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Pedestrianization around the San José market determining the walkability index

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***Abstract*—The present study responds to the problem that afflicts the citizens of the Jesús María district, mainly those who live in the buildings located around the San José market, due to the excessive use of street parking. In this sense, the objective of this research aims to improve the quality of life of residents, visitors and merchants in the area, promoting the pedestrianization of the streets located around the aforementioned supply center, by determining the walkability indices and surveys that will support the proposals made. The project contemplates the elimination of parking lots in the streets adjacent to the market, and the creation of exclusive areas for pedestrian traffic, a measure that will allow passers-by to walk with greater safety and comfort, in addition to promoting economic activity around the market. by creating a more attractive and accessible environment, thus obtaining inclusive, healthy, resilient and sustainable developments.**

***Keywords*—Walkability, pedestrianization, quality of life, pedestrians, sidewalks, population, trafficability**

I. Introduction (Heading 1)

Your The constant increase in the vehicle fleet as a result of the growth of cities, increased the number of car trips to the city centers and/or business areas; circumstance that, increases the demand for street parking [1], as is the case of the streets located around the San José market of Jesús María, where the field study was carried out and the result was turnover rates, volume of parking, average duration, average occupancy, parking capacity, parking load and the efficiency, greater than 0.98, 21, 45.1, 82.19%, 15, 9.85 and 82.19% respectively; likewise, it was determined that, these places are used by vehicles whose owners they work in the vicinity of the place. Data that allows us conclude that the use of private vehicles is increasingly unsustainable in societies and as a solution to this, they must implement sustainable transportation systems.

The readjustment of the soil consists of the recomposition of urban properties, which modifies the property structure, demolition of buildings, equipment infrastructure, relocation or resizing of roads or public spaces [2]. In modern times, the drivers and vehicles subjugate the streets despite the fact that their externalities kill thousands of people; contrary to this indeed, sidewalks generate greener, healthier and more insurance; Therefore, municipalities should adopt policies that allow allocating the spaces occupied by vehicles to pedestrians, one of them being sidewalk widening [3]. The correct design of the streets, plays a very important role in societies, new paradigms generate multidimensional aspects [4], so it is understood that the point must be changed of view that guides the use of the streets to vehicles and it is necessary to redistribute the spaces where the greatest pedestrians have priority, followed by cyclists, micro mobility users, public transportation, providers of services, business operators and finally the private vehicle users. On the other hand, the data statistics indicate that in the years 2018 and 2019, there were 90,056 and 94,685 road accidents nationwide respectively, many of them with fatal consequences. A new approach to street design, based on people and in the place, demonstrates the possibility of transform them into large urban sites, which contribute to achieve the desired results of obtaining improvements in health public, security, quality of life, environmental sustainability and economic [5]. As a result of COVID 19, which violated health worldwide, States adopted measures such as the social distancing; However, the infrastructures do not guaranteed compliance, due to the spaces reduced, a study carried out in Colombia, shows that 37% of the sidewalks do not exceed the width required for the social distancing, which indicates that it must be greater than 2 m.; In that sense, they propose an extension of the sidewalks to a width of 3.5m [6]. On the other hand, it is expected that 75% of the world population in the year 2050 will live in cities; therefore, it is necessary to compensate for the demands of a number increased pedestrian traffic and increased access to the economy of the city [5].

In the present study, the index of walkability, in order to determine the factors visible and non-visible that have to be improved for better adequate distribution of public spaces that in the currently they are being used as parking in the streets and the widening of sidewalks will be proposed, with the purpose of pedestrianizing these places, based on a field study developed in the streets located around the San José market in the Jesús María district, whose main justification is the increase unsustainable use of vehicles and consequently, the increased demand for parking spaces public and private.

