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Analysis of Territorial Accessibility to the Nodes of Health Activity in the Municipality of Pitalito, Colombia

Diego A. Escobar[1], Jorge A. Montoya[1] & Carlos A. Moncada[2]

[1] Universidad Nacional de Colombia, Sede Manizales, Facultad de Ingeniería y Arquitectura, Departamento de Ingeniería Civil, Carrera 27 # 64-60, Manizales, Colombia

[2] Universidad Nacional de Colombia, Sede Bogotá. Facultad de Ingeniería, Departamento de Ingeniería Civil y Agrícola, Ciudad Universitaria edificio 214 oficina 417, Bogotá, Colombia

Correspondence: Diego A. Escobar, Universidad Nacional de Colombia, Sede Manizales. Facultad de Ingeniería y Arquitectura, Departamento de Ingeniería Civil, Carrera 27 # 64-60, Manizales, 170004, Colombia. E-mail: daescobarga@unal.edu.co

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Abstract

The current population growth links different social and economic development problems that must be addressed, within these public health, which should be of high priority in order to minimize the threats of health in the citizenry; therefore, administrative entities must get strong commitments in minimum periods of time. Taking into account the above, it is proposed to evaluate the level of accessibility offered by the road infrastructure network in the municipality of Pitalito, department of Huila, as well as the level of coverage by population and area for the years 2015 (base scenario) and 2031 (intervened scenario), through the use of geostatistical methods from digital tools.

Keywords: accessibility, health, road infrastructure, geostatistics, coverage

1. Introduction

The municipality of Pitalito, is located south of the department of Huila on the Magdalena valley at 1 ° 51'14 "north latitude and 76° 03'05" west longitude (Figure 1), and rests on the vertex of origin of the eastern and central mountain ranges at 1 318 masl having an average temperature of 19° (Alcaldía de Pitalito, 2012). The municipality has a total area of 666 km2 (Alcaldía de Pitalito, 2012) on which 125 839 inhabitants reside (Departamento Administrativo Nacional de Estadistica, 2015), with 79.5% of urban character, distributed in 4 communes.

Its connection with the capital of the department is centered on a 188km road corridor in good condition (Alcaldía de Pitalito, 2012), however, the existing length generates the immediate need to maximize the use of health equipment, minimizing the transfer requirements to higher order entities.

In matters of health, 66.56% of the population is affiliated to the subsidized regime, 26.28% to the contributory regime and 7.16% does not have any connection (Alcaldía de Pitalito, 2012); in relation to mortality, there has been a gradual reduction since 2003, going from 63.4 deaths per 100 000 inhabitants to 34.3 per 100 000 inhabitants to 201, the main causes being: chronic diseases, violent deaths and cancer (Alcaldía de Pitalito, 2015).

The needs of access to health equipment implies a strong commitment from the municipal administration, with the aim of achieving a healthier population by minimizing travel time to these services (Unal, Chen, & Waldorf, 2007), in addition to guaranteeing a better quality of life. For this reason it is proposed to perform the assessment of accessibility to the health care centers of the municipality, taking into account the baseline situation (2015), as well as the horizon 2031, after the road interventions proposed by the administration in its Land Management Plan, still under construction.

The concept of "accessibility", in its basic form, contemplates the measurement of the ease or difficulty existing for communication between human settlements, according to the activities to be carried out taking as reference the transport modes and road infrastructure used (Morris, Dumble, & Wigan, 1978). Other forms of reference to the term relate it to the intensity of possibilities for interaction and exchange (Hansen, 1959; Enwicht, 1993); considering as elements of interaction, the population, infrastructure and health facilities, configured as origin, destination and trajectory (Monzón de Cáceres, 1988).

