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Smart Mobility and Change Management in Public Transport in Andalusia: "Perspectives towards 2030"

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Abstract
This study examines the pivotal factors that will shape the transformation of public transportation in Andalusia by 2030. The objective is to develop strategies that advance more efficient, sustainable, and inclusive mobility. By employing a forward-thinking methodology, this study has identified a series of pivotal scenarios that underscore the necessity of modernizing road infrastructure, integrating smart technologies, and strengthening collaboration between public and private actors. The findings of this study highlight the imperative for the adoption of green vehicles, the digitization of payment systems, and the enhancement of service accessibility. It is recommended that investment in infrastructure be prioritized and that informal services be regulated in order to meet the growing demand and sustainability challenges. This study offers a strategic guide for the evolution of public transport in changing urban contexts.

Keywords
Public transport, smart mobility, sustainability, advanced technologies, change management, Andalusia, prospective analysis.

Introduction

The municipality of Andalusia is confronted with considerable obstacles pertaining to public transportation, largely due to the absence of comprehensive regulatory frameworks, operational inefficiencies, and an escalating demand for sustainable solutions. In light of these circumstances, a prospective analysis is imperative to anticipate the requisite changes and propose strategies that promote efficient and sustainable mobility by 2030. The objective of this study is to identify the key factors that will influence the development of public transport and to design strategies that promote the sustainability, inclusion, and resilience of the system (Cruz et al., 2023).

The methodology employed is exploratory and descriptive, integrating prospective tools such as the Delphi method and the Importance-Governance-Uncertainty matrix to analyze the key dynamics of public transport (Godet, 2000). The application of these techniques

enables the identification of the critical variables that must be managed to ensure a successful transition to a more efficient and adaptable system (Rico, 2022). Furthermore, simulations are employed to assess the influence of potential interventions on infrastructure and transportation operations, ensuring alignment with a sustainable development approach (Bernal, 2010).

The findings underscore the significance of integrating advanced technologies, such as green vehicles and electronic payment systems, and of fostering collaboration between the public and private sectors to guarantee service enhancement (Ahmed et al., 2021). This study presents a comprehensive framework for strategic planning of public transport in Andalusia, anticipating future challenges and proposing solutions that ensure its resilience and sustainability.

Literature Review

In order to analyze the future of public transportation in Andalusia up to the year 2030, it is necessary to adopt a multidisciplinary approach that takes into account **strategic foresight, change management, innovation theories, sustainability, and transport economics**. These theoretical frameworks facilitate comprehension of the intricacies and transformations requisite for a more intelligent and efficient transport system.

Strategic Foresight

The ability to anticipate and shape the future of transport is contingent upon the application of strategic foresight (Godet, 2000). This methodology enables the analysis of pivotal trends, thereby facilitating the design of resilient policies. In his 1999 work, Callon introduces the concept of actor-network theory, which provides insight into the ways in which public and private actors influence the adoption of technological innovations. This concept is further developed by Latour (2005), who emphasizes the significance of networks of actors in driving structural change.

Change Management

Effective change management is a fundamental aspect of modernizing public transportation. Kotter (1996) presents an eight-stage model for the adoption of disruptive technological innovations, while Argyris and Schön (1996) emphasize the importance of organizational learning as a means of adapting to new realities. Senge (2006) offers further support for this view, emphasizing the capacity of organizations to learn and to continuously enhance their performance..

Theories of Innovation and Technology

Rogers (2003) provides an explanation of the adoption of technological innovations based on socioeconomic factors that are relevant to the incorporation of technologies such as the

Internet of Vehicles (IoV). In 1997, Christensen put forth the theory of disruptive innovation, which posits that emerging technologies have the potential to radically transform public transportation. Kanter (1983) offers a complementary perspective, indicating that an organization's capacity for innovation is contingent upon its flexibility and leadership.

Sustainability and Urban Development

Ensuring intergenerational equity in the use of resources depends on the concept of sustainability (Brundtland, 1987). In order to facilitate transitions to sustainable transport systems, Geels (2012) posits that it is necessary to implement technological and social changes. Similarly, Jacobs (1961) emphasises the importance of urban design being centred on the needs of the people who will use it, which is vital for the success of public transport systems.

Transportation Economics

The principles of efficiency and economic impact are fundamental to the field of transport planning (Button, 2010). As Banister (2008) notes, sustainable mobility serves as a catalyst for economic growth. Similarly, Glaeser (2011) underscores the significance of efficient systems for urban development and competitiveness.

Smart Mobility

The concept of smart mobility, which is based on the use of technologies such as the Internet of Vehicles (IoV) and the analysis of large data sets, has the potential to optimise urban traffic flows (Amer et al., 2018). As demonstrated by Bravo et al. (2016), the optimization of traffic light systems using advanced algorithms has the potential to significantly enhance mobility while concurrently reducing emissions.

Methodological Design

This *exploratory and descriptive* study aims to analyze the current state and future scenarios of public transportation in Andalusia. As Atehortúa (2012) notes, exploratory research allows for the investigation of understudied phenomena, while descriptive research, as Arias (2006) posits, offers a comprehensive account of pertinent characteristics and processes, thereby providing a foundation for strategic planning.

