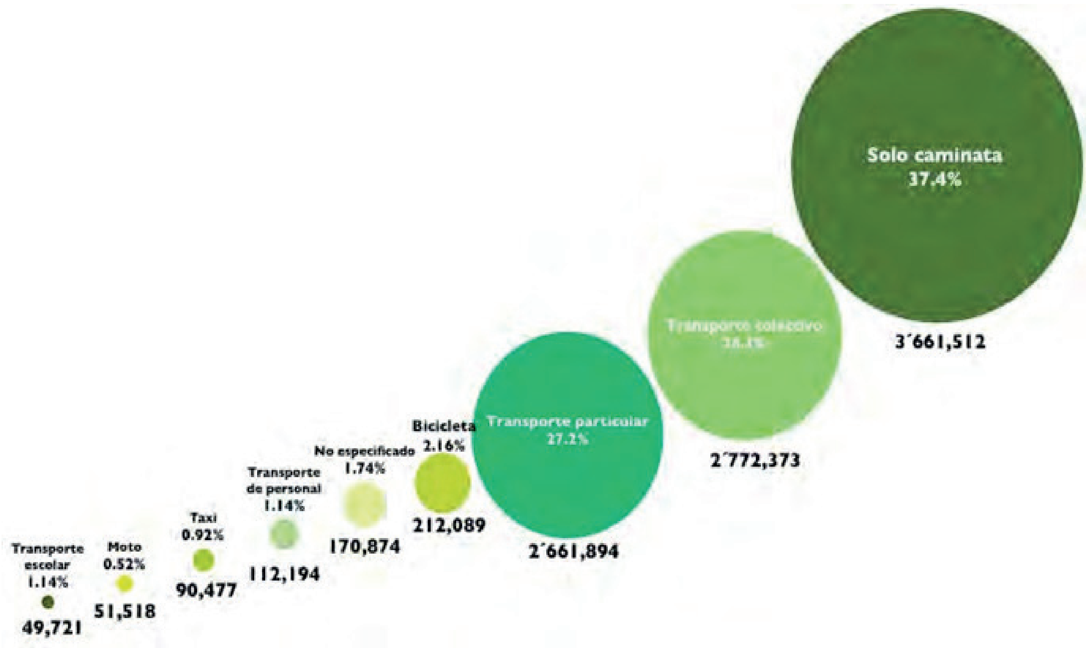

Figure 4. Modal distribution of people traveling in the ZMG

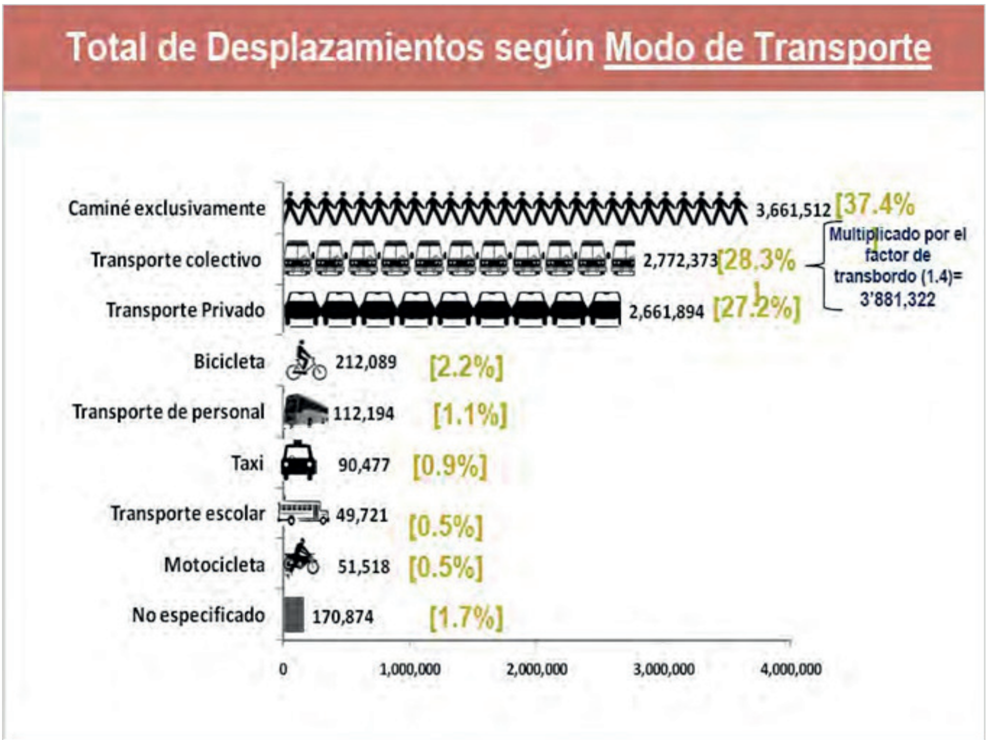

Figure 5. Total trips by mode of transport in the ZMG

Thus, in the EDMD conducted in 2007, residents of the ZMG stated that, given the possibility of choosing other forms of mobility, and provided that facilities for their use were available, BRT systems were the best option (figure 6).

Figure 6. Stated preferences regarding other forms of transport in the ZMG

However, by 2015, the INEGI intercensal survey showed that modal share in the ZMG had changed, with mass public transport now gaining ground. Private vehicles are the second most used means of transportation for commuting to work (32 % of trips) and the third most used for trips to school (21 % of trips), with public transportation or walking being more important (figure 7).