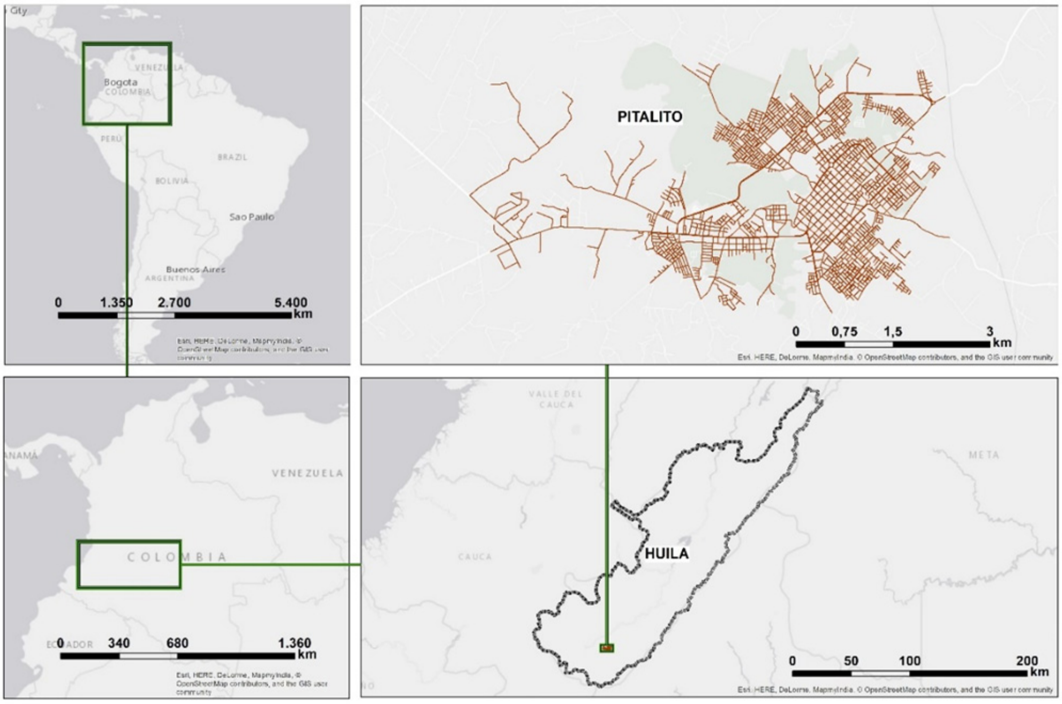

Figure 1. Location of the municipality of Pitalito, Huila

Some studies related to accessibility in our medium of study are: social exclusion (Bocarejo, & Oviedo, 2012), sustainability (Cheng, Bertolini, & Clercq, 2007; Vega, 2011), agriculture and natural resources (Gellrich & Zimmermann, 2007), trade (Montoya, Escobar, & Moncada, 2017; Montoya, Escobar, & Sabogal, 2017; Zuluaga & Escobar, 2016), health (Putri, Permanasari, & Fauziati, 2016; Rosero, 2004; Unal et al., 2007), among others.

2. Method

As a research methodology, the application of xx consecutive items is considered, which takes in account significant elements for the study, from the collection of information, to the construction of coverage graphs as shown in Figure 2.