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II. TOOLS AND METHODOLOGY

A. *Tools*

1. *Priorities for the use of public spaces*

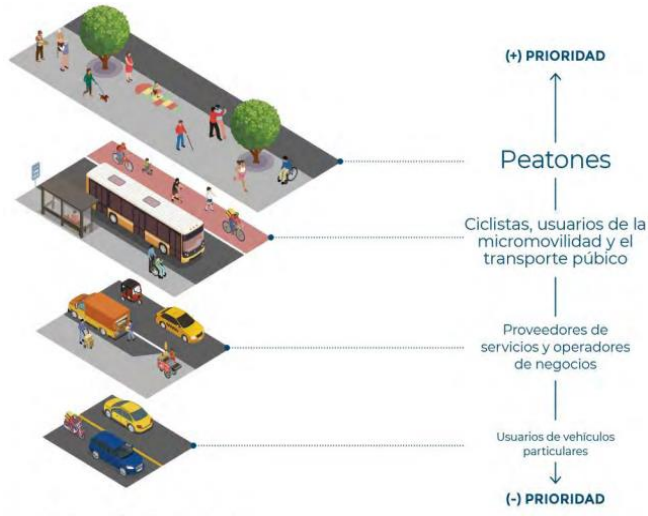

Fig. 1 Sustainable mobility pyramid, guide for the design and implementation of investments in local roads.

2. *Area of spaces occupied by transport elements.*

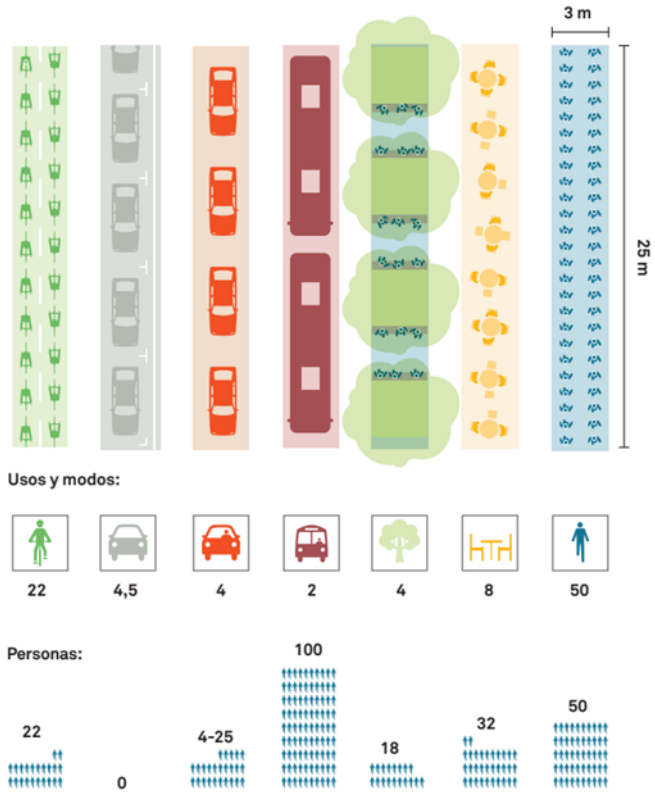

Fig. 2 Comparison of street users, global street design guide

B. *Methodology*

The criteria taken into account to pedestrianize the streets include: the estimation of priorities for its use, the number of spaces occupied by its forms of employment and people in a certain area, the walkability index and a survey carried out on pedestrians who will respond about the preferences for using public spaces.

Figure N° 01 shows the flowchart of research activities, where we first identify the area that is intended to be pedestrianized; next, a field study has been carried out using the method of counting cars and pedestrians that circulate in the streets located around the San José de Jesús María market, with the purpose of collecting the data that, when analyzed, helps us to support the proposal. The minimum width of the sidewalks required by a significant group of pedestrians has been estimated, observing what is stipulated in the guide for the design and implementation of investments in local roads, from which the sustainable mobility pyramid that places pedestrians as the main priority [4], an analysis of the feasibility of walking has then been carried out, using unobservable (perception) and observable (attributes) factors as suggested in the hierarchy of walking needs [7]. Finally, to verify the results, the extensions of the width of the sidewalks were estimated to allow adequate pedestrianization of public spaces, contributing to the organization of cities with sustainable transportation, with a lower rate of use of private vehicles.

