IMPACT ON THE ACCESSIBILITY AND OPERATING COSTS FOR THE INCLUSION OF A NEW TRANSPORT INFRASTRUCTURE IN THE CENTRAL SOUTH REGION OF THE DEPARTAMENTO DE CALDAS (COLOMBIA)

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ABSTRACT

The project "STUDIES FOR THE DEVELOPMENT OF LAND MANAGEMENT AND TECHNICAL STUDIES FOR THE ROAD SYSTEM OF THE CENTRAL SOUTH REGION OF THE DEPARTAMENTO DE CALDAS", currently under implementation by the Universidad Nacional de Colombia is taking into account the integral design of road interventions established by the State Administration, having traffic characterization, and accessibility as some of the of the key inputs for proper planning.

The transport infrastructures, as they modify the conditions of territory accessibility, are a key element in regional development policies, since new investments could contribute not only to mitigate the current problems but also could focus on empowerment of disadvantaged regions, thus achieving a dual purpose.

On the other hand, transport and communication infrastructures reduce the space cost of distance and influence location and accessibility, contributing to the modification of the settlements and economic structure of a region.

Undoubtedly most activities in a territory are directly related to the capacity of transportation of people and goods, and therefore to the efficient communication between different geographical areas.

It is necessary to evaluate all the physical and operational characteristics of the infrastructures in the studies of urban and regional planning in order to perform, by comparing parallel scenarios, the modifications and expansions that are really required by the transport system, aiming to enhance areas that literally are into oblivion because of lack or deficiency in communication.

An analysis was done of the Global Average Accessibility and the Integral Average Accessibility, provided by the actual and future road networks. It was calculated in a study area of 35 km radius from the urban sector of the town of Palestina (Caldas), in order to define a compact area of direct influence on the Central – South region, considering that the Aeropuerto del Café will be located in this town.

Based on the above, the actions in transport infrastructure alter the territorial framework, as these aim for the reduction of travel times and therefore, the concentration of different types of activities, thus territorial space is not conceived as an absolute, but as an analytical framework in which access conditions vary depending on the actions proposed. Results are presented and discussed.

Keywords: Accessibility, GIS, geostatistics, transportation, costs, infrastructure.

BACKGROUND

Accessibility is a measure of the capacity of communication provided by a network through the use of a certain mode of transport [Morris, JM, et al., (1979), Zhu, X. i Liu, S. (2004)]. It can be established that this measure is closely related to the variable "distance" [Loyola et al. (2009)], becoming a function of proximity to any geographic location in an area or region. Thus, it is valid to say that considering the current technological developments, accessibility depends less and less on the actual distance to the activity centers, and increasingly more on the distance from transport infrastructures [Gutiérrez, J. (1998)] and on how such infrastructures shorten connection times between regions.

In regional planning studies the impact produced by the insertion of new network infrastructure should be taken into account, in both the geographic and functional components in such a way that the modifications and extensions indeed required by the road and the transport system are done, looking to enhance areas that are literally into oblivion because of lack or deficiency in communication.

The analysis of accessibility of a specific area is performed by using the graph theory [Petrus, J. and Segui, J. (1991)], which uses the network morphometric study (explanatory analysis) to know the aspects of the whole network structure, based on partial data.

The accessibility studies using graph analysis can be of two types [Murillo, J., (2007)]: static and dynamic. The static is described through shape and connection indexes (although its development is produced by a temporal sequence) and the dynamic is responsible for assessing elements of the network connection using real variables associated with the operation of the system, such as distance, operation speed between nodes, road surface characteristics, costs, and circulating flows among others. Regardless of the type of accessibility study (static or dynamic), there are three levels at which accessibility can be categorized: relative integral or global [Izquierdo, R., et al. (1991)].

The relative accessibility is associated with the quality of the connection between two points in the same area; the integral accessibility measures the degree of interconnectedness of a node with others in the same area, and the global accessibility is the average of the integral accessibilities of all nodes in the area under study.

This type of analysis becomes a basic element of territorial planning which depends not only on the topological characteristics of the network, but also on its operational characteristics, where the average speed of the flow operation used is a fundamental variable for the analysis [Herce, M and Magrinyà, F (2002)], and the accuracy and reliability of the results largely depends on its attainment.

This is the first time that these type of studies are done in the Departamento de Caldas, which are an essential part of the post evaluation of the infrastructural interventions to be carried out, detecting the impact that such interventions have on travel times and operation costs in the territory.

The central region - south of the Departamento de Caldas, has an area of approximate 1.583 km^2 (20.2% of the territory of the departamento), 54.8% of the total population of the departamento and a population density of 338 inhabitants /Km^2. It is considered the most dynamic region of [Governor of Caldas (2009)] the department and covers the towns of Manizales, Chinchiná Villamaría, Neira and Palestina.

METHODOLGY

The research is framed within the context of network theory. It was carried out during the second half of 2009 and performed in consecutive steps from the very conception of the idea, using field and secondary information from official sources for its development.

In general, the main results are obtained from the processing of more than 5 million data, which together provide a framework of analysis that is reflected on the topological and operational characteristics of each of the links that make up the infrastructure network of the

Central-South region. In the preliminary analysis of the Global Average and Integral Average Accessibility, an area of study of 3848 km^2, was defined, which corresponds to a radial distribution (r = 35 km) with the center placed in the urban side of the City of Palestina. This distribution ensures an area of direct influence on the Central - South region of the Departamento de Caldas (See Figure 1).