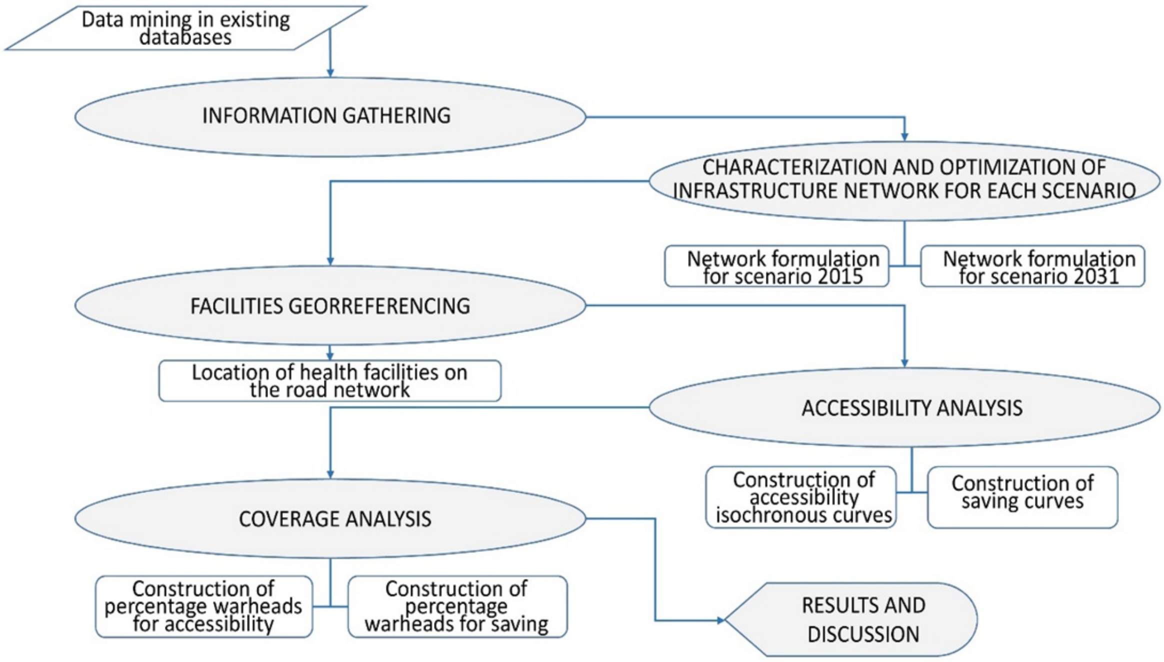

Figure 2. Applied research methodology

2.1 Information Gathering

As a first methodological item, we proceed to collect the necessary information for the characterization of the road network and health facilities; within which the different physical and operative components are considered for the current and future base.

2.2 Characterization and Optimization of the Road Network for Each Scenario

After obtaining the physical and operational characteristics of the municipality's infrastructure network (speed, directionality, length, type, etc.), the road network of each scenario is formulated.

2.2.1 Current Scenario (2015)

Figure 3 shows the configuration of the road network of the municipality of Pitalito for the current situation (2015), considering the physical and operational characteristics collected in the previous item. It is important to clarify that within the structure of the road network, two vital elements are distinguished for the use of the network, nodes (elements of virtual union between roads) and arcs (linear elements that represent a track segment).

