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Sustainable Urban Mobility Plan and its Influence on The Planning of Sustainable Transportation

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Abstract:

The development of cities is due in part to the quality offered in transportation, therefore, this research aims to determine how the SUMPs influence the integrated planning of sustainable transport in Trujillo. This project presents the perception of the SUMPs and comprehensive planning to improve the service of the north-south corridors. The methodology used was a quantitative approach based on the application of a questionnaire with the survey technique that confirmed that a holistic planning of the SUMP is needed, which would have an impact on better sustainability indexes, it has a descriptive-correlational scope with a non-experimental design. The study was carried out in Trujillo with 196 citizens, selected by means of a sample. The results were obtained using SPSS version 26 statistical analysis, which confirms that there is a considerable positive correlation of 0.737 between the study variables. This analysis allows, as a contribution, to propose strategies and report on the implementation of sustainable mobility with efficiency in the integrated system, thanks to the participation of the local population, experts and decision-makers, the latter two, who will make decisions that offer efficient and sustainable solutions.

Key words: SUMP, integrated transport planning, mobility, sustainable transport , public transport.

Introduction:

Sustainable urban mobility is a phenomenon that is not only local but also a global problem. Over the years, not only the population has increased, but also the vehicle fleet, pedestrian and bicycle mobility. In this sense, traffic is one of the causes and largest sources of pollution, an idea analyzed by the WHO and the European Environment Agency.**[1].**Faced with this, initiatives for changes in the environmental aspect emerged. For example, the European Commission**[2]**through its publication "The Green Book". In 2015, a summit in New York established 17 objectives and 169 goals that are related to the mobility of people and the sustainability of industries. Likewise, the SDGs were postulated, which are expected to be achieved as an agenda by 2030, it is worth highlighting objective 11, which deals with Cities and Communities, where it is emphasized that there must be self-sustainable, inclusive transportation planning, at accessible costs, eco-efficient and profitable [3]. The bibliographic review shows that cities show an increase in population every year, which generates social problems, one of them in transportation systems, which are intended to be sustainable [4]. Reality then requires analyzing how SUMPs influence in comprehensive sustainable transportation planning.

[5]. Various European studies reported that planners and policy makers are called upon to promote sustainability and thus reduce the negative environmental impact. [6] In Europe, many urban areas still frequently exceed the permitted concentration levels of particulate matter and nitrogen dioxide, which affects the health of citizens due to poor air quality. What is proposed is that this can be improved with interventions in the transport sector through plans in cities with the SUMP, for the studies they used the T-Net/Transtools model methodology and the Sherpa model. In this same sense, [7] ,[8], [9] proposed using the Promethee method to know the level of progress of the capitals of the European Union in the aspect of proposing and applying the SUMP. The results showed that cities that have a comprehensive transportation plan have achieved the best results in having sustainable cities with fewer emissions of nitrogen oxides and particulate matter. [10] According to ONU figures, 70% of people on the planet will live in cities by 2050, so the demand for better transportation services that adapt to collective and individual needs must be responded to the population. This is where governments and organizations must execute strategies that allow them to respond to these challenges. [11], environmental sustainability must be based on urban logistics measures and must be based on urban mobility plans, thereby achieving a quality of life.

In addition to this, in Latin America and the Caribbean it is known that there is inequality at the socioeconomic level, which is also reflected in the problem of non-inclusive public transportation[12].As a solution strategy, for example, there is the sustainable urban mobility platform called "MobiliseYourCity", which is financed by the European Union that proposes the implementation of the SUMP. In this sense, cooperating entities such as the French Development Agency (AFD), the German cooperation and the Bank of Germany (KFW), finance the SUMPs that contribute to reducing GHGs, generating correct comprehensive sustainable transport planning. In cities[13] ,[14]such as Bogotá, Buenos Aires, Curitiba, Mexico City and Rio de Janeiro even have mobile applications that offer transportation services, they maintained that business trips are the ones that generate the most congestion during peak hours in the city and that is why it is It is essential to execute mobility plans as solution strategies for sustainable modes of transport. [15] They emphasized that adequate mobility should respond in part to the perception of citizens in order to delimit a sustainable plan [16] and that due to the urbanization process, cities must be planned taking into account the mobility of people. For the study, pedestrians and cyclists were taken into account, based on this it provided management strategies for the mobility model to improve the environmental environment.

In Peru, a problem is that it is believed that Lima , the capital , is the transport model with its integrated system, but there is a deficit of specialists in local governments that are unaware of the PMUS and hire the services of supposed experts, bicycle lane networks were executed in the interior of the country with zero planning in the Covid 19 pandemic. After this period, congestion problems were generated at the national level, rejection and withdrawal of the infrastructure of the provisional bicycle lanes by residents. Specifically in Trujillo, which is the unit of analysis As part of the diagnosis carried out, weak governance is perceived in urban transportation, reflecting an inefficient, low-quality service, non-inclusive infrastructure, poor traffic management and few local policies to increase non-motorized mobility for better transportation. It is worth mentioning that [17], sustainable cities solve problems, and that some cities, suffer from urban planning. It is of vital importance, the application of the SUMP in comprehensive transportation planning through technological tools to examine the north-south corridor in the city of Trujillo in Peru, based on pre-existing models. In this sense, the research aimed to determine the influence of the PMUS Sustainable Urban Mobility Plan on comprehensive transportation planning through technological tools to examine the north-south corridor in Trujillo. In addition, identifying the demand for the trunk road network and analyzing unsatisfied demand. Therefore, the research question was posed: To what extent does the PMUS Sustainable Urban Mobility Plan influence comprehensive transportation planning in Trujillo?