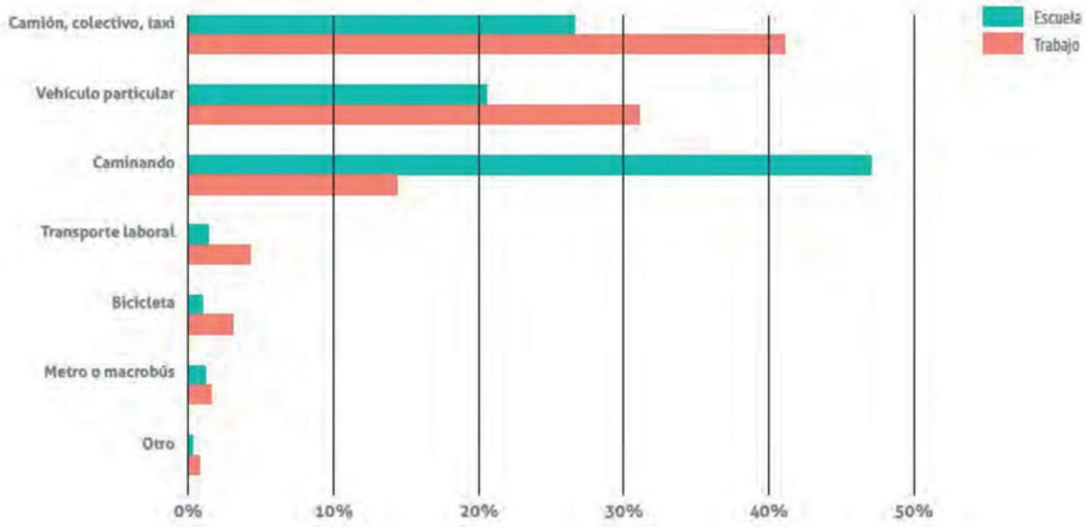

Figure 7. Trips to school and work, 2015. ITDP survey

To address mobility and accessibility challenges in the ZMG, the problems must be understood within a broad framework. Not only in terms of quantity, but also from human, social, economic, and environmental perspectives.(3)

It is clear that the city of Guadalajara suffers from the following problems: rapid and scattered urban growth, growth in the number of vehicles, frequent unacceptable pollution levels and significant damage to health in general; increased traffic and travel times, as well as longer travel distances; low population density; and a disjointed and obsolete transportation model (the “man-truck” model), which is currently being replaced by the route-company model in an attempt to take advantage of some of the management and efficiency benefits of BRT.

Currently, the issue of mass mobility systems, specifically public passenger transport, is politicized, creating an obstacle to planning. Likewise, in European cities such as Madrid and London, mass mobility has not only become an effective model for comprehensive transformation, but also an indispensable tool for public policies aimed at human and sustainable development. However, managing a new urban mobility model in a comprehensive and participatory manner also represents a challenge for citizens and their government.(3)

Therefore, to address this problem, the Jalisco State Government opted to implement urban mobility strategies with the following characteristics during the 2007-2012 period:

- Efficient, fast, and safe transportation.
- Technical basis and social participation.
- Multimodal, i.e., with links to other modes of transport.
- Inclusive.
- Urban renewal (pedestrianization, bike lanes, public spaces).
- Sustainable urban development.

Thus, given these characteristics, it is necessary to transform an existing transportation system into a new one without neglecting its physical, administrative, and economic aspects.

According to the “BRT System Planning Guide” developed in 2007 by the ITDP, Bus Rapid Transit is an innovative, high-capacity, low-cost solution that addresses urban mobility problems while providing the benefits of a rail-based system. Therefore, BRT is not superior in absolute terms to the metro or light rail, but it does have its own particular advantages.

In addition, BRT consists of the operation of articulated buses that are larger than the usual urban transport vehicles, which means they can carry more passengers (120 per unit).

Therefore, according to economist Guinés De Rus(4), each mode of transport is defined by the technologies and infrastructure it uses, as well as the very specific characteristics of the vehicles.

Based on the above, defining a public policy on mass mobility must take into account investment and passenger demand. Among the mass transportation options for the ZMG, the BRT system, Macrobús, offers the best cost-benefit ratio in terms of the relationship between the investment required and the number of passengers transported, under certain operating conditions. For example, the Macrobús system moves an expected maximum of 6000 trips per hour in each direction, according to the Guadalajara Macrobús System (https://es.slideshare.net/sibrt/sistema-macrob-guadalajara-jalisco).

According to the ITDP, the investment range for a BRT trunk line varies between US$2 million and US$15 million per kilometer (in Guadalajara, Line 1 of the Macrobús cost US$2,73 million in 2009). in this sense, the BRT system combines low infrastructure costs and a potentially significant volume of passenger transport, provided that it is properly designed.

With the above, we can say that financial viability and high demand for a BRT system business model are essential aspects to support its technical possibilities and legal measures, since its implementation depends on achieving the economic returns expected by the private sector and society.