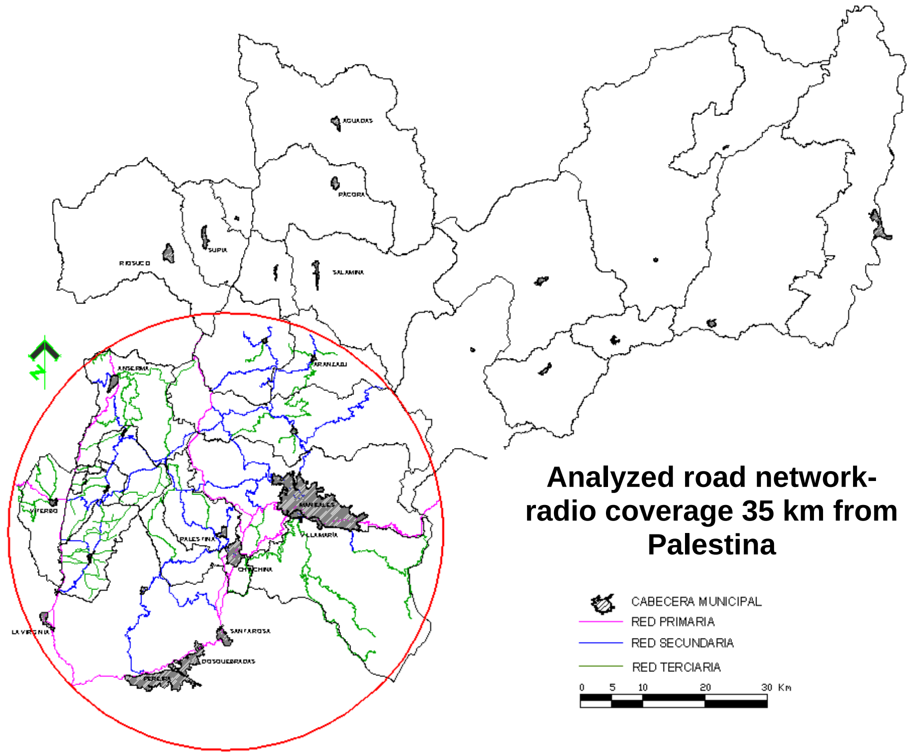


Figure 1. Analyzed Road Network

The georeferenced roads are the fundamental basis of the analysis because their characteristics fed the database, to obtain the accessibility model. This model allowed the identification of the areas with deficiencies regarding the variable connection from the analysis of the average travel times between nodes, and also allowed the location of areas of the territory that show improvement in the accessibility times for future scenarios when the different proposed road interventions are made.

Processing

The first stage consisted of obtaining the magnetic archives of the road network of the Departamento de Caldas [Government House of Caldas (2009)], which were complemented by direct georeferencing of the area using GPS equipment. Later on, the future road interventions, along each of the sections, were georeferenced

The digitization of the road network allowed the modelling of input data. This network is composed of 575 links and 446 nodes, for each node there is a number of attributes, among which is the average speed of operation in the links and the travel time by the minimum path between each pair of nodes. The value of the average operating speed on each link was obtained by floating vehicle testing, which established the operating speeds of each of the analyzed links. These values of operating speeds feed the GIS database used in the analysis of minimum paths.

The obtained floating vehicle values were incorporated into the GIS in its corresponding link, due to the inability to test vehicle floating in all links included in the area of study (see Figure 1). However, the links were not evaluated by field measurements. A statistical analysis of the previously obtained speed operating values was done and the characteristics of operating speeds were determined according to road type (primary, secondary or tertiary, national or departmental), the surface type (pavement or granular base) and condition (good, fair or bad).

The statistical analysis of operating speeds showed the percent differential for the different types of roads regarding the condition for each category, showing an average variation of 16.5% in speed decrease when moving from good, to fair to poor conditions. The speed averages in every link of the area of study were determined using this parameter.

Once the database was obtained, the second stage began. Multiple analyses were done, because the data on road network and information of operating speed and travel time in each link were simultaneously available. A matrix of average travel times between nodes was then calculated, thus obtaining the vector of average travel times by the minimum path from each network node to the others. Interpolation models for the variable average travel time of each node were applied using geostatistical software (Surfer 2009 ®) to obtain the curves of Global Average Accessibility (isochronous) offered by the infrastructure network both, for the actual and future scenarios.

Isochronous curves allow the identification of areas of the region that would have significant impacts regarding the travel time required to reach them and the result is obtained by comparing the vectors of average travel time for each scenario. An appropriate statistical analysis is performed on the values of average travel time obtained in the vector, which allows for a more reliable forecast of the average travel time at different points of the territory.

The research offers graphic results which will help identify areas of the Central-South Region that will benefit most from the construction of new transport structures.

Calculations

The processing of information required different calculations for each stage of the research. First, the average operating speed and its placement in each link of the networks is calculated, then the travel time by the minimum path is calculated from each node of the network to the others, after that the value of the Global Average Accessibility is calculated for each node, and finally the statistical validation of the vector in average travel times is done to define the model of data interpolation to implemented and thus obtain isochronous curves of time.

Operating Speed

Total travel time and travel delays were calculated using the data captured in the field for each section between checkpoints and for all sections studied. Using this information, the time measurements were converted into average speeds of travel for each section, dividing its length or the length of the corridor by travel time. The average speed for each trip was calculated using equation (1).

$$Vr = \frac{60 * D}{T} \quad (1)$$

Where,
Vr = travel speed in km/h.
D = length of the section or corridor in kilometers
T = travel time in minutes

Finally, the average speed in the link is calculated by equation (2)

$$\overline{V_a} = \frac{\sum_{i=1}^{n} V_i^a}{n} \quad (3)$$

where;

$\overline{V_a}$ = Speed average of a link
n = Number of times a vehicle passes in the link

This speed is calculated for each link of the entire road network, and then used to determine the impedances and to implement the time model.

Global and Integral Average Accessibility

This accessibility is analyzed from the vector of average travel time (Tvi), which represents the average travel time from node i to the other nodes of the network. This indicator tends to favor the points located at the center of a network because travel time from these nodes to the others is less due to their geographical location.

To calculate the above mentioned indicator a GIS algorithm is used to calculate the shortest distance between a specific node and the other nodes in the network, forming a unimodal matrix of distances. Using this matrix and knowing the average operating speed of each link, a matrix of travel of minimum average times is built, which minimizes travel time between the nodes in the network.

Once the matrix of minimum average travel times is determined, two vectors of time are obtained: first, the vector of average travel time (T_{vi}, See equation 1). Its entries are calculated by the following equation:

$$\overline{T_{vi}} = \frac{\sum_{j=1}^{m} t_{vi}}{(n-1)} \quad i = 1,2,3,\ldots,n \;\; ; \quad j = 1,2,3,\ldots,m \qquad (1)$$

Where;
n = Number of network nodes
$\overline{T_{vi}}$ = Average mínimum travel time between node *i* and the other network nodes
$\sum_{j=1}^{m} t_{vi}$ = Sum of minimum travel time between node *i* and the other network nodes

The second vector of travel time from a specific node to the others is calculated by equation (2).

$$Tv_k = \sum tv_{ki} \qquad i = 1, 2, 3, \ldots, n$$

Where;
n = Number of network nodes
k = specific nodes from which time is obtained

The obtained vectors of time (n x 1) are then connected to the geographic coordinates (longitude and latitude) of each of the nodes, to create the matrix of order (n x 3), which is used to make the isochrones of average travel time for the respective area of analysis of global average and integral average accessibility, the latest related to the analysis from the specific nodes of the network.