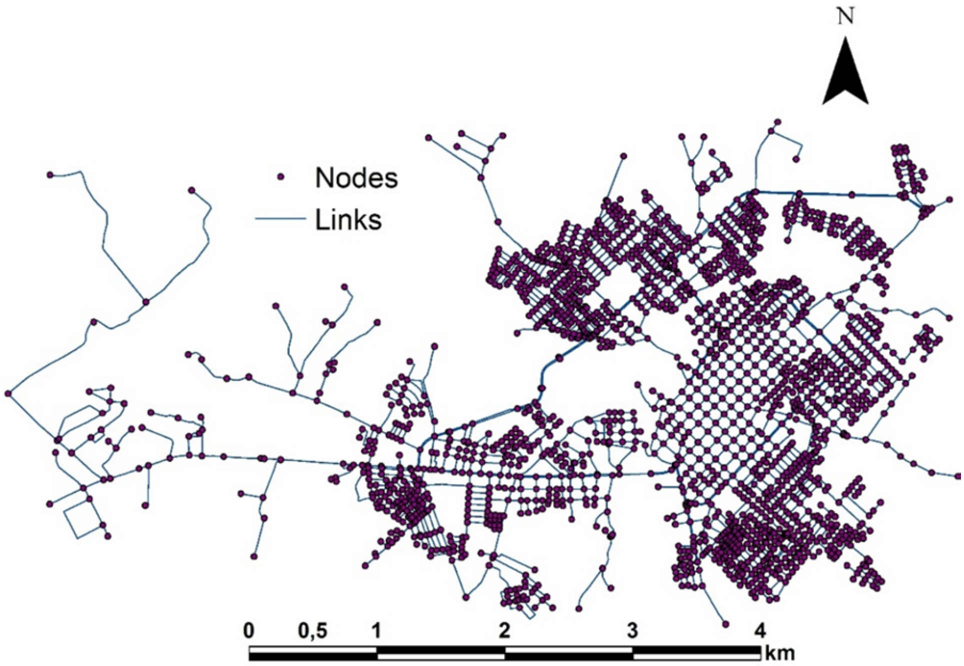

Figure 3. Road network configuration for scenario 2015

2.2.2 Future Scenario (2031)

After the formulation of the base network, we proceed to generate the sequence of links and nodes for the expansion of the infrastructure network to the future scenario, taking into account road rings, expansions and elevated sections. The interventions are carried out using the ArcMap tool and can be seen in Figure 4.

2.3 Georeferencing of Equipment

Another of the necessary inputs for the execution of the evaluation is the georeferencing of the nodes of activity in health obtained through the mining of data of the methodological item 1; which are seen in Figure 5.

2.4 Accessibility Analysis

2.4.1 Construction of Accessibility Curves

As a next methodological item, equipment and infrastructure networks are linked to formulate the accessibility curves using the ArcMap tool; within this, the links acquire the denomination of "incidents", the health care centers as "facilities" and the links as "Routes" (Montoya et al., 2017). The construction of these curves, focuses on the determination of travel times (Tt), which, using equation 1 calculates the cost of moving on each link of the road network, considering the length of the link (X) and its speed (V).