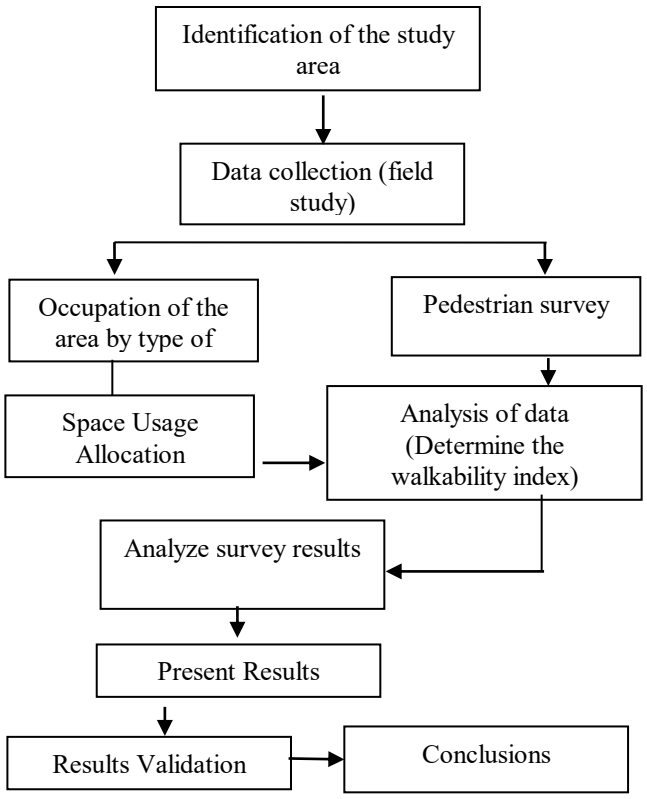

Figura 1 Flujograma de actividades

The study area includes República Dominicana, Horacio Urteaga avenues, and Arnaldo Márquez Avenue. For a better idea of the physical spaces that these contribute to the research, their contribution areas to the project will be determined, which amount to a sum of 3,921 m^2.

TABLE 1
AREAS OF THE AVENUES UNDER STUDY/SOURCE: OWN ELABORATION

TOTAL AREAS	m^2	%
Dominican Republic Avenue	1691	43
Horacio Urteaga Avenue	1115	28
Arnaldo Márquez Avenue	1115	28

Next, we proceed to identify the pedestrian and vehicular capacity points, in order to carry out the field study that showed us that the street parking visualized in the study area constitutes one of the main problems generated by the increase in traffic. vehicular traffic, affects the choice of mode, constitutes a great economic impact and contributes to environmental pollution, because stopping vehicles, turning them off and on in the parking process, causes noise and polluting smoke.

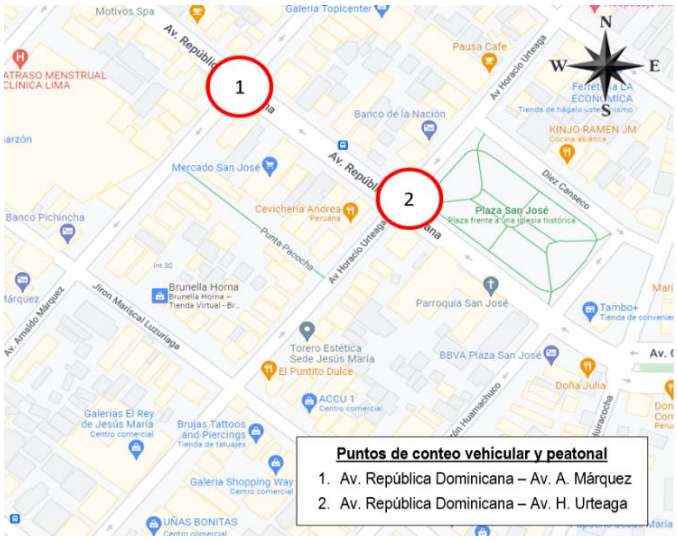

Fig. 4 Location of the vehicular and pedestrian gauging points
Data collection.

In order to determine the occupancy of the area by type of user, we count the vehicles and people in circulation and parked, considering the average obtained from field work in the considered peak hours of typical and atypical days. It is necessary to indicate that for the following analysis, the time from 6 pm to 7 pm will be considered, in the study area, in order to quantify the demand for the spaces. In this sense, a total of 3,155 pedestrians (children, adults and older adults) and 2,702 vehicles (linear motorcycle, bicycle, automobile, rural truck, minibus and light truck) were obtained, see tables 2 and 3.