In the case of light rail or tram systems, capital costs increase by between US$18 million and US$43 million per kilometer; however, the average number of passengers transported per hour in each direction is less than 20 000. Although a light rail or tram system is more expensive than the investment and operation of a BRT trunk line, this type of solution is suitable for coexistence with other modes of transport in very high-density urban areas or areas with pedestrian zones or historic centers. Conventional elevated train systems—not including Maglev, better known as magnetic levitation trains—have a capital cost ranging from $45 million to $80 million per kilometer, while the average number of passengers per hour per direction ranges from 20 000 to 80 000 passengers. Finally, metro or subway systems are designed to move large numbers of passengers, with ranges exceeding 100 000 passengers per hour per direction, which is essential for urban areas with very high population densities per square kilometer. However, the capital costs of these transportation solutions range from $60 million to $350 million per linear kilometer of infrastructure.

Based on the characteristics of each mode of mass transportation, it is difficult to compare them, as each one provides a different solution for each particular transportation problem. However, in the case of cities with low population density and low average passenger levels per hour per direction, such as Guadalajara, it would be disproportionate to implement a metro or underground transport system, as it has 1622 inhabitants per square kilometer in the metropolitan area and 7896 inhabitants per square kilometer in the urbanized area (figure 8).

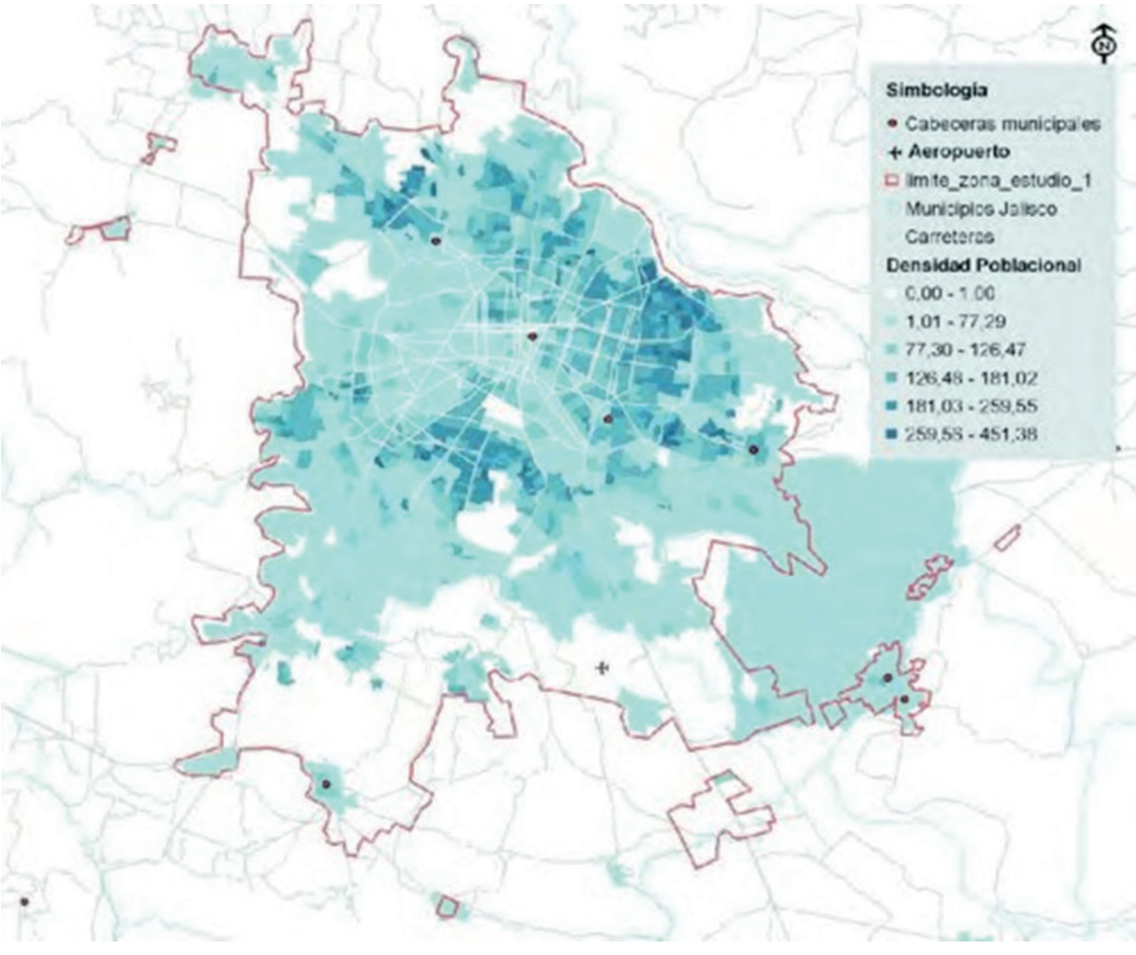

Figure 8. Population density of the ZMG for 2017

One kilometer of Metro infrastructure has an average cost of US$80 million, which could even finance the construction of up to 20 kilometers of a BRT solution, with an average cost of US$4 million per kilometer. This is despite the differences in capital costs for infrastructure between BRT and Metro.

Although there are other modes of mass transportation such as light rail, tram, metro, and elevated train, among others, De Rus[4] states that the implementation of a bus rapid transit (BRT) system has been proposed as the best option to solve carbon dioxide (CO2) emission problems due to the type of special diesel fuel they use.