It is necessary to define the interpolation method to be used to obtain the isochronous curves, thus certain statistical assumptions to be filled by the variables should be verified.

The first assumption is to verify the normality of the data for which the nonparametric test of Kolmogorov-Smirnof has been applied. If the vector of time turns out to be not normal, a vector transformation is performed using the Box-Cox Algorithm. The second assumption is to verify the existence of stationarity, by way of dispersion graphs between the vector of average travel time and the geographic position (longitude and latitude, respectively), in order to determine which section must be removed from the interpolation model. The third statistical assumption is to consider variance as finite.

Spatial variability is related to the change of data regarding distance and data orientation. The measure of the variance, in geostatistics, is the semi variance, which is defined by equation (2):

$$\bar{\gamma}(h) = \frac{\sum \left(Z(x+h) - Z(x) \right)^2}{2n} \tag{2}$$

Where;

Z(x) = Value of the variable at position x,
Z(x+h) = Sample value separated from the previous by a distance h,
h = Separation between sample values,
n = Number of pairs separated by distance h.

This function displays the properties of the spatial dependence of the process and it is calculated for various distances h. From the results of this function a semivariogram is calculated, which is the graphical representation of the semi variance of the data for distances between observation pairs. It can be established the use of a statistical interpolation method, such as the Kriging method, in the case that the normality of the vector is not met after the Box-Cox transformation is applied. The method might be applied if the vector contains Homoscedasticity, and variance equality.

Finally, the interpolation method to be used was determined (regular Kriging method with spherical semivariogram) as a model to predict the average travel time, and the cross-validation of data is done in order to ensure statistically reliable results. In this process, the observed values are compared to the values estimated by the selected interpolation model, bearing in mind that by using a linear regression, it is possible to establish the adequate or inadequate accuracy of the model to predict data.

MAIN RESULTS

Road Network

The road network in the central-south of the Departamento de Caldas has a total length of approximately 1250 km, of which over 56% belong to primary and secondary route types, similarly, more than 57% of the length present operating speeds under 30 kph, however, the entire primary network reports operating speeds above 30 kph. The analysis of the operating speed made feasible a general map of the situation (see Figure 2). It could also be established that the average speed of the network is approximately 26 kph.

Regarding category, main roads offer an average speed of 43 kph, while the secondary and tertiary category offer substantially lower operating speeds, 27.25 and 9.0 kph, respectively.

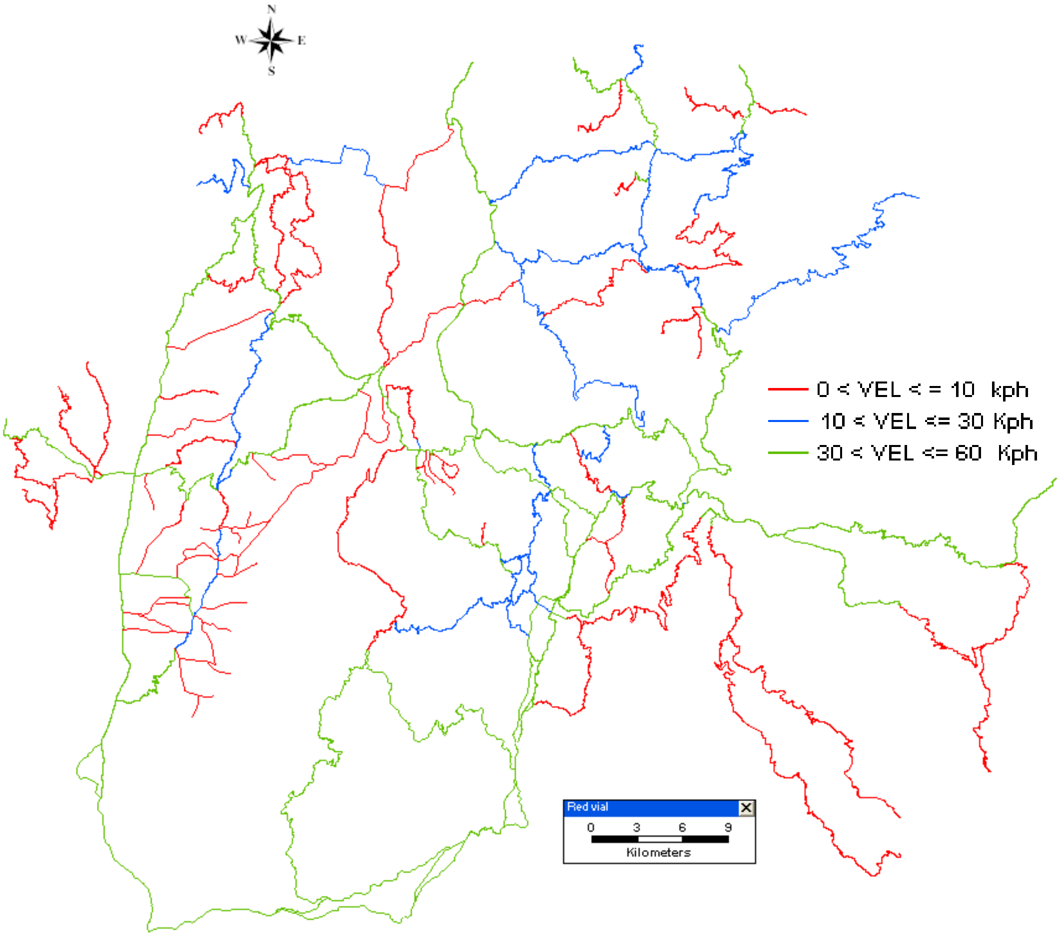


Figure 2. Analyzed Road Network

In addition, the study showed that approximately 57% of the total length of the road network expands in mountainous and undulated terrain, which directly impacts the operating speeds obtained by the floating vehicle.

Analysis of actual and future Global Average Accessibility

The isochrones are the virtual space formed by the positions reached by an object in a time Ti starting from a point i in a radial arrangement; case in point the road network in the studied area. For the analysis of the global average accessibility offered by the actual road network of the Central-South region of the Departamento de Caldas, the isochrones represent areas that could be reached in a given average travel time from any network node. This travel time depends on the physical and operational characteristics of the road (topography, road condition, category, average operating speed, geotechnical problem sites, etc).