According to the study variables, sustainable urban mobility are policies related to transportation and circulation that aim to correctly use urban space through non-motorized forms and collective transportation in

an effective, inclusive and sustainable manner with a focus on human beings [16] [18]. It is understood that sustainable transportation involves achieving an appropriate balance between present and future environmental, social and economic elements [19]. The PMUS are a set of actions that aim to establish more sustainable ways to move around the territory by walking, pedaling or using public transportation so that energy consumption and GHG emissions are reduced. These measures can improve living conditions. people's lives, democratization and economic well-being. [20] ,[21]. To prepare the SUMPs, the active participation of the local population must necessarily be included, socialization campaigns, continuous monitoring and evaluation [22] ,[18]. On the other hand, there must be a transportation assistance system. public that must address the following aspects: occupancy, transfer, luggage transportation, security of connections, number of passengers in vehicles, this must work correctly to avoid inconveniences when transporting shopping bags or luggage [23] ,[24] The shape of the city and how the land is distributed allows us to locate the emission sources and the urban traffic pattern, which generates the quality of the urban atmosphere. [25] They emphasized that cities are places of innovation and wealth creation; However, many currently prioritize the use of private motor vehicles, which contributes to low levels of physical activities and high levels of environmental pollution, which is why several experts stated that sustainable transportation infrastructure such as bicycles should be prioritized. walking and accessing public transportation with road corridors, for example in the case of our country.

Method:

To achieve the objectives of this research, a quantitative approach was applied, which consisted of collecting, analyzing and linking quantitative data to measure the study variables: PMUS and Transportation Planning. Furthermore, the research according to the purpose was of an applied type since it allowed us to analyze the current transportation and traffic situation in Trujillo to propose strategies. Likewise, it had a descriptive-correlational scope, since it allowed us to know not only the properties of the variables but also to evaluate the relationship between them. Since the study variables were not manipulated, it was a non-experimental design[27].The province of Trujillo in Peru was delimited as the study area. The cadastral plan was taken into account to delimit the avenues and streets where the north-south corridor will circulate. Based on existing documents from the municipality of Trujillo and the TransCad digital tool, the road, trunk and unsatisfied demand was determined. It should be noted that this is part of geostatistical evaluation instruments that allow data to be obtained through figures and tables on the variables and thus have the indicators [13] ,[26]. The Universe was made up of the citizens of Trujillo, who according to the INEI number 811,979 inhabitants. Therefore, a non-probabilistic sample has been determined for convenience, the reason is because the population is too large. Thus, to achieve the objectives, the sample consisted of 196 citizens (workers, experts on the subject, pedestrians and cyclists) who They will use the PMUS of the north-south corridor of Trujillo. In addition, a survey was used as a data collection technique with a questionnaire consisting of 14 items that reflected the dimensions of the SUMP and transportation planning, each question was evaluated through a Likert-type scale. The reliability of the variables was measured through Crombach's Alpha, which determined that it is above the allowed scale (p value > 0.7) with good internal consistency for a unidimensional scale.

Regarding the procedure, for field work, a log was used to record the results of the observation, which was then systematized in statistical programs. Likewise, through official documents and reports, a diagnosis of Trujillo's urban mobility was made, which was reflected in figures and tables. Before applying the survey, the project and purpose were briefly explained to motivate the support of the citizens of Trujillo. Then the instrument that was the questionnaire was applied. Finally, after acquiring the information to obtain the results.A statistical analysis was done with Excel vs. 13 and SPSS vs. 26 for the respective processing. It should be noted that the reliability of the questionnaire and the content validity were consulted with methodological experts to evaluate the items that were used. In Peru, the PMUS have become a basic tool for planning multimodal mobility systems, achieving the interconnection of urban centers prioritizing the mobility of people in cities. The SUMPs identify strategic projects that become Investment Projects in the transport