Methodological approach

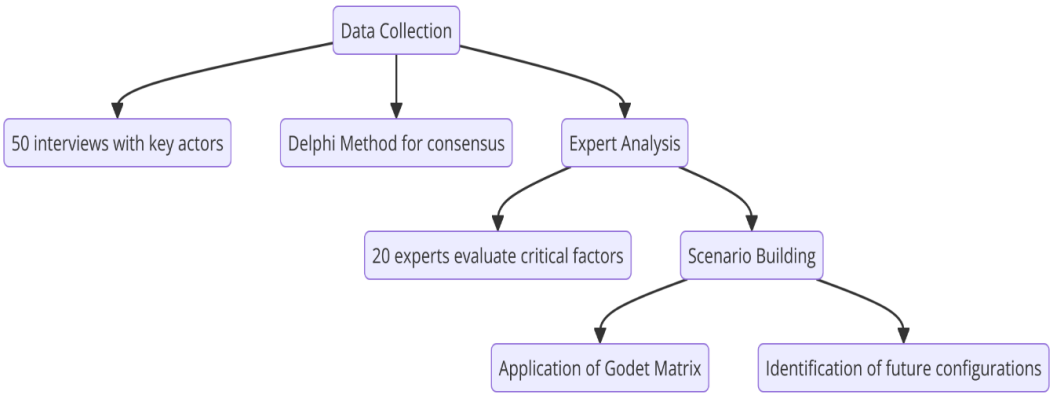
The design is based on a *prospective approach*, complemented by qualitative techniques such as the *Delphi Method* and the *Prospective Matrix of Critical Factors* (Godet, 2006). As Rico (2022) notes, foresight is a crucial tool for anticipating future scenarios and

informing present actions. This approach enabled the identification of critical factors and areas of intervention that will inform the development of transport towards 2030.

Collection of information

Over 50 interviews were conducted with key actors, including policymakers and system operators, employing the Delphi Method to achieve consensus on critical factors. Furthermore, 20 experts in the fields of mobility and technology employed Godet's Matrix to analyze these factors, thereby generating future configurations that optimize sustainability and efficiency.

Figure 1. Methodological step by step for the collection and processing of information.



Results and Discussions

The analysis of the public transport system in Andalusia reveals a complex coexistence between formal and informal services. The preference for informal services, such as "pirates" and motorcycle taxis, is largely attributable to their flexibility and economic accessibility, particularly in regions where formal services, such as Coopetrans, are scarce. However, the absence of regulatory oversight in these services presents significant safety concerns and negatively impacts the overall quality of transportation (Javed et al., 2022; Aloqaily et al., 2019).

1. **Transportagencyreports**

   The inadequacy of formal services has resulted in a significant reliance on informal options, which provide coverage in underserved areas but carry inherent safety and quality risks. To mitigate these risks, the formalization of these services through stricter supervision policies is proposed, which would improve both the security and

efficiency of the system (Perera et al., 2017; Liu, 2018). Furthermore, the expansion of formal services should guarantee equitable and efficient access, with particular consideration given to peripheral areas (Okai et al., 2018).

2. **Unfaircompetition and tensions**

   The competition between formal and informal operators has resulted in the emergence of tensions within the transport system. The absence of appropriate regulatory measures serves to exacerbate these conflicts, thereby impeding the harmonization of the two types of service. To resolve this situation, it is essential to establish a regulatory framework that ensures a level playing field for all operators, while maintaining the highest standards of safety for users (ECLAC, 2022).

3. **Security and regulation**

   The absence of regulatory oversight in informal services has had a profoundly detrimental impact on passenger safety. The establishment of minimum standards, such as mandatory insurance policies and regular technical reviews, is of great importance in enhancing public confidence in the transportation system (Javed et al., 2022). Furthermore, the implementation of Intelligent Transportation Systems (ITS) can markedly enhance safety and efficiency through the use of technologies such as the Internet of Things (IoT) and big data analytics, which optimize traffic and emergency response (Chen et al., 2019).

4. **Poor infrastructure**

   The deplorable state of roadways and the absence of sufficient signage constitute fundamental impediments to the safety and efficiency of public transportation. It is imperative that investment in road infrastructure be a priority, as the current conditions not only result in accidents but also impede the regular transport service. The advancement of technologies such as fleet electrification and the enhancement of electric charging infrastructure can also optimize the sustainability and efficiency of transportation (Aloqaily et al., 2019).

5. **User dissatisfaction**

   The conjunction of a restricted availability of formal transportation and the potential hazards associated with informal services has resulted in an increasing level of discontent among users. To reverse this trend, it is essential to improve the supply of formal transport, expand routes, and adopt sustainable and accessible

technologies (Ahmed et al., 2021). The integration of Mobility as a Service (MaaS) platforms, which consolidate various transportation modes into a unified application, may also enhance flexibility and convenience for users (Durand et al., 2018).

1. RecentTrends and Changes

The global landscape of public mobility is undergoing a period of significant transformation, driven by technological advances and the growing demand for sustainability. These trends are redefining the very nature of public and private transport, and are exerting a direct impact on the future planning of transport systems. The main trends that are shaping the sector are summarized below:

Figure2. Global trends in public mobility

Source: Own elaboration

Figure 2 provides an overview of the principal global trends in public mobility, encompassing fleet electrification, micromobility, and autonomous transport. If these trends are implemented correctly in Andalusia, they have the potential to transform the transport system into a more efficient, sustainable, and resilient one that is aligned with cutting-edge practices in urban mobility at the global level.

The public transportation systems in developed countries such as Germany, Japan, and the Netherlands serve as exemplary models of sustainable and efficient mobility. These systems have been enhanced by multimodal integration and the use of advanced technologies, which have significantly improved accessibility and reduced emissions. In

Germany, investment in infrastructure and the digitalization of the system have enabled greater intermodality and efficiency (Climate ADAPT, 2022). In Japan, the Shinkansen has revolutionized intercity transport, reducing congestion and emissions (JRPASS, 2023). In contrast, the Netherlands has distinguished itself by prioritizing sustainable mobility, integrating public transportation, bicycles, and pedestrians into an efficient network (Bnamericas, 2023).

These global trends serve to reinforce the significance of adopting integrated mobility approaches, as proposed by Rodgers (1995) and Geels (2012), in order to effectively address the challenges of congestion, pollution, and accessibility. Andalusia has the opportunity to learn from these successful models by adopting advanced technologies such as fleet electrification and Intelligent Transport Systems (ITS), as well as promoting intermodality. Despite remaining deficiencies, the implementation of these measures can facilitate a transition towards a more efficient and sustainable transportation system that is aligned with international standards.