It is necessary to make the corresponding changes in the analysis graph for the analysis of accessibility offered by the future road network, such as the layout and new speeds of operation of the sections to be intervened. Figure 3 shows Sections to be intervened: Section A (dual carriageway), B (Main), C (Main), D (dual carriageway) and E (Main).

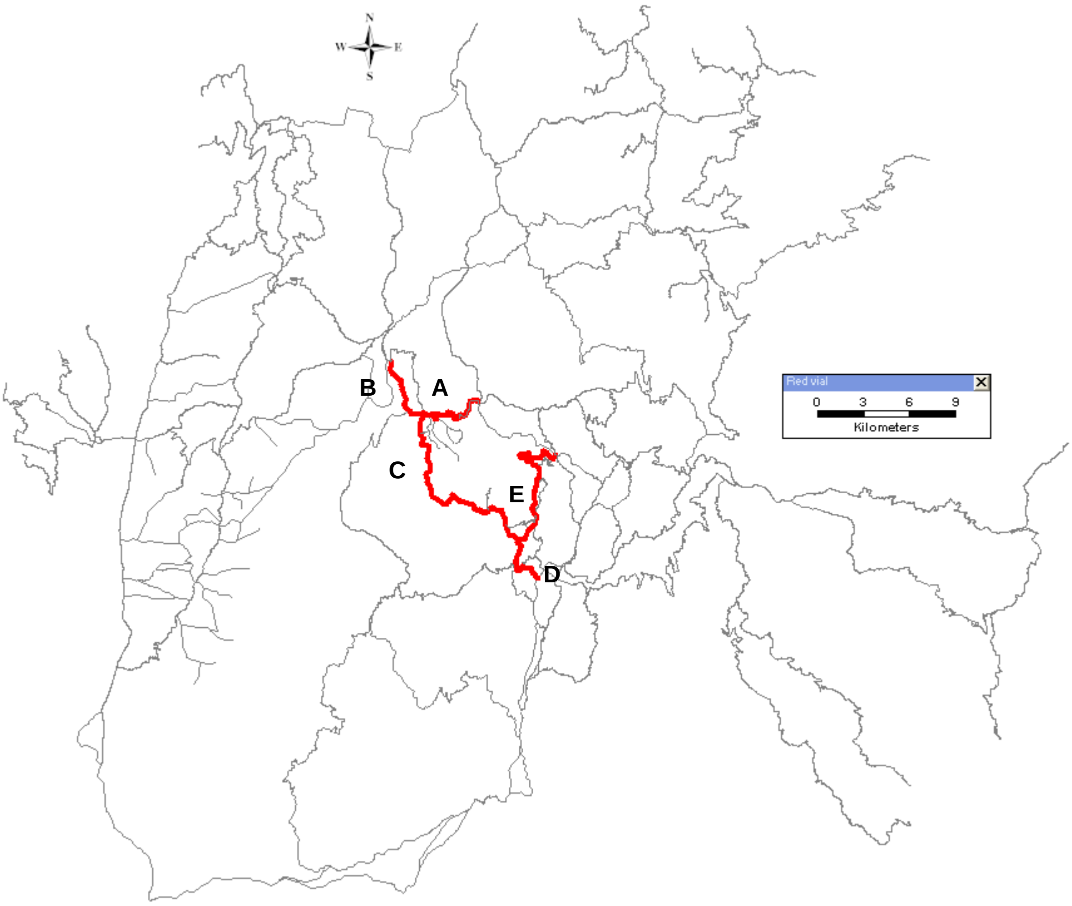


Figure 3. Roads to be intervened

A design speed of 40 km / h was established. Taking into account the theory of speed analysis, the operating speed of the road is 85% of the design speed, thus an operating speed of 34 km / h was assigned to the sections to be intervened with the aim to perform calculations and analyses of the average travel time, in its Global Average Accessibility component.

Figure 4 shows that the isochronous curve of less time is 80 min., which covers the road corridor between towns connected from south to north (Autopista del café), and a short section of the Santagueda sector (Point A, Figure 4). It can be established that given the geographical position of urban areas (lines enclosed in black) and the physical and operational characteristics of the actual road network as a whole, makes these roads the most potential for development, as in average travel time they are easier to be accessed from any other network node. It is worth to clarify that the variables of economic indicators were not included, which reinforces even more the idea that from the geographical point of view, these areas have the best accessibility of the actual road network.

With regard to future scenarios, it can be observed that the isochronous curve of 80 min. expanded significantly its coverage with respect to the actual scenario, covering the main corridor that connects the East with the West, and the corridor that leads to the town of Chinchiná (Point D, Figure 4). Using this result, it can be observed the impact in average travel time that the intervention A would produce (Dual carriageway, Figure 3), making this sector the one with the greatest accessibility and therefore the one with the greatest potential for development from the standpoint of connection between zones in the Central South region of the Departamento de Caldas.

The towns of Dosquebradas and Pereira (Southbound) are covered by the isochron of 100 min. and 105 min., respectively, which is due to the characteristics of the road network that connects them to the Central South region of the Departamento de Caldas. There is a significant expansion of the curves of accessibility to that geographical zone, finding isochronous curves of less time than the ones on the north, expanding on the south of the region under study. The reason for such spatial configuration is that this area is currently connected by a road corridor of primary category (Autopista del Café), making it clear that the accessibility of the road corridor to the West will change significantly when in the future gets connected to the "Autopista de la Montaña".

Making an analysis of the population of the towns located within the area of influence of the study, 82.7% of the population are located in urban zones and 17.3% are located in the rural zone; 55.1 % of the population of the area of influence is located in the southern towns of the area under study.

Table 1 shows the relationship between the percentages of population covered by the isochronous curves of time in future scenarios. It was found that the percentage of population of the covered area of influence suffer a minimal modification. The percentage of population covered is the same for the range of isochronous curves of time less than or equal to 95 min., the percentage of coverage for the population increases approximately by 1% for the range of isochronous curves of time between 100 and 120 min., and the percentage decreases by 1%. for the range of isochronous curves greater than 120 min. This situation leads to the conclusion that future interventions, from the standpoint of population covered at certain travel times, would not significantly impact the area.