sector because they are motivated by international cooperating entities that finance the formulation and execution of the project. , being verified by the MEF. The Universe was made up of the citizens of Trujillo, who according to the INEI number 811,979 inhabitants. Therefore, a non-probabilistic sample has been determined for convenience, the reason is because the population is too large. Thus, to achieve the objectives, the sample consisted of 196 citizens (workers, experts on the subject, pedestrians and cyclists) who They will use the PMUS of the north-south corridor of Trujillo. In addition, a survey was used as a data collection technique with a questionnaire consisting of 14 items that reflected the dimensions of the SUMP and transportation planning. Each question was evaluated through a Likert-type scale, which It ranges from no measurements (0) to very good measurements (5). The reliability of the variables was measured through Crombach's Alpha, which determined that it is above the allowed scale (p value > 0.7) with good internal consistency for a unidimensional scale. Additionally, the observation technique was used through the respective observation guides, since the North-South road corridor of Trujillo was visited, to photographically record the road infrastructure. On the one hand, for field work, a log was used to record the results of the observation, which was then systematized in statistical programs. Likewise, through official documents and reports, a diagnosis of Trujillo's urban mobility was made, which was reflected in figures and tables. Before applying the survey, the project and purpose were briefly explained to motivate the support of the citizens of Trujillo. Then the instrument was applied, which was the questionnaire that took citizens 20 minutes to respond, of course with their respective voluntary acceptance. Finally, after acquiring the information to obtain the resultsA statistical analysis was done with Excel vs. 13 and SPSS vs. 26 for the respective processing. It should be noted that the reliability of the questionnaire and the content validity were consulted with methodological experts to evaluate the items that were used.

Results and discussion:

The SUMPs play an important role in addressing the growing mobility needs of cities [29] [30] establish that it is important to determine the design capacity and speed of the roads. Figure 01 shows the Hierarchy of roads in the City of Trujillo, according to the adaptation of the MPT. The roads are classified into: (a) Metropolitan Articulation Roads that constitute 49% of the total, which have characteristics of arterial roads that run through several districts, (b) Urban Articulation Roads with 27%, also called collectors, the which provide accessibility to local and traffic-signalized roads and (c) Regional or national articulation roads with 24%, known as express roads that feed arterial roads.

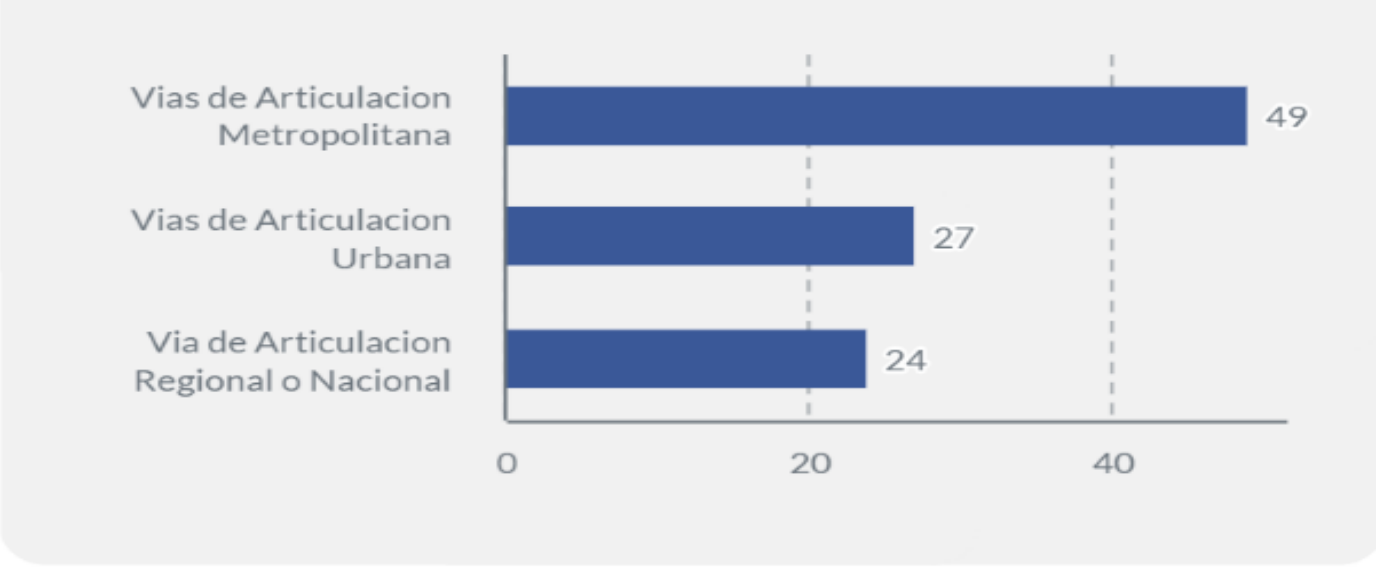

Fig. 1: Hierarchy of roads in the Metropolitan City of Trujillo. Adapted from PMUS, MPT,2022

Regarding the north-south corridor (Figure 02), the route of the bus rapid transit (BRT) route is shown, which have large capacity. Additionally, the layout of 3 feeder routes is observed where 9-meter buses will circulate, which currently provide the service. Likewise, all the whereabouts are appreciated. The map allows you to analyze the current situation that is used as a solution strategy for the SUMP as Comprehensive Planning of the Transportation System.