In the context of global warming, Mexico has expressed its willingness to develop and encourage projects that promote a reduction in pollutant emissions, particularly CO2. Based on this vision for Jalisco, the state with the second largest metropolitan area in the country, it is important to promote these projects.

Table 2. Pollutant emissions from public transport vehicles in major cities, tons/day

Metropolitan areas	CO	HC	NOx	SO	PM	CO
Belo Horizonte	22,3	3,4	16,2	0,3	0,8	1901
Bogotá	52,7	8.	21,9	1,9	0,6	2425
Buenos Aires	61,2	9,5	44,4	0,8	2,3	5195
Caracas	138,8	20,1	13,9	1,5	0,4	1212
Mexico City	578,1	78,5	61,1	0,8	1,1	4198
Curitiba	10,1	1,6	7,3	0,1	0,4	859
Guadalajara	20,1	4,4	13,5	0,3	0,9	1418
León	5,7	1,2	3,8	0,1	0,2	403
Lima	57,6	3,6	36,6	9,3	2,5	4548
Montevideo	4,7	0,8	3,6	0,1	0,2	383
Porto Alegre	15,2	2,3	11,0	0,3	0,6	1312
Rio de Janeiro	103,5	20	47,6	1,3	2,5	5909
San José	3,4	0,6	2,6	0,1	0,1	274
Santiago	27,7	2,5	6,5	0,6	0,2	2314
São Paulo	53,8	7,4	39,8	4,1	2,2	5160
Total	1154,9	163,9	329,8	21,6	15	37513

Note: CO: carbon monoxide; HC: hydrocarbons; NOx: nitrogen oxide; SO2: sulfur oxide; PM: particulate matter; CO2: carbon dioxide.

Since its inception, the BRT system for the ZMG was designed to be sustainable, and part of this refers to the environmental advantages that a project of this nature offers.

A clear example of the environmental benefits is that before the Macrobús came into operation, 13 tons of CO2 were emitted per day on Calzada Independencia. Today, approximately 3 tons are emitted per day, as it uses ultra-low sulfur diesel (UBA) supplied by PEMEX. Currently, UBA diesel continues to be used by the Macrobús system.

In other parts of the world, BRT systems have shown very specific benefits. For example, in Bogotá, Colombia, the Transmilenio system had an impact on users by significantly improving the provision of transport services. Travel times decreased, service quality and efficiency increased, and in the corridors covered by the new system, both congestion and pollution fell dramatically.

A study mentions that when talking about opportunity costs, in this case, we are referring to the value of public transport users' time that could be used for activities other than travel, which is equivalent to saying that this analysis of opportunity cost is carried out from the perspective of the consumer/user of public transport. Cervini[5] defines this as the social value of time. In this sense, it is evident that a transport system that manages to reduce travel times for users will generate significant savings in their time, which translates directly into social benefits.

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Figure 9. Transmilenio Mass Transit System

In the particular case of the ZMG, the average speed of conventional public transport is 16 km/h, while the average speed of articulated units in the Macrobús system reaches an average of 23 km/h. This difference is mainly due to the following causes:

- The use of dedicated lanes for the BRT system, without having to share the road surface with private vehicles or freight and/or service vehicles.
- The condition of the BRT lane surface, which is therefore kept in better condition than the rest of the road surface, where conventional transport units currently operate alongside other vehicles.
- The stops established for the BRT project are every 450 meters, which, combined with a compensation scheme for operators that is not based on the number of passengers transported, discourages the uncontrolled stops experienced in traditional transport, resulting in what Molinero[6] and Moller[7] call the "penny war."

In the BRT project, fares are collected automatically and in advance, which reduces the time lost in this process, which is currently carried out by conventional transport operators. With the above, we conclude that there are precedents showing that a mass transport system can bring about changes in a city's urban mobility. The data in this chapter therefore provide a reference point for how the implementation, operation, and coordination of a BRT with other modes of transport can guide future government decisions.

Transport, city, and public space

At the end of the 18th century and beginning of the 19th century, Remy et al.[8] spoke of the urbanization process, which they defined as "the process through which mobility organizes daily life, which implies a possibility and capacity for movement and a valuation of mobility." Here, we can see that the concept of urban mobility is gaining strength. At that time, the first city to undergo the changes associated with the urbanization process was Paris, whose main characteristics were the large influx of pedestrians and the tranquility of its spaces, which gradually came to an end with the invasion of horse-drawn vehicles. One of the areas that underwent these changes was the boulevard, a place that served as a space for both public and private exchanges.

In figure 11, we can see how pedestrians cross a boulevard amid the chaos of horses and vehicles, and we can now see the similarity with modern traffic. The image shows that mobility was fast and unregulated, especially for pedestrians (reflected in the fact that the material used to build the roads was suitable for horses and carriages, but dirtied pedestrians, forcing them to walk through mud, dirt, and cobblestones). Faced with this, pedestrians entered a different reality, a space in which they had to move constantly and could not stand still. While the boulevard offered a more vibrant and exciting life than ever before, it was also more dangerous and frightening for those traveling on foot. Bielich[9] argues that humans had to prioritize movement by car.

