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ORIGINAL

Strategic guidelines for intelligent traffic control

Lineamientos estratégicos para el control de tráfico inteligente

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ABSTRACT

The objective of this study was to establish strategic guidelines to solve the existing vehicular mobility problems in the District of Riohacha, proposing the adoption of advanced technologies to optimize traffic management in the city. The methodology of the study consisted in the application of surveys and the review of relevant bibliography. The results allowed the identification of various intelligent traffic control tools used in different regions of the world, determining their applicability and benefits for the context of Riohacha, where there was a notable lack of traffic signals. It was concluded that the implementation of the technological tools proposed in this study could offer effective solutions to the mobility challenges faced by the District of Riohacha.

Keywords: Traffic Control; Technological Surveillance; Technological Tools; Traffic Signals; Intelligent Traffic Control; Vehicular Congestion.

RESUMEN

El objetivo de este estudio fue establecer lineamientos estratégicos para resolver los problemas de movilidad vehicular existentes en el Distrito de Riohacha, proponiendo la adopción de tecnologías avanzadas para optimizar la gestión del tráfico en la ciudad. La metodología del estudio consistió en la aplicación de encuestas y en la revisión de bibliografía relevante. Los resultados permitieron identificar diversas herramientas de control de tráfico inteligente empleadas en diferentes regiones del mundo, determinando su aplicabilidad y beneficios para el contexto de Riohacha, en donde se evidenció una notable falta de señales de tráfico. Se concluyó que la implementación de las herramientas tecnológicas propuestas en este estudio podría ofrecer soluciones efectivas a los retos de movilidad que enfrenta el Distrito de Riohacha.

Palabras clave: Control de Tráfico; Vigilancia Tecnológica; Herramientas Tecnológicas; Señales de Tránsito; Control De Tráfico Inteligente; Congestión Vehicular.

INTRODUCTION

Traffic control is one of the most complex and significant challenges facing the urban world today. Therefore, one of the main concerns of city leaders and representatives is to achieve optimal and efficient traffic control, for which the use of technology and innovation as an alternative to these problems has proven to be one of the most promising solutions.[(1)]

In these cases, technological surveillance is a very useful tool, which is an organized and continuous process of observation and analysis of the technological environment, capable of identifying changes and thus alerting about threats and opportunities of technological development in various sectors of the economy.[(2)]

Furthermore, Riohacha is a city, which has a slowly gradual growth in road infrastructure, in opposition

to the exponential growth of the population,3 and the use of private and public land transport. The district of Riohacha is in a critical situation in terms of vehicular mobility, with a high flow of vehicles on the streets throughout the day, according to Guamaní et al.[4] this translates into greater environmental pollution due to greenhouse gas emissions from the additional fuel consumption of vehicles stopped in traffic, higher noise levels, more traffic accidents. In addition, this situation leads to intolerance of drivers and pedestrians, recklessness and non-compliance with traffic regulations, longer driving time, uncertain arrival time, higher operating costs, pollution compared to free traffic flow.[5,6,7]

It is necessary to develop and implement strategies to improve traffic management in the district, taking into account technological advances in all areas and the relevance that technologies can have for mobility and traffic management. There are several tools that can help maintain traffic capacity and improve safety, and the key is to identify them early by reviewing the bibliography through technological surveillance of different documents or articles related to technological tools for intelligent traffic control and make decisions for their acquisition.[8,9,10,11]

This research focuses on the implementation of technological surveillance as a tool for intelligent traffic control in the district of Riohacha. Its objective is to identify technological tools that can help improve traffic management in the region. For this, it is based on the fact that there are several problems with the flow of vehicles in this area due to various factors, one of which is the massive increase of vehicles that has occurred in the city, causing traffic jams. And the number of accidents has also increased. In addition, there is no proper traffic management system in this area and no type of technology is used for this system.[12,13,14,15]

METHODS

Research Type

This study adopts a mixed-methods approach, integrating quantitative and qualitative data that will be collected, analyzed, and merged into a single study. According to Hernández Sampieri et al.[16] all research is based on two fundamental approaches: quantitative and qualitative, which when combined give rise to a third approach, known as the mixed method. This study is classified as descriptive, as it aims to portray the current state of traffic management in the District of Riohacha with the purpose of proposing technological tools for intelligent traffic control, addressing the mobility challenges the district faces due to accessibility issues. The design of this research is non-experimental, cross-sectional, and field-based.

Population and Sample

The study was developed in the District of Riohacha and considered as the population the entity responsible for traffic management in said district, the District Transit and Transportation Institute of Riohacha (INSTRAMD). This is a finite population, as detailed in Table 1.

Population	No.	%
Managers	3	14,29
Operational Management Area	9	42,86
Administrative and Financial Area	5	23,81
System and Technological Support Area	4	19,05
Total	21	100

Source: own elaboration.

Given the small size of the INSTRAMD staff population in Riohacha, it was decided to use the complete population census, that is, the entire population was taken as a sample (n=21).