TABLE 2
PEAK HOUR PEDESTRIAN COUNT/SOURCE: OWN ELABORATION

Pedestrian Type	Amount	%
Child	172	5.5%
Adult	2974	94.26%
Elderly	9	0.29%

Table N°. 2 shows that the attendance of adults who probably carry out commercial activities in the area predominates and there is little attendance of the vulnerable population. This may be an indication that, in the study area, the conditions are not provided. necessary for the development of urban activities such as people's walkability and in that sense, we seek answers to these probabilities.

TABLE 3
PEAK HOUR VEHICLE COUNT/SOURCE: OWN ELABORATION

Vehicle type	Amount	%
Linear motorcycle	249	9.22%
Bicycle	33	1.22%
Cars	2345	86.79%
Tricycle	8	0.30%
Minibus	40	1.48%
Light Truck	27	1.00%

Table No. 3 shows that the streets under study are used by automobiles, since this means of transportation presents a percentage greater than 80% inclusive, so it could be represented as the main problem that must be addressed. a suitable way.

Likewise, in order to determine the allocation of use of the identified areas, we proceed to analyze the distribution of public spaces due to the importance of knowing reliably the current allocation of these places, which have been divided into sidewalk, vehicular parking, vehicular lanes and bicycle lanes, see table 4.

TABLE 4
CURRENT DISTRIBUTION OF SPACES/SOURCE: OWN ELABORATION

APPLICATIONS	Pavement m^2	Parking m^2	Road m^2	Bikeway m^2
Av. R. Dominican.	471	511	705	0
Av. Horacio U.	350	348	370	0
Av. Arnaldo M.	350	282	419	115

As we see in table No. 4, the spaces intended for the use of parking lots and vehicle lanes occupy larger areas, compared to the area intended for sidewalks and bicycle lanes. On the other hand, we will carry out a study that helps us determine the walkability index, since a correct measurement of this indicator illustrates how friendly the urban environment is for pedestrians [8]. In this study, we will use micro-scale variables, with which the aim is to determine to what extent the urban environment being studied is walkable, taking into account that the conditions of the pedestrian structures can act as limitations for walking [9].

For this process, it is necessary to carry out the analysis using unobservable factors (perception) and observable factors (attributes), which will help us establish the walkability index in the study area and, based on this, support the proposal and recommendations from a point of view. objective and realistic, see table No. 5.

TABLE 5
TABLE OF OBSERVABLE AND NON-OBSERVABLE FACTORS/SOURCE: OWN ELABORATION.

NON-VISIBLE FACTORS (PERCEPTION)	VISIBLE FACTORS	
Strength of pedestrian infrastructure	sidewalk quality	Sidewalk width
road safety	Road condition	Presence of traffic control regulators
Personal security	Presence of video surveillance cameras	Street lighting quality
Access to the food market	Access to public transportation	Sustainable transport

The perception of pedestrians regarding safety is modeled taking into account the different edges of the sidewalk [10], street parking influences the movement of pedestrians by approximately 20%, since there are multiple investigations that determine the effects that they generate, with respect to vehicular and pedestrian flow [11].

Next, we will assign a value that ranges from 0 to 1, where values that are close to 1 indicate greater walkability for pedestrians. These results were obtained from the study carried out in the field, due to the non-visible and visible factors, can be perceived and/or appreciated in the study area, for example, we can see how many cracks the sidewalk has and with the data, calculations can be made with which the quantification is carried out and express the range of the mentioned value of each factor. analyzed, see table N° 6.

TABLE 6
RANGE OF OBSERVABLE AND NON-OBSERVABLE FACTORS/SOURCE: OWN ELABORATION

NON-VISIBLE FACTORS (PERCEPTION)	VISIBLE FACTORS	MEASUREMENT	VARIABLE	Value range
Strength of pedestrian infrastructure	Sidewalk quality	Existence of cracks.	yes	0.25
			no	0.75
	Sidewalk width	Sidewalk width measurement in meters.	Broad > 4 m	0
			Broad < 4 m	1
Road safety	Road condition	Existence of cracks.	yes	0.2
			no	0.8
	Presence of traffic control regulators	Traffic lights	For vehicles	0.4
			For pedestrians	0.6
		Traffic regulatory signs	Horizontal	0.6
			Vertical	0.4
Personal security	Presence of video surveillance cameras	Existence of public and private chambers.	Public	0.15
			Private	0.85
Access to the food market	Access to public transportation	Public transport whereabouts.	Taxi	0.7
			Minibuses	0.3
	Sustainable transport	Parking lots.	Bikes	0.1
			Others	0.1