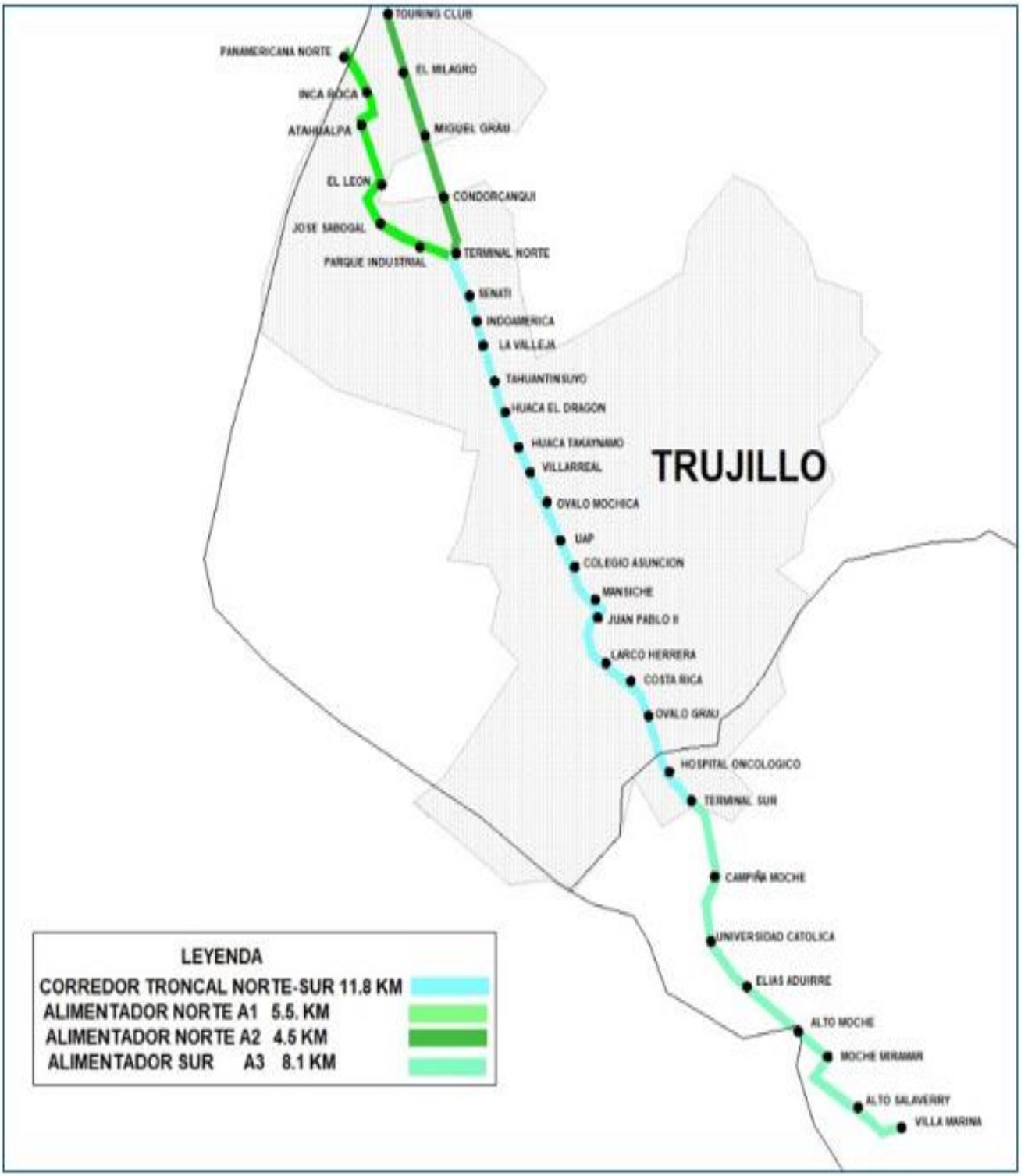

Fig. 02 Trujillo North South Corridor

In Figure 3,regarding travel demand, it is a tool that is used to determine the ideal transportation for each city. This data was obtained thanks to the collection of information from the MPT. In this regard, in 2026, as can be seen, the largest number of fleets will be made up of 18-meter BRT buses (69%), which will be exclusive, the BRS A1 feeder route (16%) are 9-meter microbuses and are divided by 3 feeder routes being the one with the greatest demand because it continues the BRT route to the north, the BRS A3 (13%) 9 meter minibuses, which is the one that continues to the south and finally the BRS A2 (2%) whose route is northwest. As seen in the projection to 2045, this has been maintained over the years, which allows us to deduce that to guarantee and provide sustainability to travel demand, new lines of feeder routes could be generated or existing ones modified. The fuel that will be used in the corridor is CNG, this will mitigate GHGs, there is also the possibility of changing to electric buses, however, some experts in the field affirm that the cost is high.