In the analysis of the gradient curves of global average accessibility between the actual and the future road networks of the Central South region of the Departamento de Caldas, the isochrones represent areas that gain relative travel time. Figure 5 shows the gradient curves of Global Average Accessibility where the roads subject to intervention are located, showing that these would cause an impact of between 2.5 and 5 min. in relative gain of average travel time.

If the main objective of road interventions is to provide relative improvements in travel times in the Central South region of Caldas, it can be concluded that such objective is met, even though the magnitude of such improvements of time are not considered to be substantial. It can also be noticed the need to build or improve the connection between the Central South region and the towns located north of the Departamento de Caldas, to ensure a proper connection of those areas with the future Aeropuerto del Café.

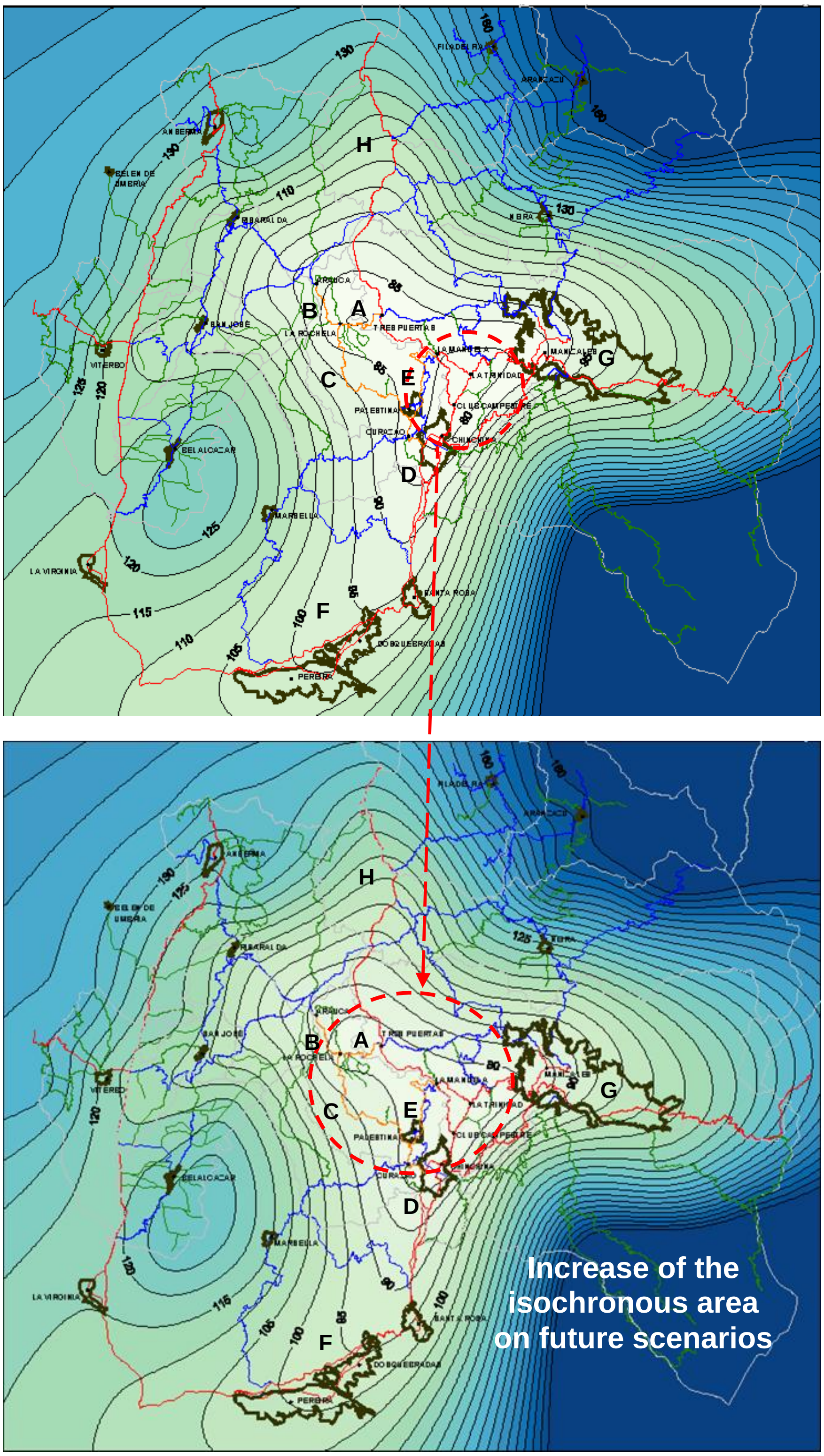


Figure 4. Isochronous curves of Global Average Accessibility at rush hour on the actual and future road networks

Table 1. Population in the towns of the area of influence according to the isochronous curve covering the future road network

Town	Total population	Isochronous curve covering it (min)	% population of the area of influence	% population of the area of influence (Accumulated)	
Chinchina	53,496	80	3.82%	3.8%	35.5%
Palestina	18,037	85	1.29%	5.1%	
Manizales	379,972	95	27.10%	32.2%	
Villamaria	46,322	95	3.30%	35.5%	
Dosquebradas	179,301	100	12.79%	48.3%	55.3%
Santa Rosa	69,960	100	4.99%	53.3%	
Pereira	443,554	105	31.64%	84.9%	
San Jose	7,572	110	0.54%	85.5%	
Risaralda	10,679	110	0.76%	86.2%	
Marsella	21,457	115	1.53%	87.8%	
La Virginia	31,261	120	2.23%	90.0%	
Belalcazar	11,872	120	0.85%	90.8%	
Viterbo	13,159	125	0.94%	91.8%	9.2%
Belén de Umbría	26,603	130	1.90%	93.7%	
Anserma	35,097	130	2.50%	96.2%	
Neira	28,140	130	2.01%	98.2%	
Filadelfia	12,737	160	0.91%	99.1%	
Aranzazu	12,815	180	0.91%	100.0%	
Population area of influence	**1,402,034**		**100%**		**100%**

Analysis of Integral Average Accessibility on the actual and future Road Networks from Palestina (Aeropuerto del Café).

Figure 6 shows the isochronous curves of Integral Accessibility from Palestina on the actual scenario. Therefore, the isochronous curve of 20 min. covers the entire town of Chinchiná (Point D), which was expected given its proximity and direct connection to the point of origin (Aeropuerto del Café, Point E).