Next, we will validate the results of the visible and non-visible factors, in order to obtain the walkability index in the area, using the following equations:

$$P_{m,u} = \frac{exp(P_{m,u})}{\sum_{\forall m,u} exp(V_{m,u})} \quad (1)$$

Where:
$P_{m,u}$ = Probability of an unobservable factor

m = Observable component.
u = Options for a pedestrian.
$U_{m,u}$ = Probability of an observable factor.
$V_{m,u}$ = Deterministic effect variable observed by a pedestrian.
$E_{m,u}$ = Probabilistic variable of observable factors.

Determination of walkability index

$$WI_{s,u} = \sum_{f \in N} W_{f,u} \, x \sum_{c \in C} W_{f,c,u} \, x \, C_{f,c,u,s} \quad (2)$$

Where:

$WI_{s,u}$ = Walkability index for street fraction s for a type u pedestrian
$W_{f,u}$ = Value of the unobservable factor f for a pedestrian u.
$W_{f,c,u}$ = Value of the observable factor c, associated with unobservable factors f by the pedestrian u.
$C_{f,c,u,s}$ = Value of the variable c, it is the observable factor grouped to the non-observable factor f for the fraction of street s for a pedestrian of type u.

Finally, a survey was carried out on pedestrians to validate the need to have references on the use that should be given to public spaces, grouping the questions based on the hierarchy of walking needs. Once the survey was completed, we will proceed to analyze the data; for this purpose, we use the following equation that will allow the calculation of the infinite population.

$$n = \frac{Z_{\alpha}^2 \times p \times q}{e^2} \quad (3)$$

Where:
n = Sample size sought
z = Statistical parameter that depends on the confidence Level (NC).
p = Probability of the studied event occurring (success)
q = (1- p) = Probability that the studied event does not occur
e = Maximum accepted estimation error

III. RESULTS AND ANALYSIS

The results of the walkability index and the survey carried out will be shown; in the same way, the analysis of the results will be carried out.

Regarding the results of the walkability index, equation (2) was carried out, where the range of results is from 0 to 1; in that sense, those closest to 1 indicate that the walkability index is adequate for that item, and those closest to 0 indicate that decisions should be made in order to overcome obstacles. Finally, the following results were obtained, see table N° 7.

TABLE 7
WALKABILITY INDEX RESULTS

NON-VISIBLE FACTORS	AVERAGE PEDESTRIAN
Strength of pedestrian infrastructure	0.221
Road safety	0.238
Personal security	0.265
Access to the food market	0.276

As can be seen in the results of the walkability index, the non-visible factors that are closest to the value 0 and have a value less than 0.25 are: strength of the pedestrian infrastructure and safety of the road. That is, they are the two factors that must be improved, so that they present an adequate walkability index; which, in the present study, should present a value >= 0.25.

On the other hand, to determine the infinite population sample of the survey carried out, equation (3) was used, obtaining a sample size of 360 respondents; in this sense, the consultation was prepared with one question and four answers, which will serve as further guidance regarding the preferences of the population studied. In this regard, 175 respondents prefer the widening of sidewalks, 6 the increase in parking, 72 choose the management of bicycle lanes and 131 want to eliminate street parking, see figure No. 5.

Fig. 5 Result of the survey carried out

According to what is observed in Figure N° 5, the responses that present the highest votes or elections are the widening of sidewalks and canceling parking on the streets; which represent a percentage of 48.6% and 36.34% respectively, compared to the responses of increased parking and management of bicycle lanes that reached percentages of 1.67% and 20% respectively.

Finally, through the field studies carried out, it was observed that, currently, great priority is given to the use of public spaces to vehicle drivers, from an evaluation by type of users that we define between pedestrian, cyclist and driver, the results they show us that pedestrians use 27.5%, cyclists 2.5% and drivers 70% of public spaces. Data that contradicts the recommendations made in the guides, standards, regulations, etc. of urban street development, in which the literature indicates that the main priority for the use of spaces are pedestrians and not vehicles as in the present case, for a better illustration, see figure N° 6.

