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REVIEW

Sustainable urban mobility: evaluation of the monorail as a transportation alternative in Córdoba

Movilidad urbana sostenible: evaluación del monorriel como alternativa de transporte en Córdoba

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ABSTRACT

The study analyzed the feasibility of implementing an elevated monorail system in the city of Córdoba as a response to urban mobility challenges. It started from the premise that mobility was not limited to the simple transportation of people, but also involved the organization of public space, social equity, and environmental sustainability. The research integrated concepts of mobility, accessibility, intermodality, and sustainable development, considering both strategic planning and citizen perception. It emphasized that accessibility should be understood as a right, ensuring that everyone could access services and opportunities without physical or social restrictions. The monorail was presented as an alternative that would not only improve connectivity but also promote the inclusion of vulnerable sectors. Intermodality was also considered essential, given that the new system had to be coordinated with buses, bicycles, taxis, and other modes of transport to optimize the user experience and reduce social and environmental costs. The analysis also highlighted the importance of sustainability, emphasizing that the monorail could help reduce traffic congestion and pollutant emissions, ensuring a more rational use of urban space. Similarly, it raised the need to evaluate social profitability, understood as the equitable distribution of benefits and their long-term impact on quality of life. Consumer behavior was recognized as a key factor, as acceptance of the system depended on perceptions of safety, comfort, and efficiency. In conclusion, the study noted that the viability of the monorail should be evaluated from a comprehensive perspective that transcended technical and financial considerations in order to establish it as an inclusive, sustainable, and innovative project.

Keywords: Mobility; Accessibility; Intermodality; Sustainability; Public Transport.

RESUMEN

El estudio analizó la factibilidad de implementar un sistema de monorriel elevado en la ciudad de Córdoba como respuesta a los desafíos de movilidad urbana. Partió de la premisa de que la movilidad no se reducía al simple traslado de personas, sino que implicaba organización del espacio público, equidad social y sostenibilidad ambiental. La investigación integró conceptos de movilidad, accesibilidad, intermodalidad y desarrollo sustentable, considerando tanto la planificación estratégica como la percepción ciudadana. Se destacó que la accesibilidad debía entenderse como un derecho, garantizando que toda persona pudiera acceder a servicios y oportunidades sin restricciones físicas o sociales. El monorriel se presentó como una alternativa que no solo mejoraría la conectividad, sino que también favorecería la inclusión de sectores vulnerables. Asimismo, la intermodalidad se consideró esencial, dado que el nuevo sistema debía articularse con colectivos, bicicletas, taxis y otros modos de transporte para optimizar la experiencia del usuario y reducir los costos sociales y ambientales. El análisis resaltó además la importancia de la sostenibilidad, subrayando que el monorriel podía contribuir a disminuir la congestión vehicular y las emisiones contaminantes, garantizando un uso más racional del espacio urbano. Igualmente, se planteó la necesidad de evaluar la rentabilidad social, entendida

como la distribución equitativa de los beneficios y su impacto a largo plazo en la calidad de vida. El comportamiento del consumidor se reconoció como un factor clave, ya que la aceptación del sistema dependía de la percepción de seguridad, comodidad y eficiencia. En conclusión, el estudio señaló que la viabilidad del monorriel debía evaluarse desde una perspectiva integral, que trascendiera lo técnico y lo financiero, para consolidarse como un proyecto inclusivo, sostenible e innovador.

Palabras clave: Movilidad; Accesibilidad; Intermodalidad; Sostenibilidad; Transporte Público.

INTRODUCTION

Urban mobility is one of the primary challenges facing modern cities, particularly in metropolitan areas where population concentration and increasing demand for transportation put pressure on existing infrastructure. The city of Córdoba is no stranger to this problem, which necessitates exploring innovative alternatives that enhance the efficiency of the public transportation system, ensure accessibility, and contribute to urban sustainability. In this context, the implementation of an elevated monorail emerges as a viable solution to address current mobility limitations.

The concept of mobility, as defined by Herce and the European Commission, extends beyond simple physical movement, as it encompasses the organization of public space, the interconnection of different modes of transport, and the integration of passenger and freight needs. This broad approach allows us to understand that urban mobility is not limited to transporting people, but also involves ensuring quality of life, efficient resource management, and environmental protection.