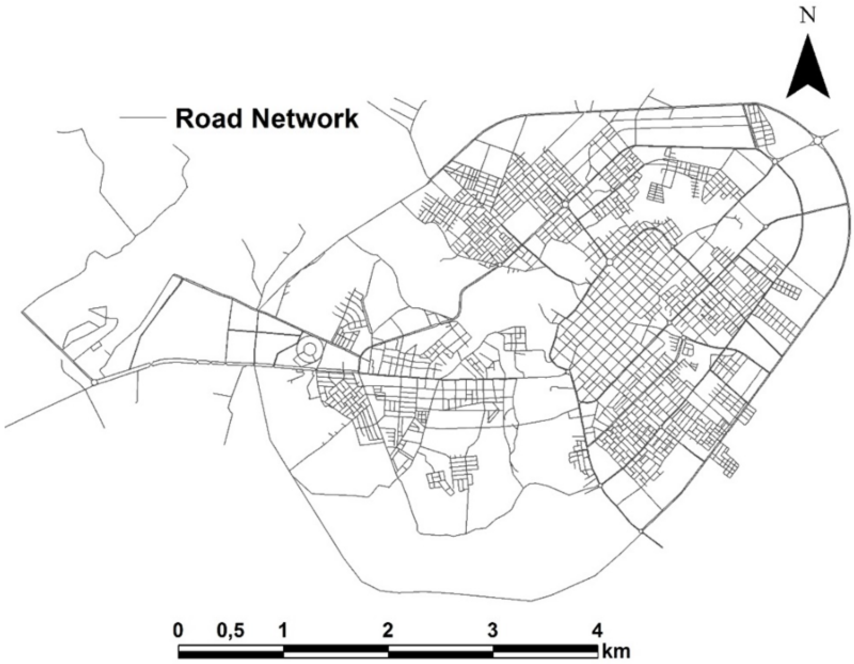

Figure 4. Road network for future scenario, 2031

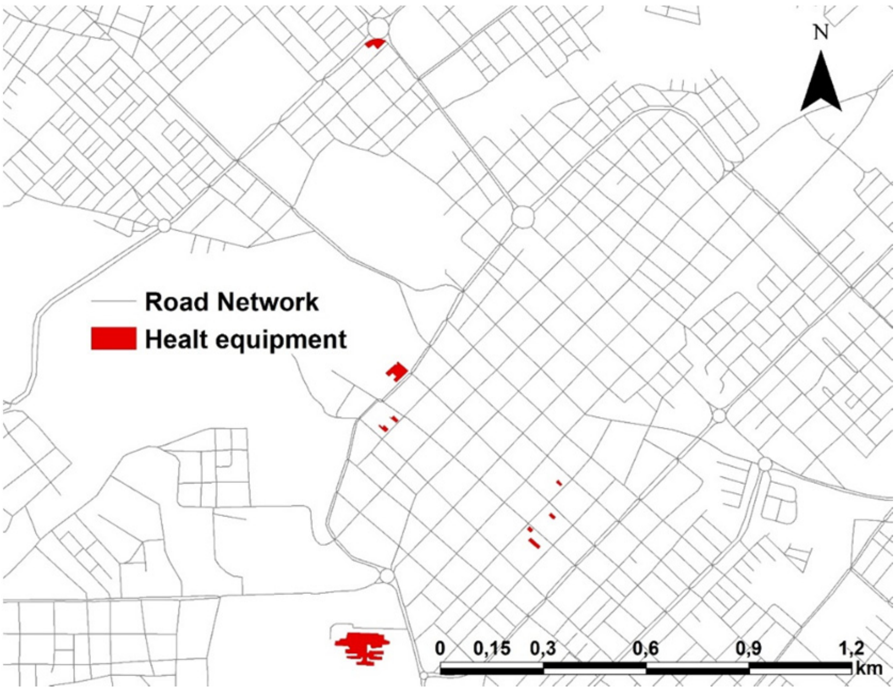

Figure 5. Health activity nodes location

$$Tt_i = \frac{X_i}{V_i} \qquad i = 1,2,3,4,\dots,n \tag{1}$$

Subsequently, the Closest facility tool immersed in the Network Analyst extension of ArcMap is executed, which, through the application of the Dijkstra algorithm, obtains the lowest cost of moving from a source node to a destination one (Montoya et al., 2017; Perilla, Escobar, & Cardona, 2017; Sallán, Guardient, & Suñé, 2010). With the values obtained for each facility, the vector of displacement times is obtained, which crossed with the spatial location of each node, formalizes the displacement time matrix.

Finally, the Geostatical Wizard tool is executed, which links the displacement time matrix and, through the ordinary Kriging interpolation method, elaborates the accessibility curves.

2.4.2 Construction of Savings Curves

Once the displacement times have been determined and the accessibility curves have been constructed for each scenario, we proceed to evaluate the savings percentage (Savings in time) generated by road interventions by 2031. The construction process considers the relationship in times of displacement of the future scenario ($Tt_{i(fut)}$) with respect to the current scenario ($Tt_{i(act)}$), using equation 2.

$$\text{Savings in time } (\%) = \left(\frac{Tt_{i(act)} - Tt_{i(fut)}}{tv_{i(act)}}\right) * 100 \tag{2}$$

With the savings values obtained, we proceed to execute the Geostatical Wizard tool, as in the elaboration of the accessibility curves, to finally obtain the graphic representation of the savings generated.

2.5 Coverage Analysis

As a last methodological item, we proceed to link the socioeconomic variables of area and population, obtained during the data mining of item 1, which are distributed over a graphic entity (shape) type polygon, with which we proceed to intercept the accessibility and savings curves obtained, using the Geoprocesing intersect tool of ArcMap.

3. Results

3.1 Accessibility Analysis in the Current Scenario (2015)

As a result of the analysis of territorial accessibility of the health care nodes in the municipality of Pitalito for the base situation, 2015, Figure 6 was obtained, in which the variation in travel time generated by the road network at intervals of 0.5 minutes is appreciated.