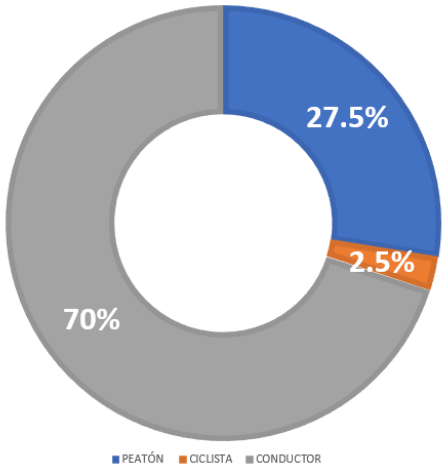

Fig. 6 Percentage of space use by type of user

IV. VALIDATION OF RESULTS

The results and analysis carried out in the previous section show that, with respect to the walkability index, the non-visible factors that must be improved are: first, strength of the infrastructure, which is subdivided into the visible factors of quality of the sidewalk and width of the sidewalk, let us take into account that this non-visible factor presented a result of 0.221, a value that indicates that it does not present an adequate design of the visible factors; secondly, road safety, which is subdivided into the visible factors of road condition and presence of traffic control regulators. Likewise, let us keep in mind that this non-visible factor presented a result of 0.238, a value that indicates that an adequate design of its visible factors is not presented. In that sense, according to the results, the sidewalks could be widened and the road maintained; However, the objective of this investigation is the pedestrianization of the area, which is why, according to the result of the walkability index, we suggest widening the sidewalks.

The results of the survey carried out determine sidewalk widening as a better option; out of a sample of 360 people, 170 chose this option, rising to a percentage of 48.6%. Result that coincides with what was analyzed in the walkability index.

These circumstances lead us to verify the necessary sidewalk width in the streets located around the San José market in the Jesús María district and, in this way, be able to verify the results achieved through the analysis of the walkability index and the surveys carried out, which determine that the pedestrianization of the area is a wise measure; therefore, taking into account that the study area is a commercial circle that demands safe and spacious spaces for the development of its activities. For the present analysis we have a population of 3,155 people who circulate during rush hour, who have an allocation of 1 m2 per person [5], so that they can walk comfortably. Next, we will carry out the following calculations that allow us to design an adequate width of sidewalks:

$$Flujo\ de\ diseño = \frac{población}{n*2} * 1 \quad pea/min/m \qquad (04)$$

Where:
n = Number of days in the month

The horizon year flow will be estimated manually, taking into account that, with a larger population, its value will also increase.

$$Ancho\ de\ acera\ = \frac{Flujo\ de\ año\ de\ horizonte}{Flujo\ de\ diseño} + 1 \qquad (05)$$

Where:
In relation to the sidewalk calculation, we take into account the aforementioned proposal that consists of the pedestrianization of the streets, in that sense, we will carry out a calculation that allows us to satisfy the needs of a horizon-year flow of 250 pedestrians/min and we will replace the data in equation (5) for sidewalk width design calculation.

$$Ancho\ de\ acera\ = \frac{250}{60} + 1 = 5.75\ m$$

The field study carried out indicates that the sidewalks located around the San José market have a width of 3 m and for a pedestrianization that presents a horizon year flow of 250 pea/min, it is necessary to have a sidewalk width of 5.75 m and rounding up, the result would be 6 m; that is, the sidewalks must be widened 3 m more. So, with this condition the results

obtained regarding the walkability index and the survey are validated, since both recommend widening the sidewalks.

V. CONCLUSIONS

The two study points were identified, where vehicular and pedestrian traffic intensifies, it was also verified that the attendance of the vulnerable population is reduced, this is due to the insufficient pedestrian structure and the high vehicle traffic, which represents a danger index for this type of pedestrians.

Through the analysis of the distribution of spaces by type of user, it is concluded that there is no good urban planning in the place, since there is abundant literature related to the design of urban streets, which puts pedestrians as first priority. and are committed to new forms of sustainable transportation in cities, this is due to the probabilities that over the years, the growth of the urban population will continue to grow abruptly, contrary to the rural population that will continue to decrease.