2. Behavior of the variables of Influence, Motricity and Dependence in the Transport Service in Andalusia

The analysis of the public transport system in Andalusia reveals a series of variables that directly influence its operation and evolution. The variables of influence, namely motor skills and dependence, are fundamental to understanding how the dynamics of transport in the region are configured. The analysis of these variables enables the anticipation of scenarios and the formulation of strategic decisions that optimize the efficiency and sustainability of the transport system.

Identification of Key Variables

The key variables identified through local and global studies encompass a range of elements, including road infrastructure, environmental impact, urban logistics planning, and technological factors. These variables comprise an integrated system that defines the capacity of public transport to respond to current and future mobility demands in Andalusia. The most influential factors are transport infrastructure and mobility technology, which play a foundational role in the safety, speed, and sustainability of the system (Rodgers, 1995; GOV.CO, 2021).

Qualification of the Variables

The evaluation of these variables was conducted through an analysis with experts, employing a scale of 1 to 5. The results demonstrate that the most influential and critical variables for the transport system are road infrastructure, investment in advanced technology, and strategic planning of public transport. These elements are indispensable for ensuring an efficient and sustainable system that responds to the needs of a growing population.

Table 1. Rating of Critical Variables for Public Transport in Andalusia

Variable	Value	Short Name
Formal public transport	5	Transpo
Informal public transport	5	Transpi
Unemployment	5	Desm
Travel time of public transport users	5	Tidutranp
Population growth	5	Crepe
Knowledge of transport alternatives	4	Coaltrans
Knowledge about sustainable mobility	4	Consmosos
Number of formal and informal agencies	4	Canafoin
Signaling and road quality	5	Sign
Permanent presence of traffic agents	5	Presperagen
Planning in urban logistics	5	Plalour
Bicycle transport infrastructure	5	Infrapabici
Environmental impact	5	Impacambi
Characterization of public transport	4	Cartransp
Road infrastructure maintenance	5	Maninfra
Improvement in Road Infrastructure	5	Meinfra
Structuring urban development for public mobility	5	Estdeurba
Application of the Strategic Public Transport System (SETP)	3	Youapplied
Investment in infrastructure for public transport	5	Inverinfra
Ability to adapt to new public transport systems	2	Capasispu
Financial viability for the development of public transport projects	5	Viafinanpro
Technology for the development of mobility	5	Tecmo
Implementation of public policies	4	Implepopu
Pedestrian perception of transport and mobility	5	Perestra
Strategic planning of public transport	5	Platranspu
Accessibility conditions for public transport	4	Condemnations
Signaling and demarcation of areas of high vehicular flow	5	Señaflu
Pedestrian infrastructure	5	Infrapea

Source: Ownelaboration

Influence and Motor Skills Variables

The most pertinent variables that exert a significant influence on this phenomenon are those pertaining to the advancement of mobility and the development of road infrastructure. The implementation of sophisticated technologies, including electronic payment, electric vehicles, and Intelligent Transportation Systems (ITS), has the potential to revolutionize the transportation system, enhancing its operational efficiency and reducing carbon emissions (Rodgers, 1995; GOV.CO, 2021). Conversely, the quality of the road infrastructure is of paramount importance for the safety and efficiency of the service, as it directly affects travel times and the quality of the service (Buchwald, 1968).

Figure 3. Direct Influence Graph.