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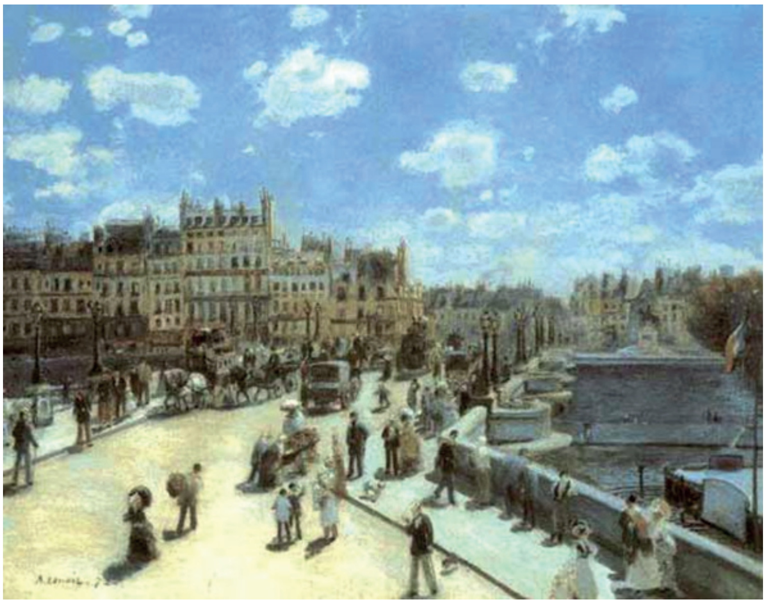

Figure 10. French society in the mid-19th century

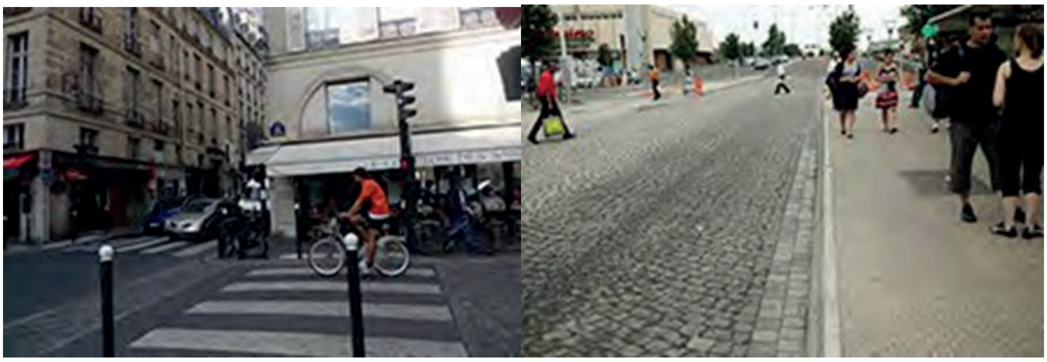

Figure 11. Pedestrian spaces in France

For Berman[10], the incipient traffic on streets and boulevards knows no spatial or temporal limits, flooding all urban spaces, imposing its rhythm on everyone's time, transforming the entire modern environment into "chaos in motion."

The statements by Berman, Bielich, and the poems of Baudelaire suggest that the construction of boulevards and streets led to a prioritization of travel in cities. Movement brought with it disorder and danger. This initially affected ordinary citizens. Urbanization favored drivers. Cities shifted from being pedestrian-focused to driver-focused.

Figure 12. BRT system in Paris, France

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Therefore, the car became the owner of the street. The man on the street, Berman argues, had to assimilate to the new situation and rejoin the ranks of the powerful by becoming the man in the car (Berman, 1989: 167). Berman finds that power lay with the man in the car. Therefore, urban planning needed "a new type of street that will be a 'traffic machine,' or, to vary the basic metaphor, a 'traffic factory'".(10) This is the highway, which separated and divided the city: "here the people, there the traffic; here the work, there the homes." To analyze the world of the highway, as he calls it, Berman focuses on the case of New York. In the early decades of the 20th century, there was an effervescence to build roads and develop, regardless of the consequences this would have for those who had to live in cities in interaction with the new infrastructure.(9)

Figure 13. Paris Metro, France

Figure 14. Map of the Paris Metro, France

Bielich(9) therefore considers that the development of cities is closely linked to the massive incorporation of means of transport into everyday life. Cities were reorganized to prioritize traffic flow. To this end, wide roads were built, the most important of which were highways, which facilitated rapid travel.

In the current era, called the "information age" the city is organized into nodes. Each node represents a focus of interest that is important to the network society, since it is through the nodes that the flows of information and knowledge that move the societies of the world immersed in this information network are transmitted. Thus, the city is organized into a network of nodes in which different flows are interconnected, giving rise to the space of flows. "Networks process flows. Flows are currents of information between nodes that circulate through the channels that connect the nodes".[11,12]

Roads are a product of the need for mobility that arises in modern cities. The relationship between cities and mobility is dialectical. Both variables influence each other: the distribution of land conditions the need for mobility, but mobility also influences the way in which cities are organized.[9]

Figure 15. Current BRT system in Paris, France

General background of urban mobility in Latin America
Paraná in Curitiba, Brazil

Figure 16. Curitiba Metropolitan Area, Brazil

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Mass transportation by rapid bus transit (BRT) began more than 40 years ago in Latin America. It started in Curitiba, Brazil, in 1966 with the approval of a master plan for the city that included a very special bus system: BRT, designed by Jaime Lerner, then mayor of the city.(13,14)