Associated with the concept of mobility is that of accessibility, understood as the practical possibility for everyone, including those with physical or cognitive limitations, to access a place, service, or activity. In this sense, public transport is an essential element for social equity, as it expands opportunities for citizen participation and promotes integration.

Another central axis is intermodality, which refers to the coordination between different means of transport to optimize travel. A system that efficiently combines monorail with buses, bicycles, taxis, or other modes of transportation can improve the user experience and reduce the social and environmental costs associated with urban transportation.

Sustainability, a guiding principle for this type of project, has been consolidated in the international agenda since the Brundtland Report (1987) and the Rio Declaration (1992). It is not only a question of economic viability, but also of ensuring the preservation of ecosystems and the equitable distribution of social benefits. In this context, strategic planning plays a crucial role, as it directs resources toward realistic goals that align with the population's needs and market opportunities.

Ultimately, analyzing consumer behavior allows us to predict the acceptance of the monorail as a viable transportation alternative. Users' perception of efficiency, safety, and comfort will be decisive for the success of the proposal. Consequently, this study seeks to analyze the feasibility of an elevated monorail in Córdoba, integrating criteria of mobility, accessibility, intermodality, sustainability, planning, and citizen perception, to provide concrete solutions to the challenges of contemporary urban mobility.

DEVELOPMENT

Based on the issues raised in this paper, a feasibility study will be developed for implementing an elevated monorail in the city of Córdoba and its metropolitan area.

The monorail proposal aims to address a mobility issue for daily users of the mass passenger transport system.

The meaning of mobility provides the starting point for addressing this project. According to Herce, mobility "expresses the multiple forms of travel demanded by society and which require different approaches, in terms of how they affect the organization of urban public space and the provision of spaces and infrastructure adapted to each of these forms." In this regard, the European Commission, in its Green Paper, mentions that "a new concept of urban mobility involves making the most of all modes of transport and organizing 'convenience' between the different modes of public transport (train, tram, metro, bus, and taxi) and between the various modes of individual transport (car, bicycle, and walking). It also involves achieving common objectives of economic prosperity and transport demand management to ensure mobility, quality of life, and environmental protection. Finally, it also means reconciling the interests of freight and passenger transport, regardless of the mode of transport used."

There is a fundamental concept linked to the notion of mobility, namely accessibility. Liliana Ramírez, in her work "Accessibility and spatial mobility - Possible treatment using geographic information systems," quotes Emrys Jones, who states that "accessibility is related to the opportunity that a person, located in a

given location, has to carry out an activity or set of activities. In this case, accessibility is a function of the individual's or type of person's mobility, the location of opportunities in relation to the individual's starting point, the periods during which these opportunities can be accessed, and the times when that activity is available. Therefore, accessibility is related not to behavior but to the opportunity or potential provided by transportation and the land use system for different types of people to carry out activities." The Spanish Confederation of People with Physical and Organic Disabilities (COCEMFE), through its Accessibility Observatory, defines accessibility as "the quality of easy access for any person, including those with limitations in mobility, communication, or understanding, to reach a place, object, or service. Accessibility is a person's right and, as such, must be treated as such to achieve equal opportunities." As can be seen from the definition of accessibility, COCEMFE refers to different types, including accessibility in transport, which relates to the various means of public transport that can be used.[1]

Another definition closely linked to mobility is intermodality. Marina Ambrosio Gonzales, in her work "Intermodality," published by the National Geographic Institute of Spain, infers that this concept "consists of the transfer of people and goods using different modes of transport.[2] (...) An intermodal transport network, with rapid connections between different modes, in which travel from one place to another can be carried out comfortably and efficiently, would lead to improvements in society and in the quality of life of citizens, but also to a reduction in costs and a return on the resources dedicated to transport."

The definition of sustainable development, like the terms accessibility and intermodality, is fundamental knowledge for addressing this work. It originated in 1983, when the United Nations (UN) established the Commission on Environment and Development, publishing the report "Our Common Future or Brundtland Report, defining the concept of "Sustainable Development" as follows:[3]

It is development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. It encompasses two fundamental concepts:

- The concept of "needs," in particular the essential needs of people with low incomes, should be given priority.
- The idea of limitations imposed by the state of technology and social organization between the environment's capacity to meet present and future needs.