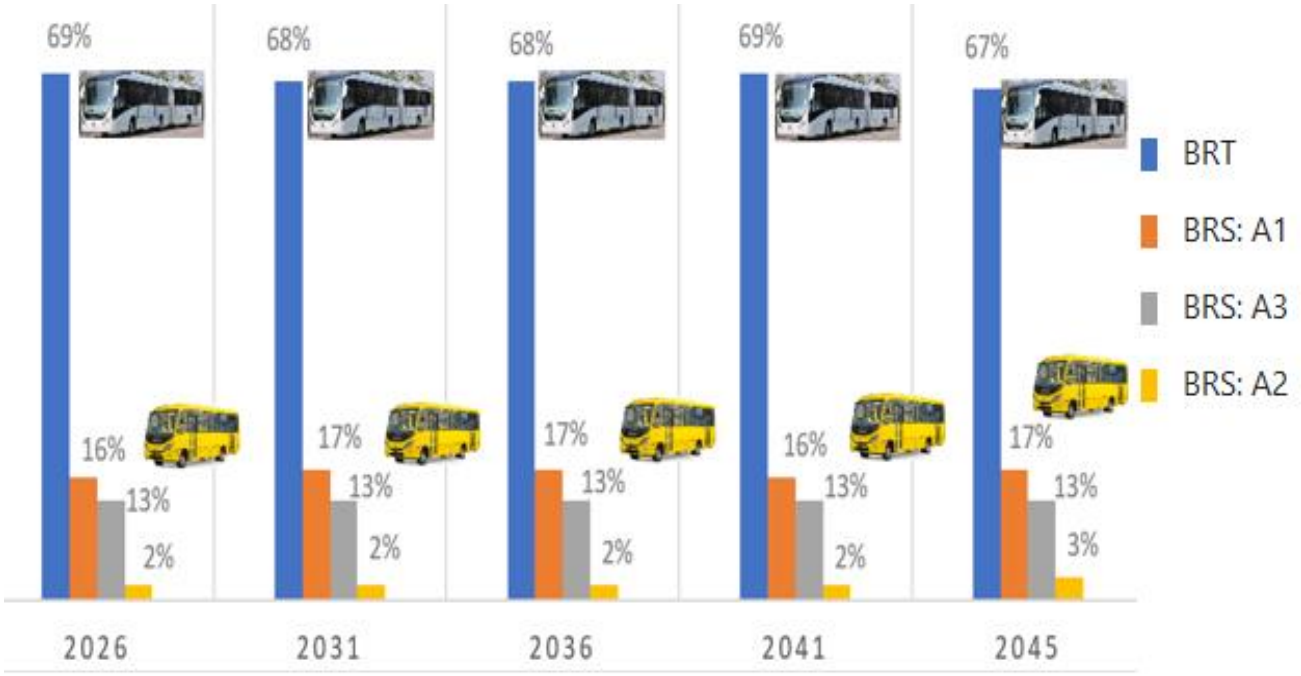

Fig.3: Travel demand (2026-2045)

In Figure 4 ,regarding the number of trips, by 2026 it is estimated that 92,577 will travel on the BRT, 21,726 on the BRSA1, BRSA 17,076 and BRSA2 2,486 respectively, making a total of 133,865 daily trips. A factor that can vary these estimates It is constituted by migrations, mainly of Venezuelans. That is why the demand has to be updated periodically so that costs do not increase and, above all, it is profitable and self-sustaining, since the Ministry of Economy does not give subsidies for operational costs.