When making an overall comparison of isochronous curves in the Actual and Future scenarios, a variation of times can be found along the Autopista del Cafe corridor and its extension towards the north (road corridor leading to the city of Medellin). The western corridor and the road corridor connecting north of the Departamento de Caldas suffer no greater variation of time. In fact the variation of average travel time occurs in the south - north and vice versa, being less noticeable the variation in average travel time west - east and vice versa. The isochronous curves of Integral Accessibility from Palestina on future scenarios show that the roads to be intervened would get an average travel time of approximately 45 min., time that has decreased compared to the actual scenario, in which the roads to be intervened reach an average travel time of 50 min. On the other hand, the isochronous curve of 50 min.covers strategic points of the entrances to the town of Palestina, such as the road corridor Autopista del Café that connects the region south-northeast (line connecting the points FDG, Figure 5), and also the roads to be intervened in the project.

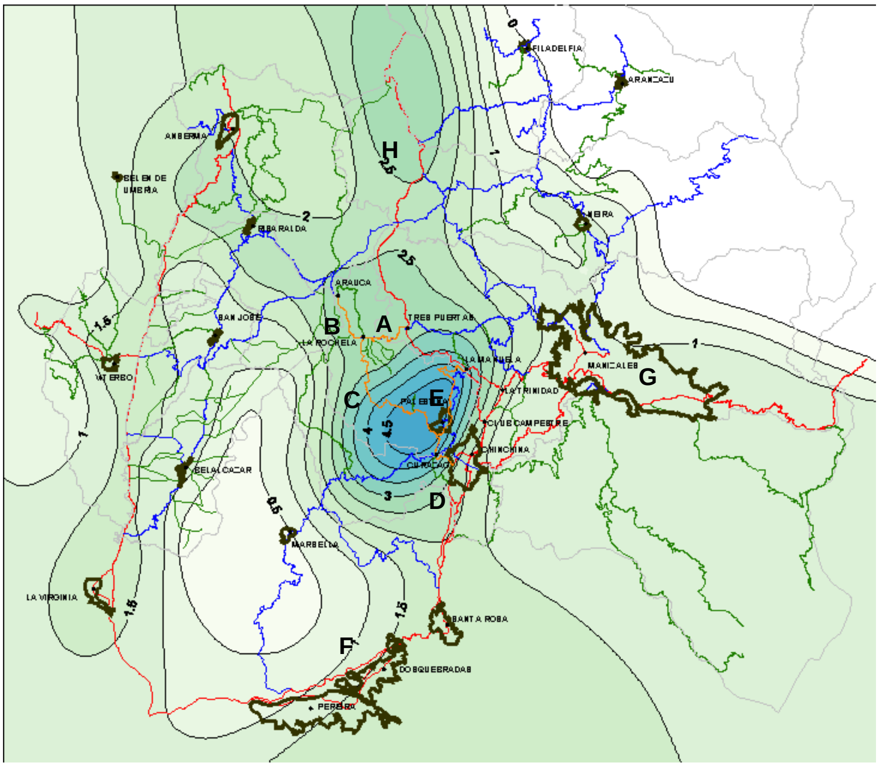


Figure 5. Isochronous Curves of Global Average Accessibility of the Gradient of average travel Time on the actual and future scenarios.

The analysis of the gradient curves of Integral Accessibility from the town of Palestina (Aeropuerto del café , Point E, Figure 7), shows that the isochronous curves represent areas with relative gain in travel time from Palestina, using the future road network.

Comparing the obtained vectors of time in each scenario, it is possible to find the isochronous curves of the Global Average Accessibility for the gradient vector of travel average times. Figure 7 shows the results of the time vector.

It should stressed that the greatest impact on average travel time takes place along the road corridor of Autopista del Café and its connection north towards the city of Medellin (line connecting points FDGAH, Figure 7) The relative gain on average travel time from Palestina is more to 6 min. in the DF section, while in the DHA section the curves vary between 5 and 12 min., concluding then, that there is impact of road interventions over the entire area of influence regarding the average time from Palestina. Likewise, there is impact on the most economically active cities in the area of influence (Manizales and Pereira) regarding average travel time.