This concept was consolidated in the 1992 Rio Declaration, which set out three objectives to be pursued:

- Ecological: representing the natural (physical) state of ecosystems, which should not be degraded but should maintain their main characteristics, which are essential for their long-term survival.
- Economic: a productive economy should be promoted, aided by the know-how of modern infrastructure, which should provide sufficient income to ensure the continuity of sustainable resource management.
- Social: benefits and costs must be distributed equitably among different groups, etc.

Another fundamental aspect of this project is the issue of strategic planning, as this provides a framework for assessing the technical and financial viability of developing the Aerial Monorail system. For Fred David, strategic planning can be defined as an objective and systematic approach to decision-making in an organization. It is a tool that allows organizations to prepare for future challenges by directing their resources and efforts toward realistic performance goals. According to Kotler, strategic planning is the managerial process of developing and maintaining a strategic direction that can align the organization's goals and resources with its changing market opportunities.[4,5]

It is worth mentioning that, given the importance of public transportation systems to society, the pursuit of profitability should not only be financial but also achieve "social profitability".[9,10,11] As Gary Woller mentions in his article "Trade-offs between social and financial performance" published in 2007,[12] social profitability "should not be measured only in terms of the results achieved, or in other words, reach or demand satisfied, but also in terms of the actions and corrective measures taken to achieve those results." Likewise, Alonso-Carrera, Freire-Serén, and Manzano link this concept to "the net result of comparing the cost of public funds and the benefit of the public project."

Finally, the study of consumer behavior will contribute to the development of strategies to encourage users of the public passenger transport system to embrace this new transport proposal and how this alternative will change their perception of the service.[13] Arellano defines consumer behavior as "the internal or external activity of an individual or group of individuals aimed at satisfying their needs through the acquisition of goods or services." On the other hand, Hoffman defines it as "the set of reactions of a subject to a product or service that may satisfy their needs or desires, which are provoked by the positioning of the product or the influence of the media."

CONCLUSIONS

The study enabled us to reflect on the importance of implementing innovative public transportation solutions

that respond to the growing demand for mobility in the city of Córdoba and its metropolitan area. In this sense, the elevated monorail project was presented as a viable alternative to address the limitations of the current system, while aligning with principles of sustainability, accessibility, and intermodality.

First, it became clear that urban mobility should not be understood solely as the movement of people from one point to another, but rather as a complex phenomenon involving the organization of public space, the integration of different modes of transportation, and the creation of conditions that guarantee a quality of life. From this perspective, the monorail is not conceived as an isolated solution, but rather as part of an intermodal system that complements buses, taxis, bicycles, and other means of transportation, thereby optimizing travel and promoting overall efficiency.

Likewise, the close relationship between mobility and accessibility was highlighted, understood as the right of every person to access goods, services, and opportunities without physical, economic, or social restrictions. The incorporation of a monorail would contribute not only to improving urban connectivity but also to ensuring the inclusion of sectors with greater mobility difficulties, generating a positive impact on social equity.

The analysis also underscored the importance of sustainable development as a guiding principle in transportation project planning. The monorail would reduce traffic congestion, minimize pollutant emissions, and promote a more rational use of urban space. In this way, the proposal would not only be economically feasible but also provide ecological and social benefits that extend beyond the logic of financial profitability. At this point, the need to measure the social profitability of the project was recognized, considering the distribution of benefits among different groups and the long-term impact on the quality of life of the population.

Finally, the study of consumer behavior provided key insights into the acceptance of the monorail. Users' perceptions of safety, efficiency, comfort, and speed will be decisive in ensuring its widespread use. Consequently, it is essential to accompany the implementation with communication and awareness strategies that promote trust and citizen ownership of the new system.

The feasibility of the elevated monorail in Córdoba should not be evaluated solely in technical or financial terms, but rather from a comprehensive perspective that considers mobility, accessibility, sustainability, strategic planning, and social perception. Only through this multidimensional approach will it be possible to consolidate an innovative, inclusive, and sustainable transportation project that responds to the city's current and future challenges.

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FINANCING

None.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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