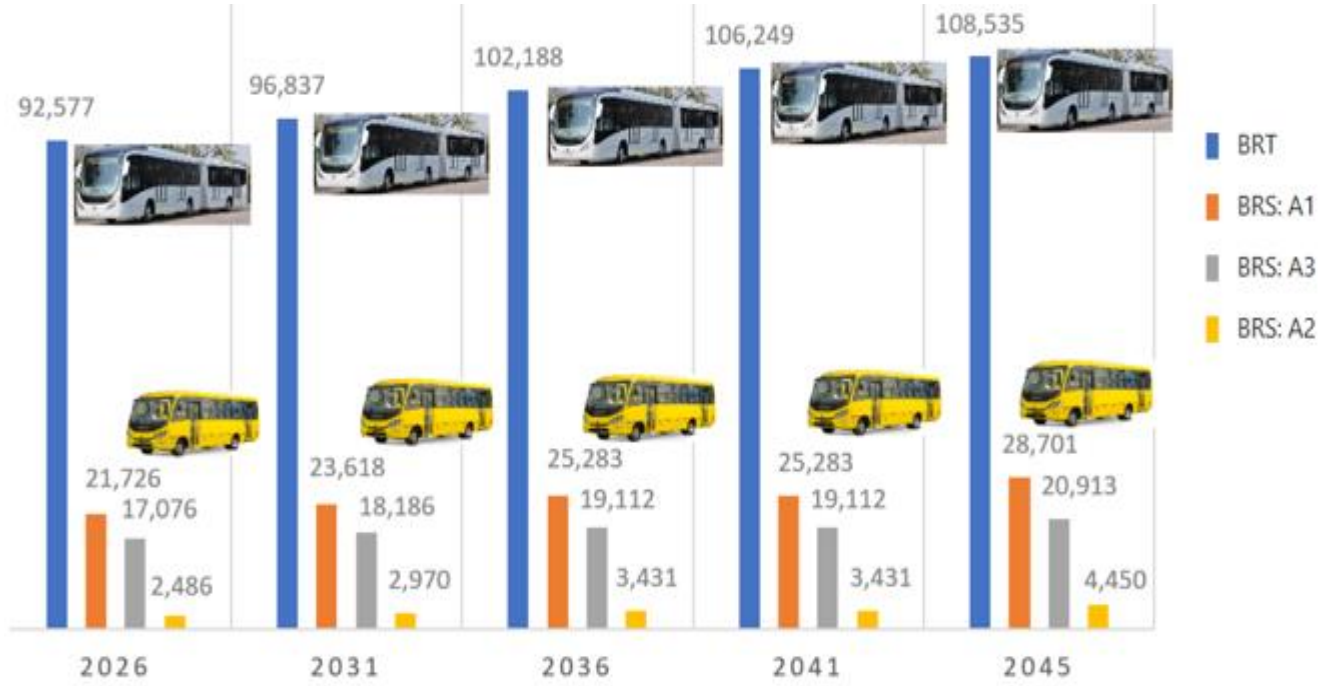

Figure 04 ***Number of trips (2026-2045)***

The figure 5 shows that for 2026 to 2045 the average fleet is maintained over time and that the majority will be assisted by BRT buses since these will cover the trunk corridor. However, feeder routes could be increased to cover greater demand and maintain the profitability of the system and mitigate unsatisfied demand.

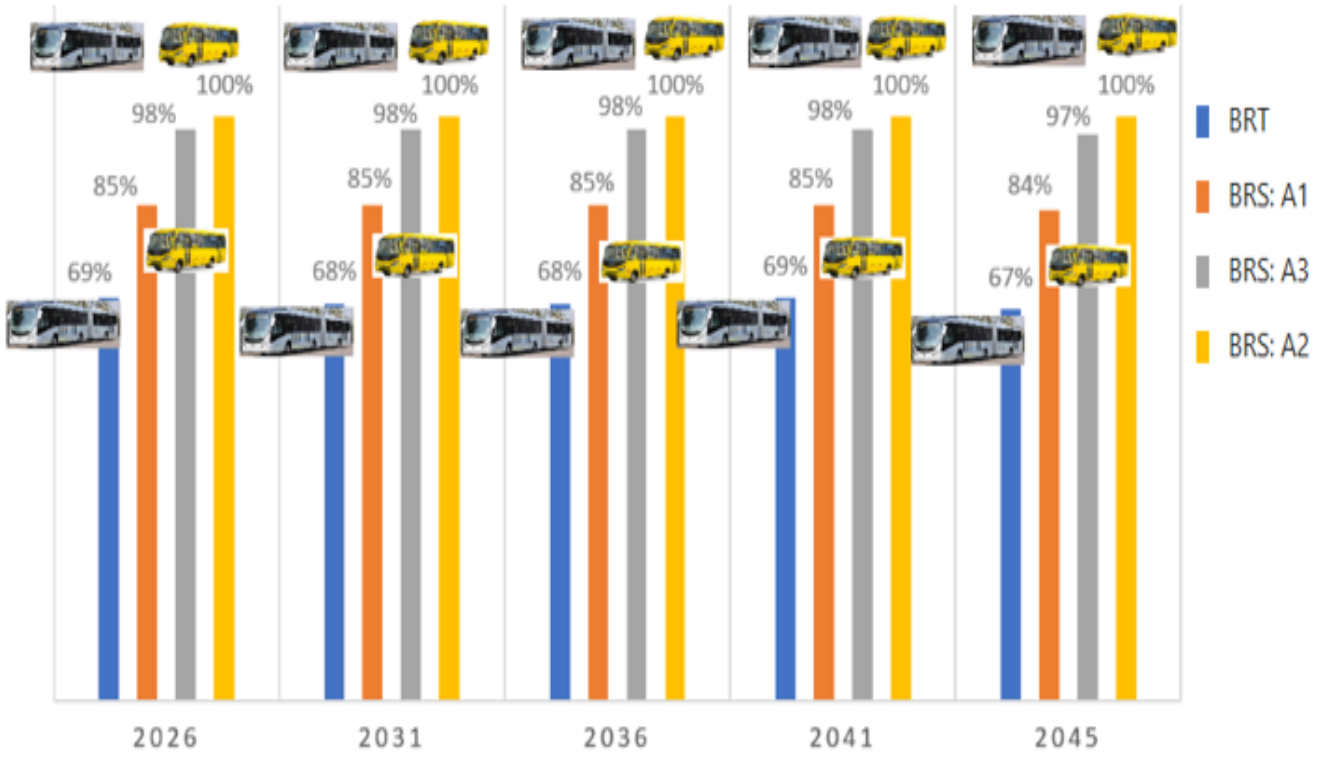

Fig.5: Cumulative percentage of the corridor fleet (2026-2045)

With respect to passenger capacity, in figure 6 ,the public transportation system is assisted by conventional 12-meter buses for average demand and for low demand by 9-meter microbuses. In such a way, when there is a lot of travel demand, it is assisted with BRT buses measuring 18 meters or more, having characteristics similar to a metro or tram system. In the north-south corridor, the trunk route will be covered by BRT buses with an average capacity of 140 passengers, which is assumed to have a constant frequency during peak and off-peak hours. . The figure also shows the 3 feeder routes that will attract passengers to the trunk corridor, guaranteeing demand. These routes are winding, which is why the vehicles are not large (9 meters) so that they have less risk of economic loss in the event of little demand unlike a conventional 12 meter bus, if demand increases, therefore the frequency. Regarding conventional buses, these do not exist because the demand is uncertain unlike large cities like Metropolitan Lima.