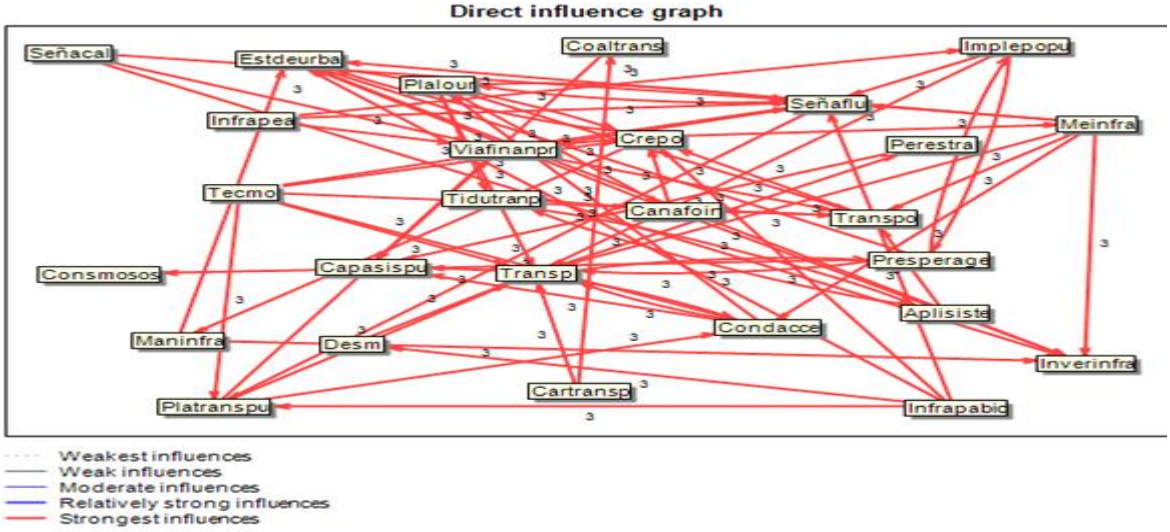
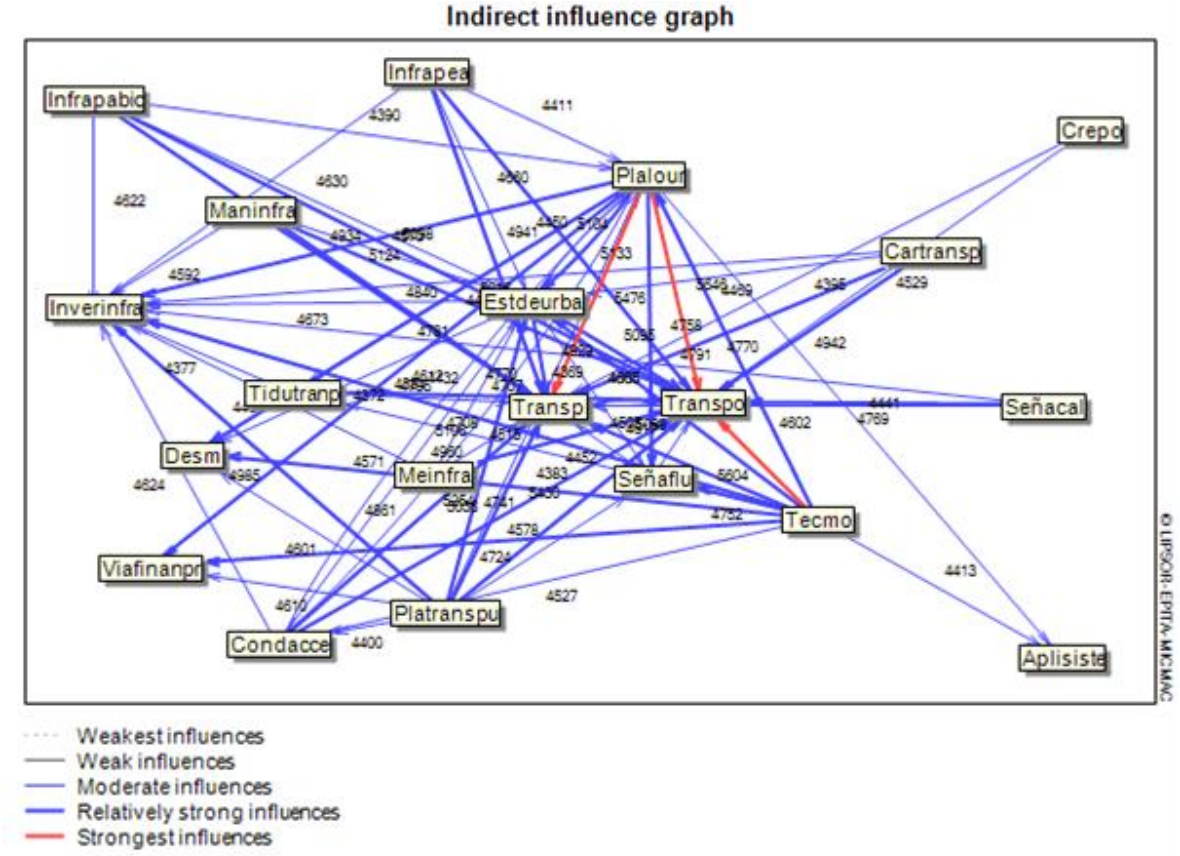


Figure 4. IndirectInfluenceGraph.



Dependent Variables

The dependent variables encompass both informal transportation and infrastructure investment. The prevalence of informal transportation in specific regions of Andalusia indicates deficiencies in the formal system, emphasizing the necessity for integrating both sectors through inclusive policies. Investment in infrastructure, particularly in the realms of road and signaling improvements, is of considerable importance in facilitating the transition to a more formal and regulated transport system (Aloqaily et al., 2019).

Key Results

1. **Investment in Infrastructure**: Investment in road infrastructure is a priority to improve safety, increase coverage and ensure the efficiency of the transport system. Improving road signage andmaintenanceis essential to optimize the operability of public transport in Andalusia.
2. **Adoption of Advanced Technologies**: The adoption ofinnovative technologies**,** such asIntelligent Transportation Systems (ITS) will optimize the operation and monitoring of the transportation system, improving both safety and user experience. Electric vehiclesanddigital payment systems are some of the solutions that can boost system efficiency (Rodgers, 1995; GOV.CO, 2021).

3. **Strategic Planning**: It is crucial to develop comprehensive planning that considers the interrelationship between the variables of influence and dependence. This will make it possible to address the structural problems of the transport system and guarantee its long-term sustainability, adapting to the future demands of the population.

The analysis of the variables of influence, motor skills, and dependence in the transport system of Andalusia has revealed the importance of a robust infrastructure and the adoption of advanced technologies as fundamental pillars to improve the efficiency and sustainability of public transport. It is imperative that investments in road infrastructure and technological development be prioritized to ensure that the public transport system is capable of adapting and responding to current and future mobility demands.

3.Prioritization of the Variables according to their level of Importance and Current and Future Impact of the Public Transport System in the Municipality of Andalusia

It is of the utmost importance to correctly prioritize the key variables in the prospective analysis of public transport in Andalusia. This will ensure that resources are focused on the critical areas that will guarantee the sustainability and accessibility of the transport system. This approach allows for the identification of high-impact variables that require immediate intervention, as well as the prediction of those that will influence the future of the system.

Structuring Variables

The key variables are classified into distinct categories, thereby facilitating a systematic examination of the public transportation system. The aforementioned variables are subdivided into the following categories:

- **Demographic**: Population growth, conditions of accessibility to public transport.
- **Transportation infrastructure**: Commuting time, road quality, formal/informal agencies, bicycle and pedestrian infrastructure, infrastructure investment.
- **Socioeconomic factors**: Unemployment, knowledge of transport alternatives, pedestrian perception.
- **Technological factors**: Technology applied to transport.
- **Environmentalaspects**: Environmentalimpact.
- **Urban planning**: Logistics planning, urban development, financial viability.
- **Policies and regulations**: Implementation of public policies, traffic agents.
- **Public transport**: Formal and informal transport.