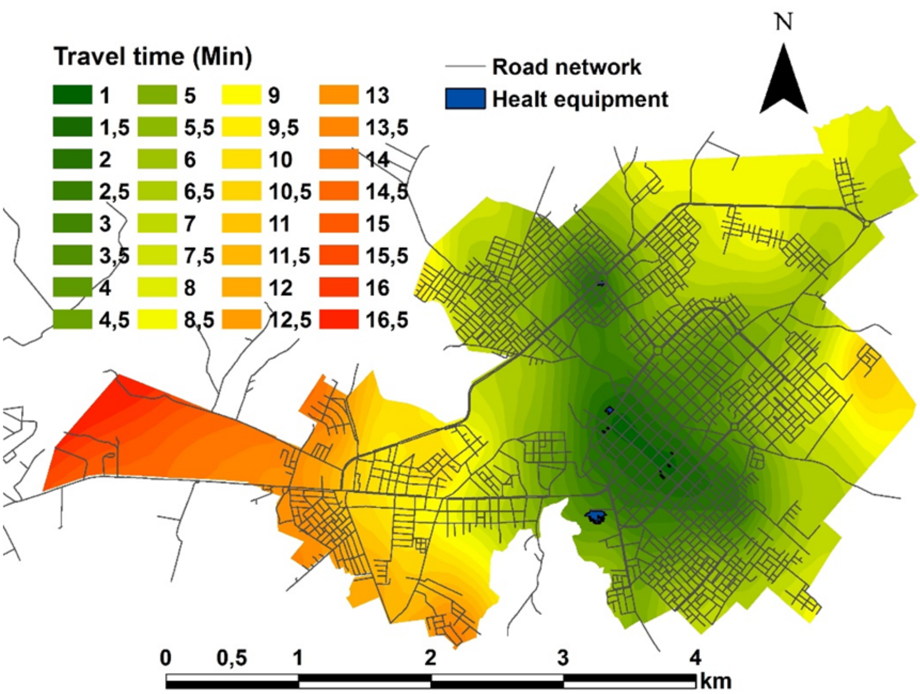

Figure 6. Territorial accessibility curves for the current scenario, 2015

There is a high percentage of the municipality covered by a travel time of less than 8 minutes (eastern sector), which guarantees quick access to at least one of the health entities. On the other hand, there is an observed maximum of 16 minutes towards the western part of the municipality, which shows the need for intervention, either in infrastructure or generation of a new health center.

Figure 7 shows the percentage of coverage by population and area generated by the infrastructure network to health facilities, managing to cover 70% of both variables in less than 7 minutes, in addition to a similar behavior between curves, which can be interpreted as a balanced distribution of the population on the surface of the municipality.

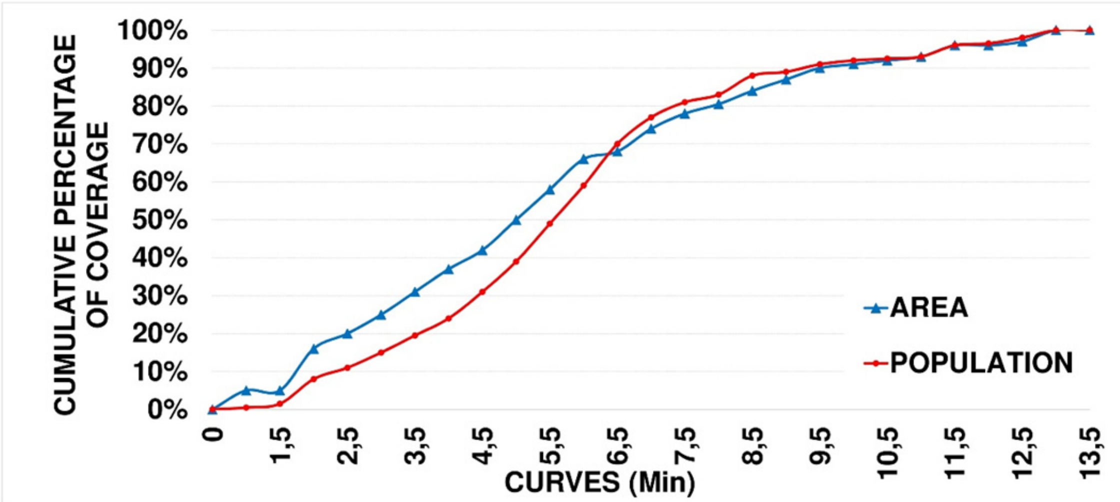

Figure 7. Accumulated percentage of coverage by variable to 2015

3.2 Future Scenario (2031)

As a result of the evaluation of accessibility to health facilities once the road interventions to the 2031 horizon have been established, Figure 8 is presented, where the variation in the displacement cost obtained can be seen at 2.5-minute intervals.