The case of Curitiba has a unique feature that makes it a model of urban transportation that has been replicated in many other parts of the world. In most cities, houses are built first and then bus routes are planned, and Guadalajara is no exception. In Curitiba, the city has been planned in such a way that the largest population concentrations are located on either side of the BRT lines. The same is true for commercial, work, and leisure areas. People do not have to travel to the other side of the city. "This allows the city to grow without major changes to its physical structure."(15,16,17)

The Curitiba experience was very successful, but it would have been difficult to achieve without the contribution of two important factors, the second of which was entirely fortuitous. If these two factors had not been present, mass bus transport would certainly have existed, but it would not have achieved the level of acceptance it has today. The first factor was political: architect Jaime Lerner, the driving force behind the system, was elected mayor of the city for three terms, which ensured strong continuity in the progressive development of the system.(18,19,20) The second factor was the 1973 oil crisis, which raised the price of oil to unimaginable heights and led the Brazilian military government to adopt drastic measures to reduce dependence on imported oil. The most important of these was the program to produce sugarcane-based alcohol as fuel for automobiles, but mass transportation by bus was also part of the response to the crisis. In this regard, it is significant that the then de facto president, General Ernesto Geisel, accompanied Jaime Lerner at the inauguration of the pioneering Bus Rapid Transit (BRT) system in Curitiba.(21,22,23,24)

In the city of Guadalajara, the BRT system transformed the Calzada Independencia corridor, and it is the system itself that has to adapt to the city, unlike in Curitiba.

Figure 17. BRT Mass Transit System in Curitiba, Brazil

Figure 18. Segregated lanes of the BRT Mass Transit System in Curitiba, Brazil

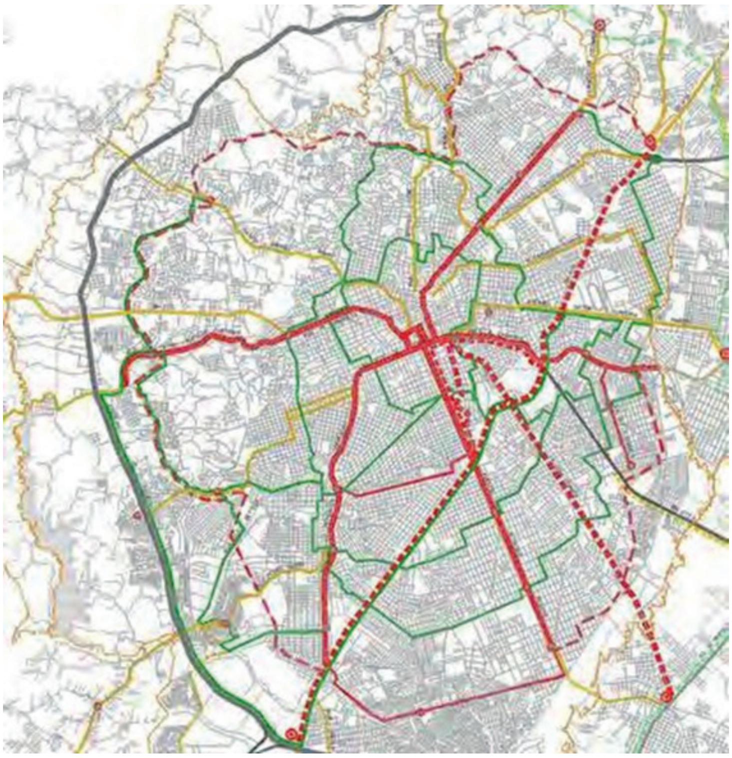

Figure 19. Integrated Transport Network (RIT) in Curitiba, Brazil

Transmilenio in Bogotá, Colombia

Construction began in 1998, during the mayoralty of Enrique Peñalosa, and it was inaugurated on December 4, 2000, entering into operation on the 18th of the same month. Both the Transmilenio in Bogotá and the Macrobús in Guadalajara were designed based on the Brazilian experience. Although Peñalosa's term lasted only three years, it was enough for him to cut the ribbon on the first section before leaving office. Transmilenio was part of Peñalosa's plan to humanize the Colombian capital. In the long term, the idea was for the Transmilenio network to cover the entire city. Although the publicity it has received may exceed the actual scope of its undoubted benefits, the truth is that it has been successful and has been supported by Peñalosa's successor, Antanas Mockus. In the case of the Guadalajara Macrobús, the idea was also to create a network covering the entire city, but now line three of the light rail system is under construction.

The first step in the Transmilenio project was the Troncal Caracas, with two lanes in each direction, operated in a disorderly manner. Then, under Peñalosa and Mockus, the infrastructure was rebuilt and the route network redesigned. The trunk lines were put out to tender, a modern fare payment system was installed, and interchange stations were built to connect these lines with local bus services. New articulated buses were also added to the trunk lines. As a result, the system achieved an hourly transport capacity (on two lanes in each direction) of around 35 000 people, at a speed of 26 kilometers per hour.

Figure 20. Caracas Avenue, before and after Transmilenio

At this stage, Transmilenio was close to the metro in terms of both capacity and speed, at an infrastructure cost of less than US$6 million per kilometer, which is relatively high compared to systems in other cities but low in relation to what it would cost to build a metro.

However, systems of this type are not a panacea and also involve a number of problems.

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Figure 21. Maximum capacity at Transmilenio stations

In cities that do not have sufficient funds to invest in options such as the metro, these systems are likely to remain in place, as they meet the demand that is often satisfied by trams or metros in European cities.