Data Collection Instruments

For data collection in this project, a closed Likert scale questionnaire, developed by the authors, was used first, containing a total of 36 items. Each item presented five (5) response options: Strongly Agree, Agree, Neither Agree nor Disagree, Disagree, Strongly Disagree. This tool was used with the sample composed of INSTRAMD staff in Riohacha.

In addition, an exhaustive literature review was carried out to establish the theoretical framework, focusing on the two (2) research variables: intelligent traffic control and technological surveillance.

RESULTS AND DISCUSSION

Description of the current state of traffic control in the district of Riohacha

Through this study, the current state of traffic control in the district of Riohacha was determined, through

the application of a closed Likert scale questionnaire from which the following results were obtained.

Table 2. Dimension: Current status of traffic control in the Riohacha district

Ítems	Indicators	Arithmetic mean	Category	Standard deviation	Category
1,2,3	Signs	3,81	High	0,92	Very low dispersion
4,5,6	Regulatory	3,68	High	0,94	Very low dispersion
7,8,9,10	Preventive Signs	2,50	Low	1,22	Low dispersion
11,12	Informative signs	3,76	High	1,00	Low dispersion
13,14	Transitory signs	1,38	Very Low	0,65	Very low dispersion
15	Variable message signs	2,57	Low	0,85	Very low dispersion
16,17	Stop line	2,00	Low	0,82	Very low dispersion
18,19	Passing zone	2,62	Moderate	0,84	Very low dispersion
20,21,22,23	Curb markings curb markings	3,49	High	1,22	Low dispersion
24,25	Vehicular traffic signals	2,05	Low	1,02	Low dispersion
26	Pedestrian traffic signals	1,38	Very low	0,58	Very low dispersion
27,28	Traffic sensors or detectors sensors or detectors	1,12	Very low	0,32	Very low dispersion
29	Traffic light programming	2,33	Low	0,84	Very low dispersion
30,31	Intelligent traffic lights	3,02	Moderate	0,77	Very low dispersion
32,33,34	Condition and maintenance of signals	2,08	Low	0,88	Very low dispersion
35,36	Citizen knowledge and culture	2,98	Moderate	1,28	Low dispersion
Dimensión		2,7	Moderate	1,3	Low

Source: own elaboration.

Among the most notable findings of the study, it was discovered that only 29 % of respondents agreed that the district of Riohacha has regulatory traffic signs. Similarly, 47 % of participants agreed with the adequate presence of preventive traffic signs on the district's roads, while only 5 % expressed disagreement. Regarding the existence of informative traffic signs, 52 % of respondents disagreed, and none of the respondents agreed. On the other hand, 57 % agreed that preventive signs are used during the execution of works in the district of Riohacha.

In line with these results, 76 % of respondents were completely in disagreement with the existence of variable message signs in the district of Riohacha. In terms of traffic sensors or detectors, 67 % were completely in disagreement with their presence, and 95 % were completely in disagreement with the existence of a traffic control center that allows real-time monitoring of roads.

These findings reveal that the district of Riohacha has various traffic devices, such as regulatory, preventive, and temporary signs, vehicular and pedestrian traffic lights. Likewise, an adequate quantity of these devices for the control of vehicle and pedestrian traffic is perceived. However, it was observed that the district lacks essential elements for traffic control, such as informative signs, stop lines, and crossing zones. In addition, it was found that the district does not have state-of-the-art traffic lights that allow efficient traffic management, but continues to use traditional traffic lights with obsolete technology, which are not sufficient to address the district's current mobility problems.

On the other hand, a low level of knowledge among drivers and pedestrians about different traffic control signs and their function was detected. In addition, a low level of civic culture among the users of the district's roads and moderate control in vehicle and pedestrian circulation was observed.

Likewise, it was evident that the district does not employ vehicular and pedestrian traffic detection elements, such as traffic sensors or detectors. In addition, traffic lights are not programmed based on real-time vehicular flow, but have a preset programming that does not allow efficient control of vehicular flow.

Strategic Guidelines for Intelligent Traffic Control in the District of Riohacha

From the results obtained in this study, and through the literature review of various information sources to analyze the technological tools used in intelligent traffic control, elements applicable to the district were identified. Consequently, strategic guidelines for intelligent traffic control in the district of Riohacha were

proposed.

To define the strategic guidelines, the definition of intelligent traffic control systems proposed by Quiñonez et al. was taken as a basis: "ITS are essentially the fusion of development in computing, information technology, and telecommunications combined with the automotive and transportation sector. ITS can then be defined as the application of computer, information and communications technologies to real-time management of vehicles and networks involving the movement of people and goods." Considering this definition, Table 3 presents the strategic guidelines for intelligent traffic control in the district of Riohacha.