Table 2. Classification of Key Variables in the Transportation System

Category	Key Variable
Demographic	Population growth, accessibility to public transport

TransportationInfrastructure	Commute time, road quality, formal/informal agencies, bicycle and pedestrian infrastructure, infrastructure investment
SocioeconomicFactors	Unemployment, knowledge of transport alternatives, pedestrian perception
TechnologicalFactors	Technology for the development of mobility
EnvironmentalAspects	Environmental impact
Urban planning	Logistics planning, urban development, financial viability
Policies and Regulations	Implementation of public policies, traffic agents

Variable	EvaluationCriteria	Measurement
Publictransport	Formal transport, informal transport	

Source: Own elaboration

Definition of the Evaluation Criteria

The evaluation criteria were used to measure the relevance and impact of the variables on the transportsystem. The measurements were made on an objective basis, using specific indicators for each variable. Prominent criteria include:

- **Population growth**: Measured by the annual growth rate of the population.
- **Accessibility to public transport**: Assessed through the accessibility index, which measures the percentage of the population with close access to stops or stations.
- **Commuting time**: The average time users spend traveling on public transportation.
- **Quality of road infrastructure**: Evaluation of the condition of the roads and signage.
- **Citizen perception**: Measured through surveys that capture satisfaction with the transportation system.

Table 3. Evaluation Criteria for Key Variables

Populationgrowth	Annualgrowthrate	% change in population
Accessibilitytopublictransport	Accessibilityindex	% of population with adequate access
Travel time	Averagetravel time	Average minutes/hours on public transport
Road quality and signalling	Road QualityIndex	QualitativeInfrastructureAssessment
Citizenperception	Perceptionindex	Satisfactionsurveys
Strategic planning of public transport	Planningeffectiveness	EvaluationofImplementationSuccess

Source: Ownelaboration

Stakeholder Survey: Perception of the Present and Future (2030)

A survey was conducted with key stakeholders in the transportation system, including government officials, transportation operators, and users. The survey evaluated the variables in both their current state and in terms of their projected trajectory towards the year 2030. The results were presented on a scale of 1 to 5, with 1 representing "very unfavorable" and 5 "very favorable."

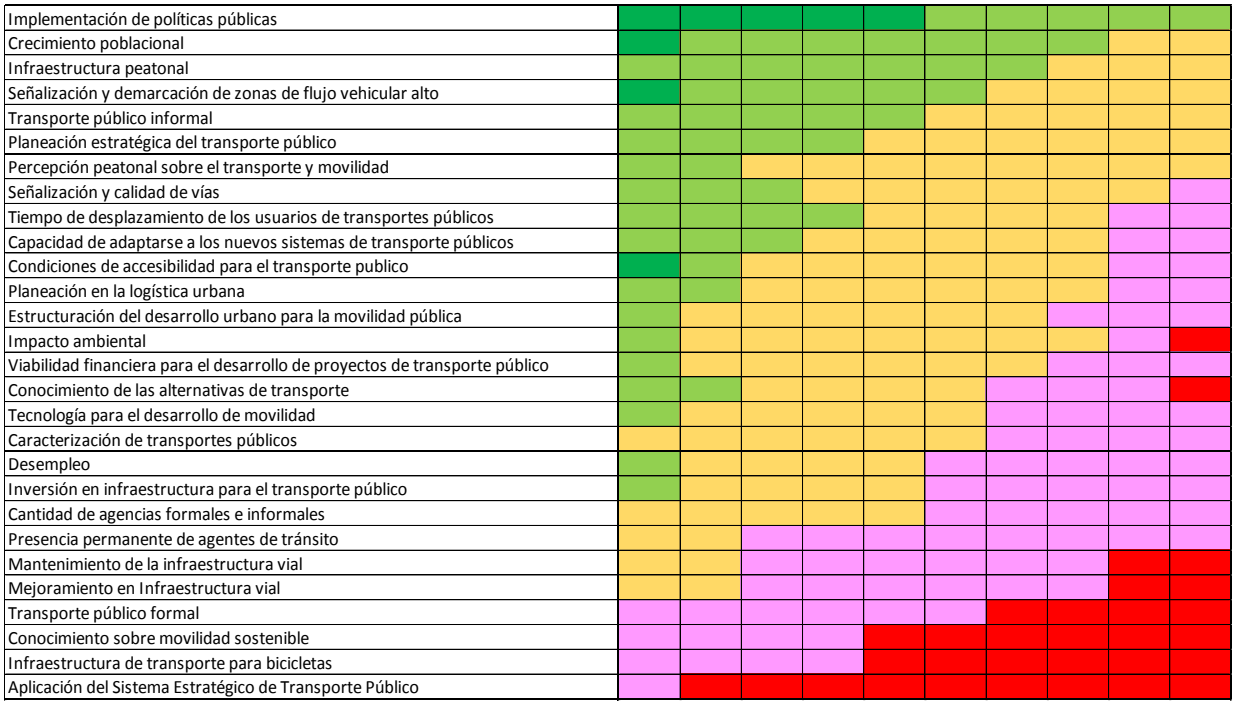
Table 4. Results of Regnier's Abacus for Perception of the Present

Very favorable	5
Favorable	4
Doubt	3
Unfavourable	2
Very unfavorable	1

Source: Own elaboration

Figure 5 presents the results of the perception of the present of the variables according to the key actors