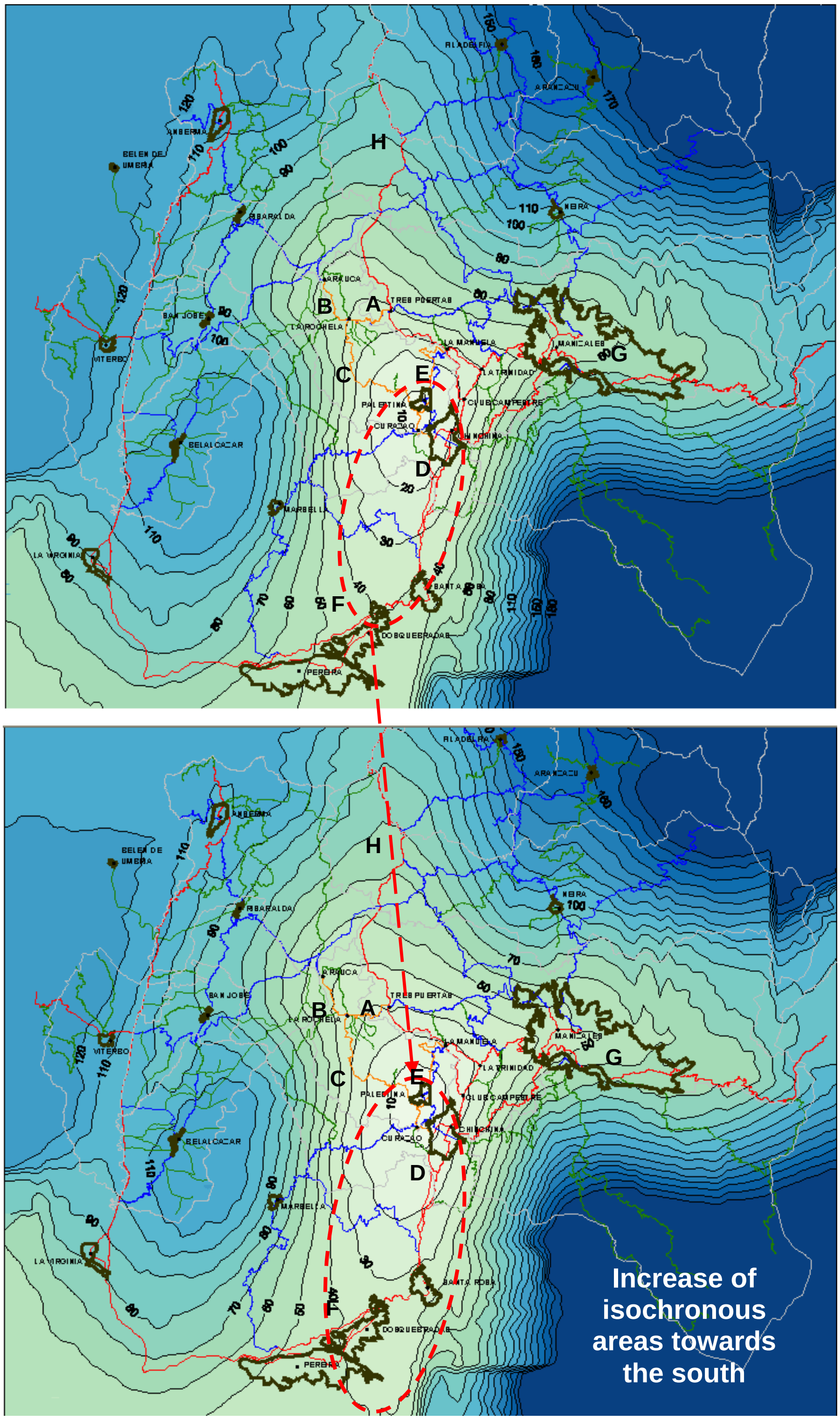


Figure 6. Isochronous Curves of Integral Average Accessibility on the Actual and Future Road from Palestina

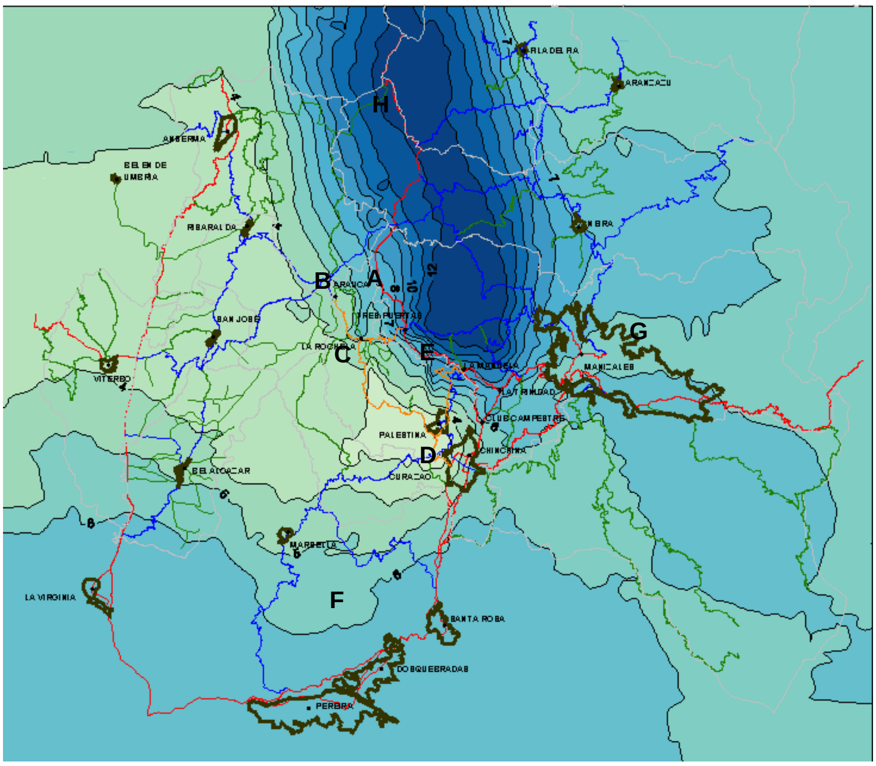


Figure 7.Isochronous Curves of Integral Average Accessibility for the Gradient of Average Travel Time between Actual and Future Scenarios, from Palestina.

Geographical Analysis regarding costs between the three different types of vehicles.

The officially vehicle operating costs published by INVIAS (INVIAS, 2007) were taken as the basis for the analysis of transport costs. The isochronous curves for each type of vehicle (car, bus and truck) were obtained, both for the Actual and Future scenarios, which allowed a comparison between cost matrices and obtain the gradient curves in $ / Pas for cars and buses, and $ / Ton for truck. The curves represent areas that could be reached at a specific average travel cost from any node in the network. This travelling cost depends on the physical and operational characteristics of the road (topography, road condition, etc.).

According to the analysis, almost all the analyzed area show savings in operating costs and the area with the greater impact on these variables is precisely where the road interventions will take place; which was an expected result.

The operating costs in private vehicles (U.S.$ 1 = 2000 Colombian pesos) range from U.S.$16 and $31 in the entire region. Figure 8 shows that the savings in operating costs range from U.S.$0.13 and $0.75 per vehicle with a capacity of 5 passengers, once the interventions are completed. This indicates savings between 0.4% and 4.6% in private vehicle trips by comparing the results on both scenarios.

The operating costs in bus (U.S.$1 = 2000 Colombian pesos) range from U.S.$54 and $U.S.96 in the entire region. Figure 9 shows that a bus travelling on full capacity (24 passengers) can save between U.S.$ 0.3 and U.S. $ 2.4. This indicates savings between 0.31% and 4.44% for this type of vehicle, travelling full capacity for both scenarios.