Pedestrianizing these streets located around the San José de Jesús María market is feasible, since the walkability index shows that of the 4 non-visible factors that were analyzed, two of them are above the established range so that they can be defined as "adequate." " and the other two did not exceed the indicated range; However, they have a very attractive solution which is the widening of the sidewalks to a length that was calculated in the verification of the results presented.

With the pedestrianization of the streets through the widening of sidewalks, it is possible to eliminate the spaces that are used as street parking and it will be possible to reduce vehicular traffic by a high percentage; since, as there are no parking spaces for private vehicles, the use of this means of transportation will be discouraged and citizens will look for other alternatives, one of them being walking on wide and safe streets.

The study shows that the implementation of measures to improve the walkability of streets can be beneficial for both the physical and mental health of people, as well as for the economy and the environment. Additionally, the authors highlight the importance of considering the needs of people with disabilities and other special needs when designing and planning cities.

It was identified that the spaces intended for the use of parking lots and vehicular lanes occupy more significant areas, compared to the area intended for sidewalks and bicycle lanes. That is why, through micro-scale variables, the appropriate measure of breathability on sidewalks was determined, in order to establish a pedestrian-friendly urban environment.

The proposed walkability index is, in itself, a measure of the interaction of people with the city; each of its dimensions measures the state of an urban sector in a specific component, and provides information about spatial relationships, social and economic between people and their environment.

REFERENCES

[1] Ninad Gore, Sanjay Dave, Jiten Shah, Shriniwas Arkatkar, Srinivas Pulugurtha, Effect of On-Street parking on pedestrian flow characteristics and level of service - an Indian viewpoint, Case Studies on Transport Policy, Volume 9, Issue 3, 2021, Pages 1386-139

[2] Congreso de la República del Perú. (2021, 23 de julio). Ley de Desarrollo Urbano Sostenible. Diario Oficial El Peruano. https://busquedas.elperuano.pe/normaslegales/ley-de-desarrollo-urbano-sostenible-ley-n-31313-1976352-2/

[3] Perez, V. C. (2021). Reclaiming the streets. Iowa Law Review, 106(5), 2185-2213. Retrieved from www.scopus.com

[4] Ministerio de Vivienda, C. y. (2021). Guía de Diseño e Implementación de Diseño e Inversiones en Vías Locales. Obtenido de https://cdn.www.gob.pe.

[5] Officials, N. A. (2016). Guía Global de Diseño de Calles. Islandpress.

[6] Sánchez-Gómez, J. S., & Gutiérrez-Aguilar, L. A. (2022). A geographical method for assessing social distancing as a preliminary tool for implementation planning. A case study: Chapinero, bogota. [Método geográfico para la evaluación del distanciamiento social como una herramienta preliminar para la planificación de la implementación. Caso de estudio: Chapinero, Bogotá] Ingenieria y Universidad, 26 doi:10.11144/Javeriana.iued26.gmas

[7] Alfonzo, M. A. (2005). To Walk or Not to Walk? The Hierarchy of Walking Needs. Environment and Behavior, 37(6), 808–836. https://doi.org/10.1177/0013916504274016

[8] Filipe Moura, Paulo Cambra, Alexandre B. Gonçalves, Measuring walkability for distinct pedestrian groups with a participatory assessment method: A case study in Lisbon, Landscape and Urban Planning, Volume 157, 2017, Pages 282-296.

[9] Ana Margarita Larrañaga, Luis Ignacio Rizzi, Julian Arellana, Orlando Strambi, Helena Beatriz Bettella Cybis, The influence of built environment and travel attitudes on walking: A case study of Porto Alegre, Brazil, International Journal of Sustainable Transportation, Volume 10, Issue 4, 2016, Pages 332-342, ISSN 1556-8318.

[10] Landis, B. W., Vattikuti, V. R., Ottenberg, R. M., McLeod, D. S., & Guttenplan, M. (2001). Modeling the roadside walking environment: Pedestrian level of service doi:10.3141/1773-10 Retrieved from www.scopus.com.

[11] Hongwei, G., Ziyou, G., Xiaobo, Y., Xiaomei, Z., & Wuhong, W. (2012). Modelling of travel time under influence of on-street parking. J.Transp.Eng., 130(2), 229-235. Retrieved from www.scopus.com.