Figure 22. Transmilenio Mass Transit System network

Transantiago in Santiago, Chile

This is an urban public transport system operating in the metropolitan area of Santiago, the capital of Chile. It began operating in its first phase on October 22, 2005, and was completed on February 10, 2007, when the final transition to the new system took place. The deadline for the implementation of new buses, routes, and infrastructure is 2011. In the case of the city of Guadalajara, the government term during which the implementation of the Macrobús system would be formulated was just beginning.

Figure 23. Santiago Metropolitan Region, Chile

The launch of Transantiago generated a series of problems, revealing significant deficiencies and errors in both the design and implementation of the project. This led to a serious crisis at the national level, both socially and politically, severely damaging the government of Michelle Bachelet.

Figure 24. Transantiago BRT transport system

Although the magnificent Curitiba model of integration between urban development and mass bus transport was not adopted exactly as it was anywhere else, the BRT component, Transantiago, is a system that would have been more successful if the segregated lanes envisaged in its planning had been ready at the time of its inauguration.

Figure 25. Transantiago unit traveling on a normal road

Table 3. Comparison of the cost of traveling by public transport in the Santiago Metropolitan Region (RMS)

Metropolitan areas	Minimum fare	Means of transport	Minimum wage	Population
Bogotá, Colombia	0,80	Minibuses-Micro-BRT	307	7 823 957
Buenos Aires, Argentina	0	Buses-bondis	445	13 267 181
Caracas, Venezuela	0,23	Van-minibus-metro	37	3 140 076
Mexico City	0,18	Micro-BRT-metro	125	19 239 910
Guadalajara-Mexico	0,44	Bus-BRT-metro	12	4 393 420
Lima, Peru	0,30	Combi-microbus	219	8 482 619
Montevideo, Uruguay	0,58	Micro-bus-BRT	193	1 325 968
San José, Costa Rica	0,19	Bus	301	1 286 877
Santa Cruz-Bolivia	0,21	Micro	116	2 670 602
Santiago-Chile	1,30	Micro-metro-BRT	404	6 038 971
São Paulo, Brazil	1,28	Micro-bus-BRT-metro	212	18 783 649

Wealthier citizens, who drive cars, reduce the well-being of lower-income people, who travel by bus.

In Santiago, Chile, only 15 % of trips made by families in the wealthiest neighborhoods are made by public transport, while in the poorest municipalities, only 15 % of trips are made by private transport.

Currently, the Transantiago mass transit system has shown progress in its infrastructure since it began operating, as shown in the following figure:

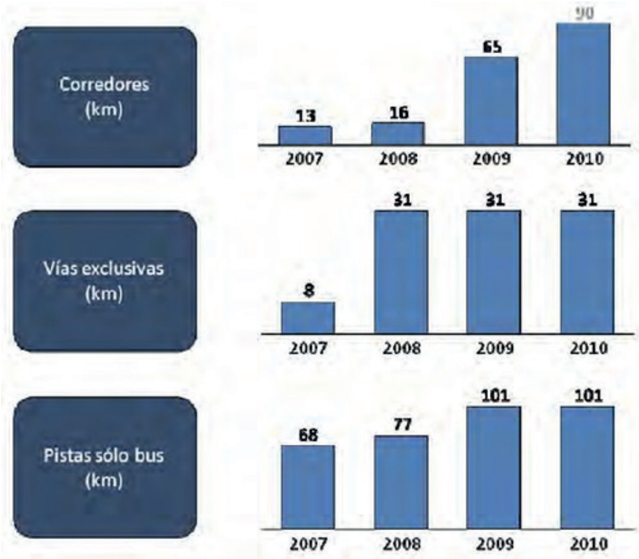

Figure 26. Progress in Transantiago infrastructure since its launch

Also, according to the 2006 Origin-Destination Survey (EOD) conducted by the Chilean Ministry of Transportation, mobility behaves as follows: on a typical workday in Santiago, 16 120 905 trips are made, of which 9 579 162 are in motorized vehicles; This indicates that 40,6 % of daily trips are made on foot or by bicycle. On average, each city resident makes 2,81 trips per day.

Table 4. Distribution of motorized and non-motorized trips in Santiago

Mode	Time of day					
	Peak Morning	Peak Afternoon	Off Tip	Rest of Day	No information	Total
Motorized	1 974 044	1 568 357	818 074	5 207 887	10 800	9 579 162
(%)	20,6	16,4	8,5	54,4	0,1	100,0
Non-motorized	805 912	1 180 703	770 774	3 782 562	1 791	6 541 743
(%)	12,3	18	11,8	57,8	0	100,0
Total	2 779 956	2 749 060	1 588 848	8 990 450	12 591	16 120 905
(%)	17	17	9,9	55,8	0,1	100,0

The survey also shows that most motorized trips are made by public transport (54,7 %); private car and taxi trips account for 37,3 % of these trips (38,6 % if motorcycles are included), and the rest of motorized trips are made using a combination of public and private transport (0,7 %) or other modes such as institutional or school transport (5,6 %). According to the survey, 743,985 trips are made daily by subway, representing 7,8 % of motorized trips. Finally, a detailed analysis of public transportation trips shows that buses and taxi buses are the most commonly used modes, accounting for 78,5 % of these trips.