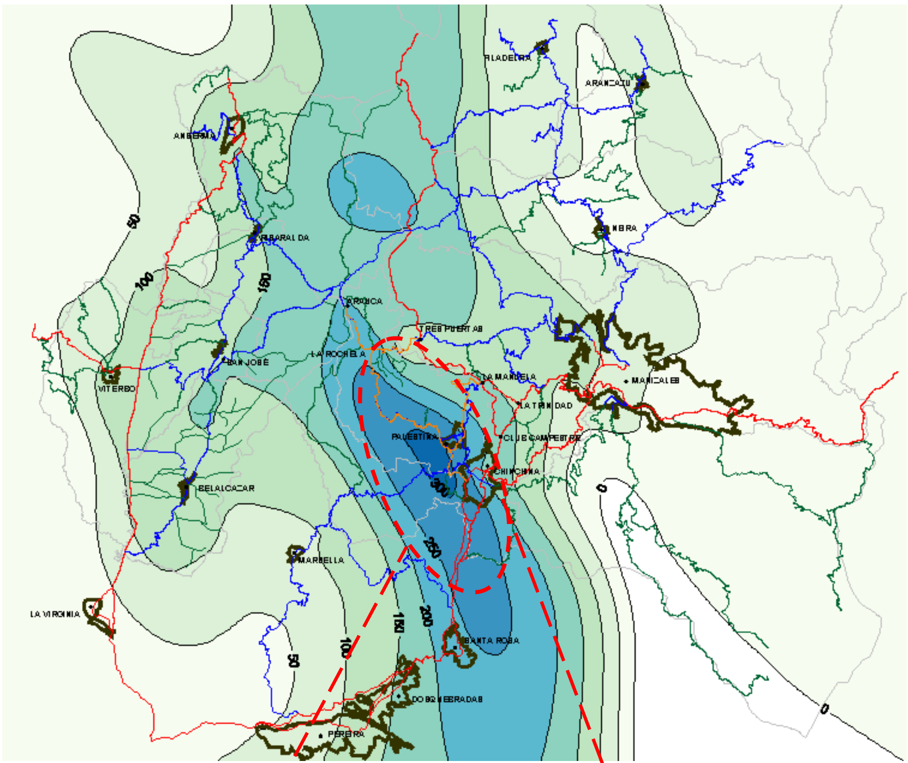
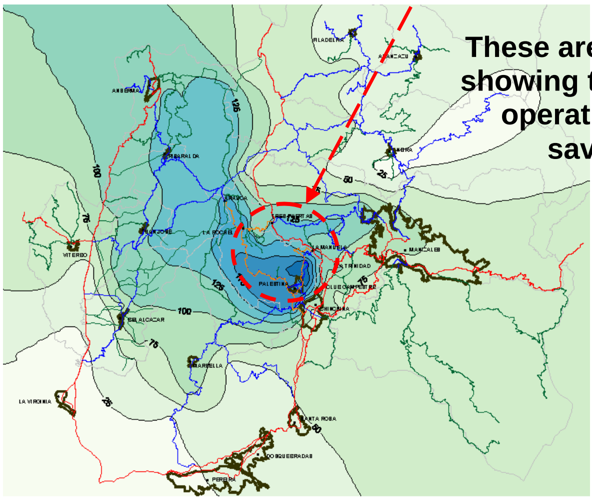


Figure 8. Gradient of Isocost curves ($/Pas) of Global Average Accessibility by car.



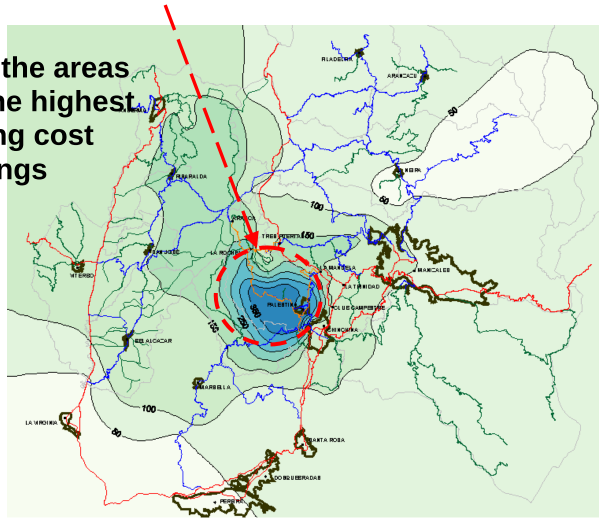


Figure 9. Gradient of Isocost Curves ($/Pas) of Global Average Accessibility for Buses.

Figure 10. Gradient of Isocost Curves ($/Pas) of Global Average Accessibility for trucks.

The Truck operating costs (U.S.$1 = 2000 Colombian pesos) range between U.S.$83 and U.S.$154 in the entire region. Figure 10 shows that a truck with an average capacity of 23.7 tons. might have savings between U.S.$ 0.6 and U.S. $4.. This indicates savings in operating costs between 0.38% y 0.50% for this type of vehicle, with average capacity, on both scenarios.

Based on the previous results, the truck is the vehicle with higher benefits regarding savings in operating costs, which would directly benefit the future Aeropuerto del Café. It is worth noting that although the percentage of variation in operating costs is considered low, it is necessary to take into account the total traffic travelling within the area under study in order to make projections of the real savings that would take place years after investments are made.

It was found that in general the towns located on the periphery of the area under study are the ones with the lowest savings in operating costs.

CONCLUSIONS

In general, the analysis of Global Average Accessibility shows that the entire area under study is covered with average travel times between 80 and 120 min. It is observed that there is a more limited accessibility to the north of the area under study, however, the results of the gradient curves of average times between the Actual and Future scenarios show that the area to the north and the sector where road interventions are to be made are the areas benefited most. The result is positive given the national projections of major roadworks such as the Autopista de la Montaña, which will connect the central-south with the northern region of the country, along the western side.

The analysis of Integral Average Accessibility from the future Aeropuerto del Café shows that there is more efficient communication with the towns located south of the Central-South region than with the towns located north. However, given the future interventions, the north will benefit most. There is a need for better connectivity among towns located along the road corridor towards north of the Departmento de Caldas to the Central South Region in order to achieve an integration that strengthen the potential specialized freight services from the future Aeropuerto del Café.

The towns along the eastern corridor have a greater relative gain of average travel time (7 min.), from the Aeropuerto del Café, while the same road corridor has no change in average travel time from the towns of Manizales and Pereira. There is less impact on the western road corridor because of future interventions.

If the main objective of the road interventions to be undertaken is to provide relative improvements in travel times in the Central-South region of the Departamento de Caldas, it can be concluded that such objective is met, even though the magnitude of those improvements are not considered substantial.

It can also be concluded that combining the analyzed variables in terms of travel time and cost ($ / ton) the greatest benefits will be from Palestina, which will provide this town with the necessary impulse for its development.

The truck would be the vehicle with greater benefits regarding savings in operating costs, which would directly benefit the future Aeropuerto del Café. It is worth noting that although the percentage of variation in operating costs is considered low, it is necessary to take into account the total traffic travelling within the area under study in order to make real saving projections for the years after the investments are done

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