Figure 5. Results Regnier's abacus present



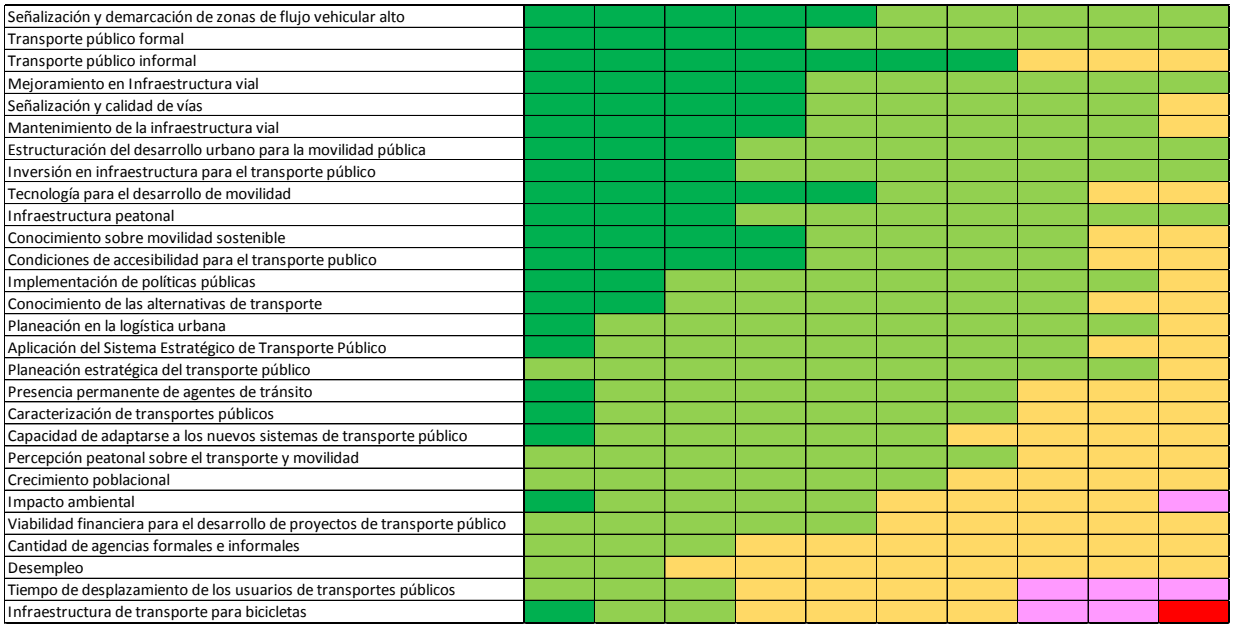
Source: Own elaboration

Perception of the Present and the Future

Perception of the future

Figure 6 shows the results of the perception of the future of the variables according to the key actors.

Figure 6 Perception of the future



Source: Own elaboration

Survey Results

- **Perception of the present**: The key actors highlighted the implementation of public policies and pedestrian infrastructure as favorable. On the other hand, the deficiencies were found in the infrastructure for bicycles and the application of the strategic public transport system.
- **Perception of the future (2030):** By 2030, formal andinformalpublic transport are expected to improve significantly, although concerns related to road infrastructure and travel times persist

Table 5. Perception of variables in the present and future (2030).

BestPerceived Variables (Present)	**Worst Perceived Variables (Present)**	**Best Perceived Variables (Future)**	**Worst Perceived Variables (Future)**
Implementation of public policies	Bicycle infrastructure	Formal public transport	Informal transport
Pedestrian infrastructure	Implementation of the strategic transport system	PedestrianInfrastructure	Bicycle infrastructure

Signaling and demarcation of flow zones	Travel time	Implementation of public policies	Implementation of the strategic transport system
Investment in infrastructure	Knowledge of transport alternatives	High-flow area marking	Travel time
Road infrastructure maintenance	Adapting to new transport systems	StrategicTransportationPlanning	Quality of road infrastructure
Citizens' perception of mobility	Road infrastructure		

Source: Ownelaboration

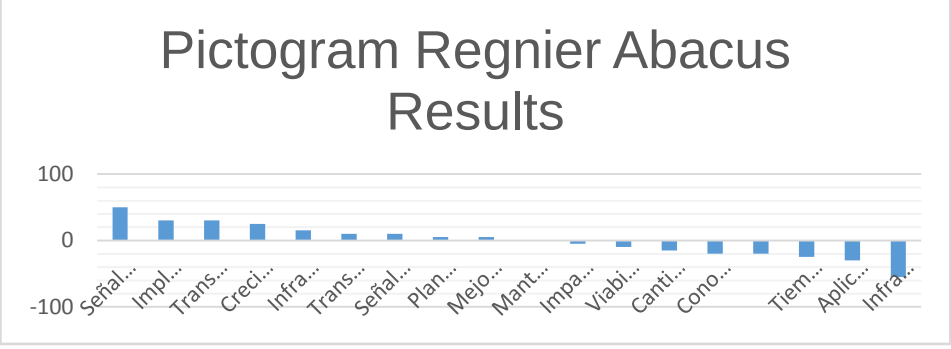
The analysis of the most and least favorable variables in the present and future indicates that public policies and pedestrian infrastructure are perceived as the most positive aspects of the current system, suggesting improvements in accessibility and safety. However, there are critical areas, such as bicycle infrastructure and the implementation of the strategic transportation system, that require immediate attention due to their suboptimal performance. In the future, improvements in formal public transportation and pedestrian infrastructure are anticipated. However, concerns about informal transportation and commuting times persist, underscoring the need for structural and technological intervention.

Ranking of Results

The results were classified to prioritize those variables that must be addressed immediately and those that require long-term corrective measures.

Regnier's Abacus and Analysis

Regnier's Abacus is used to visualize the hierarchy of variables and their impact.



Source: Authors.

The prospective analysis of the public transport system in Andalusia reveals the imperative necessity for intervention in pivotal domains, including road infrastructure and the reduction of travel times. While enhancements in specific areas are projected to be realized by 2030, it is imperative to prioritize the resolution of identified deficiencies in bicycle infrastructure and the implementation of a strategic public transportation system, as these variables exert a significant influence on sustainable mobility.

The implementation of pedestrian infrastructure and signage in high-flow areas has been demonstrated to be an effective strategy, confirming the efficacy of public policies applied in these areas. Nevertheless, for the system to evolve towards a more efficient model aligned with the demands of a growing population, a coordinated approach is necessary that includes the development of advanced technologies such as Intelligent Transport Systems (ITS) and the digitalization of transport. This will optimize the operation, reduce travel times, improve safety, and guarantee a more integrated and accessible mobility experience for all users.