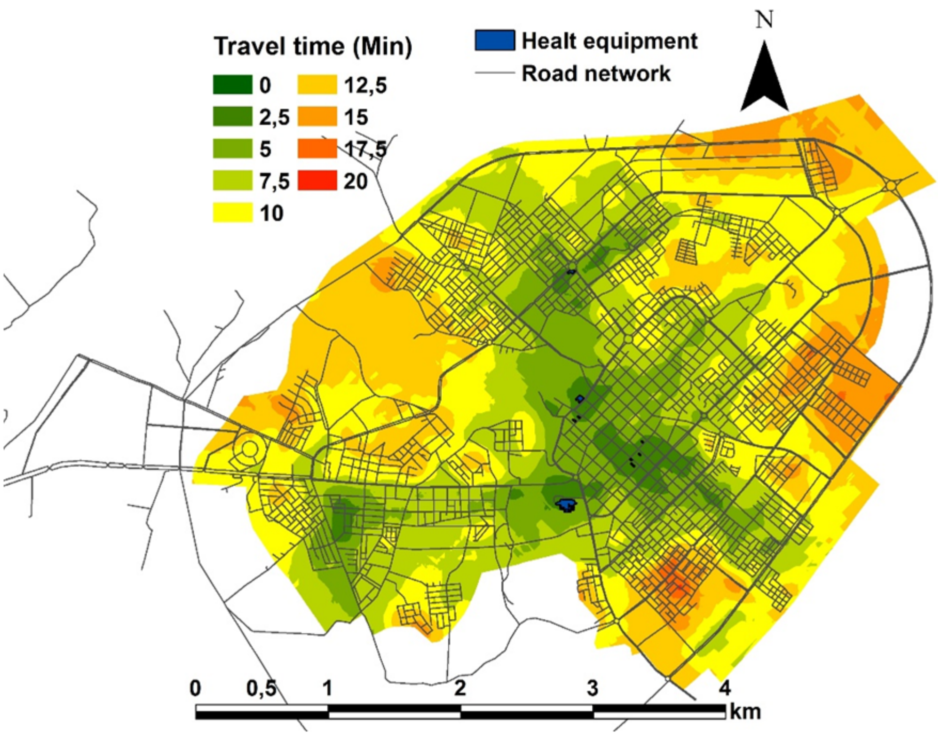

Figure 8. Territorial accessibility curves for the future scenario, 2031

A strong coverage concentration of less than 8 minutes is identified, around 45% of the total map, towards the sectors with the highest population density in the road network. The peripheral and expansion sectors in the network require a higher displacement cost, however, low density is evident, which is why there is no displacement deficit; additionally, the mark in coverage of the western sector observed in Figure 6 is suppressed, because this acquires the connotation of industrial zone and requires a differentiated treatment.

Complementarily, in Figure 9, the results obtained from coverage by population and area are shown, the similarity between curves with respect to Figure 7, increased, presenting a discrepancy of 10% at 10 minutes. Regarding coverage percentages, 70% of the variables are framed in a travel time of less than 10 minutes, which when compared to the current scenario, increases the cost in time for the same coverage margin; however, it must be considered that at the 2031 horizon the population value increases to 150 432 inhabitants (Consorcio Aguas del Huila, 2014).