Fig. 6: Passenger capacity by type

The following, it is a Descriptive Analysis of the Study Variables:

a. Level of the Comprehensive Transportation Planning Variable

Table 01 Levels obtained for the Comprehensive Transportation Planning Variable of the city of Trujillo.

Level	Respondents	%
Negative	53	27.04%
Regular	142	72.45%
Positive	1	0.51%
Total	196	100.00%

Note: Data analysis in IBM SPSS Statistics Vs. 26. Own preparation.

In the table we observe that of all those surveyed, 27% have a negative opinion regarding Comprehensive Transportation Planning in the city of Trujillo, 72% specify that planning is neither good nor bad and 1% consider comprehensive planning positive. of transportation in the city.

b. Level of the Sustainable Urban Mobility Plan (SUMP) Variable

Table 02. Levels obtained for the Sustainable Urban Mobility Plan Variable (PMUS). from the city of Trujillo

Level	Respondents	%
Inadequate	4	2.04%
Regular	3. 4	17.35%
Suitable	158	80.61%
Total	196	100.00%

*Note.*Data analysis in IBM SPSS Statistics Vs. 26. Own preparation.

In the table we observe that of all those surveyed believe that the development of the Sustainable Urban Mobility Plan for the city of Trujillo is adequate by 81%, that it is neither adequate nor inadequate by 17% and that it is not adequate by 2%.Now, regarding the Normality Test, for the study variables: Comprehensive Transportation Planning and Sustainable Urban Mobility Plan (PMUS), the following results are obtained.

Table 03: Normality test for study variables

Pruebas de normalidad

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Estadístico	gl	Sig.	Estadístico	gl	Sig.
V1: Planificación Integral del Transporte	,185	196	,000	,945	196	,000
V2: Plan de Movilidad Urbana Sostenible (PMUS)	,204	196	,000	,839	196	,000

*. Esto es un límite inferior de la significación verdadera.

a. Corrección de significación de Lilliefors

From the analysis carried out, it was considered correct to use the Kolmogorov-Smirnov test; Because the sample considered for the present study was above 50 informants, otherwise the Shapiro-Wilk test would be used.It is observed in this analysis that the statistic for the Comprehensive Transportation Planning variable has obtained a value of 0.185 and that the value of statistical significance (p) has been 0.000, that is, less than 0.05 and, therefore, it is rejected. Ho and Ha is accepted, which means that the variable does not follow a normal distribution.

Likewise, for the variable Sustainable Urban Mobility Plan (PMUS), a value of 0.204 has been obtained; the value of statistical significance (p) has been 0.000, that is, less than 0.05 and, therefore, Ho is rejected and accepts Ha, which means that the variable does not follow a normal distribution. Based on these results, it is interpreted that both variables do not follow a normal distribution, therefore it is correct to apply non-parametric tests, which in the case of correlation and the nature of the collected data, the execution of Spearman's Rho correlation test is ideal.

c. Relationship between variables: Comprehensive Transportation Planning and Sustainable Urban Mobility Plan (PMUS)

Table 4 Correlation of study variables

Correlaciones

			V1: Planificación Integral del Transporte	V2: Plan de Movilidad Urbana Sostenible (PMUS)
Rho de Spearman	V1: Planificación Integral del Transporte	Coeficiente de correlación	1,000	,737**
		Sig. (bilateral)	.	,000
		N	196	196
	V2: Plan de Movilidad Urbana Sostenible (PMUS)	Coeficiente de correlación	,737**	1,000
		Sig. (bilateral)	,000	.
		N	196	196

**. La correlación es significativa al nivel 0,01 (bilateral).

H1: There is a relationship between the Sustainable Urban Mobility Plan (PMUS) and Comprehensive Transportation Planning (Alternate Hypothesis)

H0: There is no relationship between the Sustainable Urban Mobility Plan (PMUS) and Comprehensive Transportation Planning (Null Hypothesis)

According to the results of the Spearman Rho correlation test between: Comprehensive Transportation Planning and the Sustainable Urban Mobility Plan (PMUS) of the 196 respondents in the Province of Trujillo, there is a correlation coefficient of 0.737, according to the scale of Correlation, indicates that there is a considerable positive correlation. The bilateral significance value (Sig.) is also 0.000, and it is also direct, therefore the null hypothesis is rejected and the alternative hypothesis is accepted, the Sustainable Urban Mobility Plan does influence the perception of the Comprehensive Urban Planning. Transportation in the city of Trujillo.