In summary, the study provides a clear roadmap for prioritizing investments and planning strategies in Andalusia's public transport, ensuring that the system responds effectively to current and future needs, with a focus on sustainability and accessibility.

4. Consultation with experts

The consultation of experts represents a fundamental instrument for the acquisition of a comprehensive and multidimensional vision of the future of public transport in the municipality of Andalusia. This method is frequently employed in prospective research, as it enables the integration of the specialized knowledge and practical experience of professionals in pertinent fields (Rowe & Wright, 1999). In order to gain a comprehensive understanding of the current and future challenges facing the public transportation system, as well as to identify potential strategies for improvement, this study conducted 30 interviews with experts in transportation, urban planning, technology, and sustainability.

Interview Questions

1. Evaluation of the current state of public transport in terms of efficiency and accessibility.
2. Identification of the main current and future challenges of the public transport service.
3. Socioeconomic impacts of public transport in the next five years.
4. Technological advances that could significantly influence the improvement of the service.
5. Impact of sustainability and the environment on transport design.
6. Influence of demographic changes on the demand for public transport.
7. Perception of the quality of the service and ways of improvement.

8. Essential management measures to ensure a safe and efficient service.
9. Main barriers to improving public transport.
10. Key trends that will shape the future of transport in Andalusia.

Interview Results

The experts agreed on several key points that reveal the current weaknesses of the system and opportunities for improvement. The most relevant answers in relation to the questions asked are summarized below.

1. **Current status**: The public transport system in Andalusia faces serious challenges in terms of efficiency and accessibility. Congestion points and lack of adequate infrastructure are mentioned as major problems (Black, 2010).
2. **Future challenges**: The lack of a formal system and the need to optimize routes to adapt to population growth emerge as the most urgent challenges (Banister, 2008).
3. **Socioeconomic impacts**: Experts indicated that while public transport can boost local economic development, its capacity is limited by unfair competition from informal services and a lack of public investment (Cervero, 2013).
4. **Technological advances**: Technologies such as fleet management systems, electronic payments, and vehicle control cameras were identified as key elements to improve system efficiency and user experience (Shaheen et al., 2015).
5. **Sustainability**: The adoption of electric vehicles and the optimization of routes to reduce emissions are perceived as essential to meet sustainability goals (Geels, 2012).
6. **Demographic changes**: Population growth will require adjustments in transport routes and frequencies, which requires more dynamic and flexible planning (Rodrigue et al., 2016).
7. **Quality of service**: The quality of service is perceived as poor, especially in terms of punctuality and comfort. Experts suggest modernizing the fleet and better training drivers to improve user satisfaction (Gwilliam, 2002).
8. **Management measures**: The recommendations focused on the promotion of safe driving practices and inter-agency collaboration to improve road safety and reduce congestion points (May, 2009).
9. **Barriers to improvement**: Budgetary constraints, lack of inter-institutional coordination, and negative public perception were identified as the main barriers to improving public transport (Vuchic, 2005).
10. **Future trends**: Experts highlighted the importance of integrating advanced technologies, adopting sustainable practices and adapting to demographic changes to ensure the development of public transport in Andalusia in the coming years (Marsden & Reardon, 2017).

Unified Perspectives

From the interviews, the following perspectives were consolidated:

1. **Current State of Transportation**: The public transportation system has deficiencies in efficiency and accessibility due to limited infrastructure and a supply that does not meet the needs of the growing population (Banister, 2008).
2. **Current and Future Challenges**: The need to create an economical and sustainable urban system is urgent, as the expansion of informal transport is affecting the profitability of the formal sector (Cervero, 2013).
3. **Socioeconomic Impacts**: Informal competition poses a significant risk to formal public transport. In addition, the tariff flexibility of informal services generates unfair competition that negatively impacts financial viability (Geels, 2012).
4. **Technological Advances**: Experts agree that emerging technologies, such as real-time monitoring systems, will be instrumental in improving the operational efficiency of transportation (Shaheen et al., 2015).
5. **Sustainability and Environment**: The future of public transport in Andalusia depends on the adoption of electric vehicles and the optimization of routes, thus contributing to the reduction of the carbon footprint (Geels, 2012).
6. **Quality of Service**: Modernization of the fleet and improvement in operator training are essential measures to improve service quality and increase user satisfaction (Gwilliam, 2002).

A consultation with experts has revealed that public transport in Andalusia is confronted with structural challenges that necessitate prompt intervention, particularly in the enhancement of infrastructure and the integration of cutting-edge technologies. The interviews underscore the pivotal role of sustainability and technology as drivers of change, enabling the system to align with global urban mobility trends. The integration of strategic planning with inter-institutional collaboration is a crucial step in overcoming existing barriers and ensuring the long-term viability of public transportation. This study provides a robust framework for strategic decision-making, ensuring the evolution of the system towards a more efficient, accessible, and sustainable model.

5. Scenario Planning for the Future of Public Transport in Andalusia

The construction of prospective scenarios enables the exploration of potential futures for public transport in Andalusia. This is achieved through the analysis of key variables using the MICMAC method, Regnier's Abacus, and consultation with experts. The four scenarios, namely optimistic, pessimistic, trend, and bet, present different potential trajectories for the system, contingent on the manner in which the critical variables identified in the analysis are managed.

Optimistic scenario

In the optimistic scenario, public transportation in Andalusia will undergo a significant transformation, driven by improvements in road infrastructure and the adoption of advanced technologies (Geels, 2012). The effective management of population growth is achieved through the optimization of transportation routes and the expansion of the

transportation network. It is evident that public policies play a pivotal role in ensuring the harmonious coexistence between formal and informal transportation systems, with the implementation of effective regulatory frameworks that guarantee the efficiency of the system (Banister, 2008). The formation of public-private partnerships allows for the financing of pivotal projects, thereby facilitating a sustainable and modernized service. Furthermore, this scenario encourages the adoption of environmentally friendly vehicles, which has the additional benefit of significantly reducing carbon emissions (Cervero, 2013). The construction of new infrastructure facilitates enhanced accessibility, thereby positioning public transport as an attractive and efficient option for the population.