Table 3. Strategic guidelines for intelligent traffic control in the district of Riohacha

Guidelines	Strategic actions
The district of Riohacha must formulate	Formulate all strategic actions and establish a Mobility Plan to be carried out in order to build a safe city. control traffic in the district, with a view to improving mobility and establishing measures to control the excessive increase in automobile traffic.
To carry out campaigns to generate	Conduct lectures and campaigns on road culture by the people where the inhabitants of the district of Riohacha are sensitized on the proper use of traffic signs and road culture. Incentivize through different strategies the inhabitants of the district of Riohacha to have a road culture. Create suitable spaces so that the inhabitants of the district can have knowledge about everything related to road culture.
Strengthen the entity in charge of regulating traffic control in the district, Instramd.	Establish concrete actions to improve the operation of the transit and transportation institute of the district of Riohacha. To carry out a technological modernization of the tools used by Instramd to offer better mobility in the city.
Implementing a traffic control center in the district of Riohacha	Establish the necessary requirements to create a traffic control center. Formulate a project for the creation of a traffic control center in the district of Riohacha. Develop all necessary actions to carry out the construction and implementation of the traffic control center.
Provide the Riohacha district with the different technologies proposed in Table 4.	Establish the necessary requirements for the implementation of the different technologies for intelligent traffic control in the district. Generate strategies for the necessary financing for the implementation of the different technologies in the district. Formulate and execute projects for the implementation of the different technologies for intelligent traffic control in the district.

Source: Own elaboration

Table 4. Intelligent traffic control elements applicable to the Riohacha District

Name	Implementation benefits
Intelligent traffic lights 	• Manage vehicle traffic more efficiently. • Adjust speed holding for continuous flow rather than general control and harmony. • Can be programmed remotely according to current flow requirements. • Significantly reduce waiting time. • Reduce pollution by reducing vehicle waiting time.[19]

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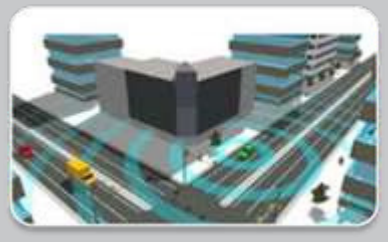
Variable message signs 	• Provide information to users on the go. • Communicate with tourist information and activities. • Distribution of real-real-time traffic information. • Warning of severe environmental conditions such as rain, fog, thunderstorms.[20]
Closed-circuit television (CCTV) 	• Provide information to users on the go. • Communicate with tourist information and activities. • Distribution of real-time traffic information. • Warning of severe environmental conditions such as rain, fog, storms.[20] • Allow operators to identify and verify events that control the command center. • Enable automatic recording of events. • Allows capture of traffic information such as intensity, congestion, average speed, number of vehicles and distance between vehicles. • Allows control center operators to make informed and timely decisions to resolve incidents in the shortest possible time.[21]
Electronic photodetection system 	• Reduce traffic violations. • Reduce the number of accidents. • Improve road culture.[21]
Traffic sensors or detectors 	• Enable the detection of accidents and emergency situations. • Provide real-time access to relevant information about road conditions. • Incident detection and resolution • Allows you to monitor and control speed • Allows you to monitor and publish weather and road conditions.[22]
Operation and data processing center 	• Enable the detection of accidents and emergency situations. • Provide real-time access to relevant information about road conditions. • Enable detection of infractions • Incident detection and resolution • Allows you to monitor and control speed • Allows you to monitor and publish weather and road conditions.[21]

Source: Own elaboration.

CONCLUSIONS

The results of the research aimed at proposing technological tools to optimize traffic control in the district

of Riohacha, allow us to present the following conclusions:

Globally, various cities have resorted to various technologies to regulate both vehicular and pedestrian traffic. Although the impact of these strategies has varied, in general, such technologies have demonstrated significant benefits in terms of urban mobility, addressing certain inherent needs of traffic control systems and facilitating more effective management.

It was identified that intelligent traffic control systems apply a series of strategies and actions aimed at mitigating the negative impact of vehicular traffic. These improve response times to incidents, regulate and control traffic, and contribute to reducing the accident rate.

In a large part of intelligent traffic control systems, five fundamental technological components are evident to guarantee efficient mobility: the electronic recording of traffic infractions, video surveillance, variable information panels, user information systems, and support for traffic light network planning. All these elements must be integrated into a traffic management center for proper monitoring and control of urban mobility.

It was possible to determine which elements of intelligent traffic control are applicable in the district of Riohacha, and the potential benefits that each of these could bring to the district's mobility were established. Among these elements are: intelligent traffic lights, variable message signs, closed-circuit television, electronic photo detection systems, traffic sensors or detectors, and a data operation and processing center.

The district of Riohacha will need to design and implement a mobility plan that defines the necessary operations and strategies for effective traffic control. This plan should focus on improving mobility and establishing measures to control the excessive increase of the vehicle fleet.

It is imperative that the district of Riohacha generates a road culture among its inhabitants through various strategies, such as awareness campaigns and talks, to highlight the importance of complying with traffic signs and promoting a responsible road culture.

Finally, the district of Riohacha must implement strategies that strengthen the transit and transport institute, modernize the tools used for traffic control, and train the staff in charge of the entity. Likewise, it is necessary to generate an integration between the Instramd and the district mayor's office for better ordering of actions aimed at improving the district's mobility.

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