The Matrix is shown for the levels of the variables Comprehensive Transportation Planning and Sustainable Urban Mobility Plan (PMUS) (Exploratory Analysis)

Table 5: Contingency table for the levels of the study variables

Tabla de contingencia						
			Plan de Movilidad Urbana Sostenible (PMUS)			Total
			Inadecuado	Regular	Adecuado	
Planificación Integral del Transporte	Negativa	Recuento	4	30	19	53
		% del total	2,0%	15,3%	9,7%	27,0%
	Regular	Recuento	0	4	138	142
		% del total	0,0%	2,0%	70,4%	72,4%
	Positiva	Recuento	0	0	1	1
		% del total	0,0%	0,0%	0,5%	0,5%
Total		Recuento	4	34	158	196
		% del total	2,0%	17,3%	80,6%	100,0 %

In the graphic representation we observe in an exploratory manner without applying a statistical test that the levels are related in that those who have a negative opinion of planning consider it regular and appropriate to have a SUMP in the city to improve the reality of transportation.

The objective of the research was to determine the influence of PMUS on comprehensive transportation planning through technological tools to evaluate the north-south corridor in Trujillo, in a sample of 196 citizens. The data obtained show a considerable positive correlation between the variables, which allows us to affirm that the PMUS does influence the perception of Comprehensive Transportation Planning, since it has been evident in the collection of information that the people of Trujillo believe that the PMUS I would order the city, significantly improving the quality of life of Trujillo residents, which is consistent with previous studies that indicate that the PMUS allows achieving Sustainable Urban Mobility with accessibility for all, improving the urban environment, in ways that are more respectful of ecosystems, promoting integration of other modes of transport, with a holistic approach [31], [32]. [9].

The results showed that the measures to regulate parking are partially complied with. It highlights that to improve the comprehensive plan, logistics must be analyzed in relation to this issue as stated [33]. The use of the bicycle has not been standardized as a means of transportation, which is partly due to what they maintain [16] who affirm that the infrastructure must be available for this modality. Likewise, measures to promote mobility on foot are still in process, there are authors such as [11]; [34], who agree in proposing the “Car-Free Day” to democratize public space with more sustainable and inclusive territorial and urban development. Additionally, there are still few measures of modal integration, a statement that is corroborated by [16]. If carried out, it would be a factor to reduce the types of environmental pollution, having a positive impact on pedestrian environments. Also, there is a perception of poor road safety that has become a problem that affects the high rate of fatal accidents [33]. The city is affected by pollution, by the increase in GHGs, therefore experts point out that there must be a panoramic review of international and national agreements because if this continues there will be a negative impact on public health [36]. Participants stated that there is still little citizen participation, which makes it difficult to know and integrate the Transportation Plans[31].

On the other hand, regarding the designs and modifications that have been made to the public space, there is good acceptance by citizens, who consider that it is a factor to improve the sustainable mobility of workers in the different industries that exist in the city of Trujillo. , this improves the system and travel efficiency [32] which is confirmed with the prioritization of the restructuring of the existing road by implementing basic networks [16] In particular, the results indicate an acceptance of the operation of the Integrated Bus System,

which will improve the timesoftrip and the quality of Service[34] which must have permanent evaluation and monitoring [35] in which said system has its own self-sustaining budget and does not depend on subsequent subsidies from the government[24] and above all that has a schedule with planning activities that allow them to be executed assuming the challenges and potential of the city of Trujillo [34]. Finally, the main strengths of this study are a considerable sample of citizens of the city of Trujillo that has allowed us to know the perception on the study variables. which makes one reflect that elementary factors in the SUMP and in transportation planning are the democratization of space, multimodal integration, walking, reduction of travel time and GHG. However, there are weaknesses that have been perceived through The results are that there are few pedestrianized roads and green areas, a disorderly transportation system that is polluting and unprofitable. One aspect that should be considered is travel demand studies and the opinion of all citizens to determine unmet travel demand.

Conclusion:

Planning the city of Trujillo shows a starting point to achieve sustainable urban mobility. It has been proven that without planning it will not be possible to take advantage of public space that favors mobility. Likewise, the local government directly influences the success or failure of any intervention that develops the urban mobility of a society because they manage public space. It is important to specify, in mobility, an analysis of travel demand and the capacity to implement bike lanes. and that these are integrated with mobility on foot, generating pedestrianized roads and green areas that are integrated into the various modes of transport. The SUMPs developed must be comprehensive where pedestrian mobility, cycling, mass public transport and goods are complemented with clean technologies. that mitigate GHGs. Thus, efficient and optimal road connectivity is essential to combat vehicle congestion, giving priority to mass, fast, safe, warm transportation at a modest and inclusive cost.

As recommendations, an appropriate strategy is to involve universities and municipalities in the development of city planning, thus ensuring that a solid, competent technical team is formed and that the projects are concluded in such a way that they are not truncated. . Also, it is vitally important to recognize the culture, dialect, history and idiosyncrasy of the native peoples where the SUMP will be implemented so that citizens take it as their own and contribute to their local government. In short, it is essential to have a system of mass transportation in a city where maximum use is made of the hierarchical routes that are the result of the PMUS, this involves the democratization of public space since true modal and foot integration will be achieved in the terminals, centers that attract and generate trips, where it is manifested the participation and acceptance of citizens. The task that remains is to also achieve traffic management, database connectivity and intermodal planning in the medium and long term.

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