Pessimistic scenario

In contrast, the pessimistic scenario posits a scenario in which public transportation in Andalusia faces a decline due to a dearth of investment and planning. The lack of modernization of road infrastructure has resulted in congestion and safety issues (Rodrigue et al., 2016). The absence of financial resources precludes the implementation of sophisticated technologies, such as fleet monitoring and management systems, which ultimately impairs the efficacy of service delivery (Shaheen et al., 2015). The coexistence between formal and informal transportation systems is chaotic due to the lack of regulations, which creates an environment of unfair competition that weakens the formal system. The informal transport sector has a dominant presence in the market, which introduces uncertainty and has a detrimental impact on the mobility of users. In this scenario, the quality of service declines significantly, which has a detrimental impact on user satisfaction and local economic development (Vuchic, 2005).

Trend Scenario

The trend scenario represents a moderate evolution of the public transport system in Andalusia. In this scenario, the road infrastructure undergoes gradual improvements as a result of strategic government investments, although these are limited (Black, 2010). Technological advances, such as mobile applications for route management and electronic payment, partially optimize the service; however, they do not reach their full potential due to budget constraints (Shaheen et al., 2015). The implementation of sustainability policies is not uniform, which constrains the potential for emission reductions (Geels, 2012). Notwithstanding enhancements in accessibility and a partial reduction in travel times, informal transportation persists as a notable phenomenon, albeit with heightened regulatory oversight. This scenario suggests gradual but insufficient progress to meet long-term challenges, particularly in light of population growth and modernization demands (Banister, 2008).

Bet Scenario

The bet scenario represents the most ambitious future for public transport in Andalusia, aligned with the objectives of sustainability, technology, and efficiency that have been proposed by various studies (Rodrigue et al., 2016; Cervero, 2013). This scenario is predicated on a substantial investment in road infrastructure and the implementation of

sophisticated technologies, including real-time monitoring systems and comprehensive traffic management through the use of big data and the Internet of Things (IoT) (Geels, 2012). Strategic planning is designed to adapt in a dynamic manner to fluctuations in population growth, with the objective of effectively responding to transport demand in real time through the design of optimal routes and frequencies.

A pivotal aspect of this scenario is the revitalization of intermunicipal transportation, with a clear delineation between formal and informal services through efficacious regulations that guarantee the safety and quality of the service. The involvement of the private sector, through public-private partnerships, facilitates project financing, enabling the modernisation of the fleet with electric and hybrid vehicles and a notable reduction in CO_2 emissions (Shaheen et al., 2015).

Furthermore, this scenario is distinguished by the implementation of proactive public policies that promote sustainability and ecological mobility. The adoption of electric vehicles not only improves operational efficiency but also contributes to a reduction in the carbon footprint (Geels, 2012). Furthermore, inter-institutional collaboration facilitates the resolution of current barriers, including the lack of investment and coordination between sectors. This is achieved through the implementation of effective communication strategies and the utilisation of advanced technology to enhance traffic management and reduce travel times (Cervero, 2013).

It is similarly crucial to consider the training of operators and the enhancement of public perception of the service as integral elements of this scenario. Comprehensive training programs are essential for ensuring that staff are adequately prepared to handle emerging technologies and to provide a quality service (Vuchic, 2005). Ultimately, urban planning is aligned with the objectives of sustainable growth, with a particular emphasis on accessibility and the integration of public transportation into the urban fabric. This facilitates the mobility of citizens and reduces their dependence on private vehicles (Banister, 2008).

This scenario projects a future in which Andalusia becomes a model for sustainable and efficient mobility, aligning its transport policies with the most effective international practices, and creating a system that responds to the needs of the population, encourages investment, and promotes innovation.

Conclusion

This study offers a comprehensive examination of the public transport system in Andalusia through prospective analysis, employing techniques such as the Method of Influence by Causes (MICMAC), Regnier's Abacus, and interviews with experts. The findings indicate that the modernization of public transportation represents a complex challenge, yet it is a

crucial step in ensuring sustainable mobility in the future. This study's primary contribution is the identification of pivotal variables and their influence on prospective scenarios, which provides a strategic framework for change management in this sector.

The "bet" scenario is distinguished as the most ambitious and essential for attaining an efficient and sustainable model that is aligned with global mobility objectives. The proposed transformation includes investment in road infrastructure, the adoption of advanced technologies such as real-time monitoring, and public-private collaboration to finance fleet modernization with electric and hybrid vehicles (Shaheen et al., 2015; Geels, 2012). Furthermore, this scenario calls for the implementation of policies that reduce the carbon footprint and promote environmental sustainability (Cervero, 2013).

One of the most significant deficiencies identified is the absence of an efficacious regulatory framework to regulate informal transportation, which represents a substantial impediment to the development of an efficient formal system (Banister, 2008). Furthermore, the absence of inter-institutional coordination and budgetary constraints impede the potential for substantial improvements to the current system. To address this gap, future research must prioritize the development of regulatory strategies and the identification of new sources of funding, in addition to the improvement of public mobility policies.

In conclusion, this study underscores the necessity for a comprehensive approach to planning that prioritizes the sustainability and efficiency of public transportation in Andalusia. Future research should concentrate on the adaptation of emerging technologies, such as the Internet of Things (IoT) and big data, which will facilitate a more dynamic and precise management of the transport system. Furthermore, there is a need to promote a greater integration of public transport into urban development, with the aim of reducing dependence on private cars and improving the quality of life of citizens.

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