When looking at the purpose of the trips, it can be seen that work and study account for 27,1 % and 19,0 %, respectively. The remaining 53,9 % includes all other reasons, with shopping being the most common.

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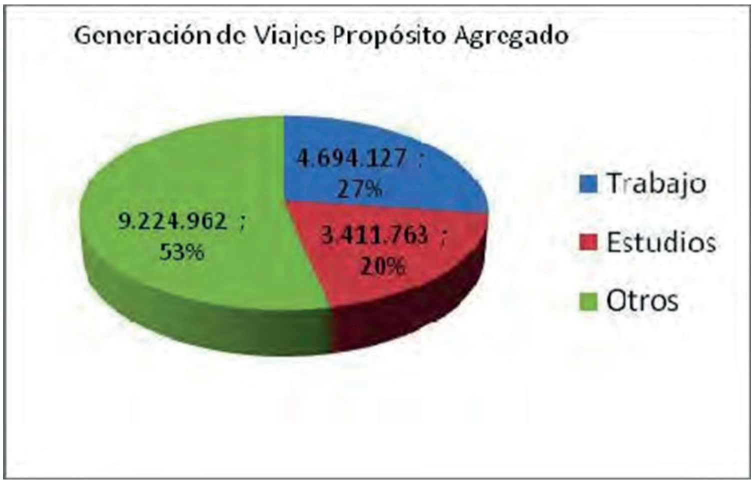

Figure 27. Trips by purpose

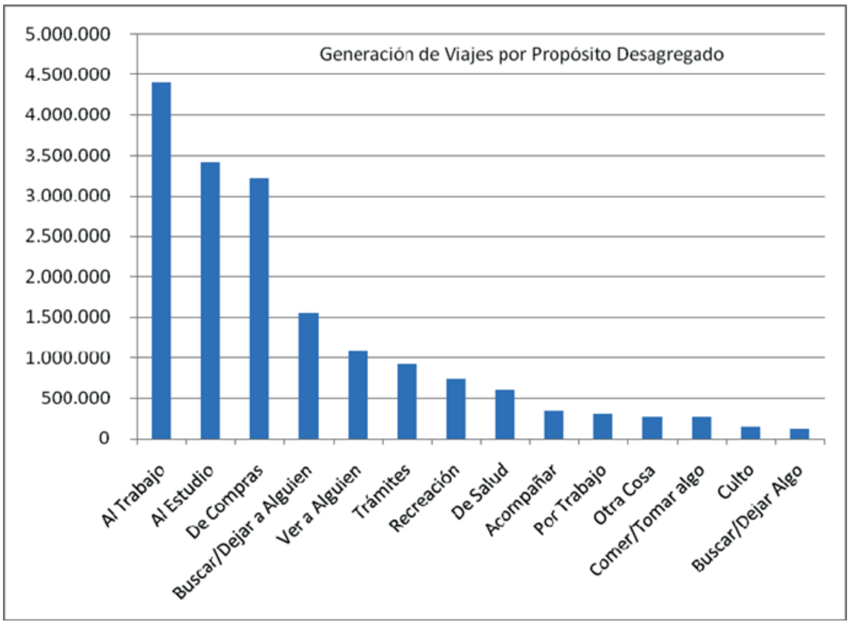

Figure 28. Generation of trips by disaggregated purpose

CONCLUSIONS

A comprehensive analysis of the BRT system in the Guadalajara Metropolitan Area (GMA) shows that this model represents a viable and strategic alternative to the historical urban mobility challenges facing the region. With rapid territorial expansion, disorderly population growth, and heavy dependence on private cars, the implementation of the Macrobús has offered concrete solutions to improve the efficiency, accessibility, and sustainability of public transportation in the metropolis. Its design, inspired by successful cases such as Curitiba and Bogotá, has been adapted to the socio-spati l characteristics of Guadalajara, providing a faster, safer, and less polluting service than the traditional transport system.

Among the main advantages of the BRT system are its low infrastructure cost compared to other mass transportation modes such as the subway or light rail, its positive impact on reducing pollutant emissions—thanks to the use of ultra-low sulfur diesel—and the significant reduction in travel times for users. In addition, by operating in dedicated lanes and having prepaid stations, BRT improves average speed and the user experience, mitigating common problems of the man-truck model, such as fare evasion and unregulated stops.

However, it is also recognized that its implementation has not been without challenges. The politicization of technical decisions, the lack of integrated urban planning, and limited citizen participation have hindered the development of a truly articulated and multimodal transportation network. Likewise, the low population density in many areas of the ZMG represents a structural limitation to replicating underground or elevated transportation models with economic efficiency.

In this context, BRT is positioned as a pragmatic solution that, while not universally superior to other systems, does respond effectively to the demographic, economic, and spatial conditions of Guadalajara. Comparative experience in Latin America, such as the cases of Transmilenio in Bogotá and Transantiago in Chile, reinforces the idea that the success of these systems depends as much on their technical design as on their governance, political continuity, and social acceptance.

In conclusion, BRT can and should become the backbone of a sustainable mobility model for Guadalajara, provided that it is accompanied by a comprehensive vision that includes urban renewal, social equity, citizen participation, and effective connections with other modes of transport.

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CONFLICT OF INTEREST

Authors declare that there is no conflict of interest.

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