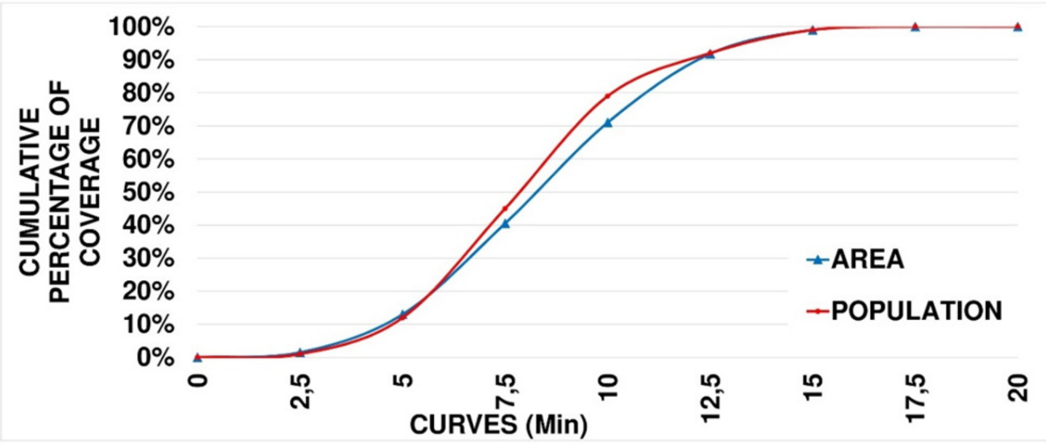

Figure 9. Accumulated percentage of coverage by variable to 2031

3.3 Savings percentage

Taking into account the accessibility results obtained for the 2015 and 2031 scenarios, it was possible to construct Figure 10, which shows the percentage of savings generated by road interventions at intervals of 10 units.

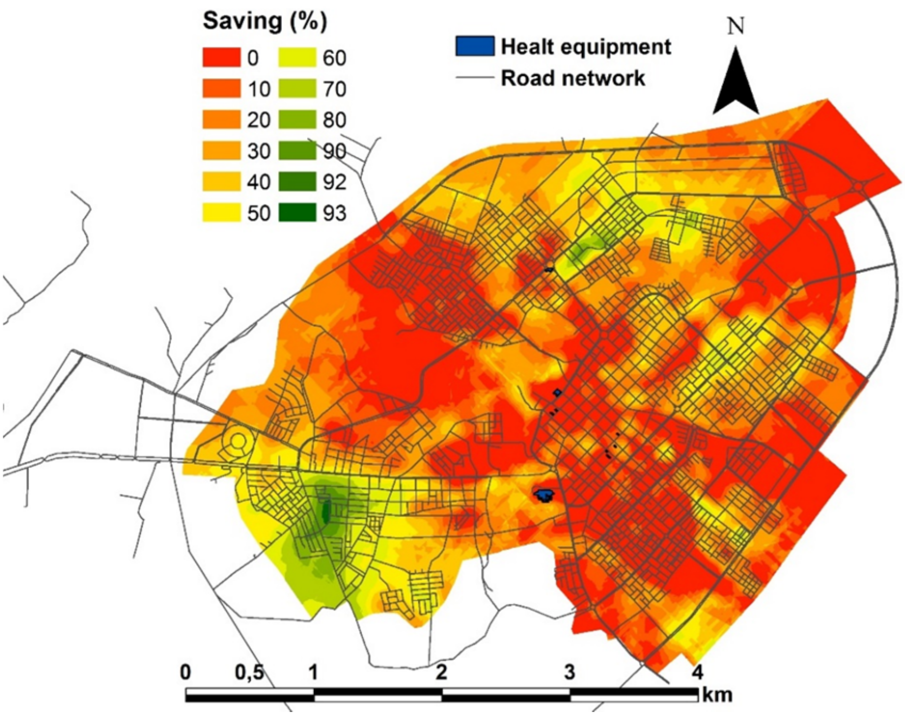

Figure 10. Curves of percentage of savings for health equipment to the 2031 horizon

It is appreciated that around 60% of the surface perceives savings of at least 10%, with the southwest sector having the highest value with perceptions of up to 93%. The sectors that do not perceive savings do not imply a deterioration in the mobility of the population, however, it is possible to access the health entities within an established limit of 10 minutes, which could be reduced in a possible intervention.

Figure 11 shows the results obtained for the perception of savings per variable; from which it can be observed that around 50% of the population perceives a saving of up to 25%, which can be assumed as having a high impact, considering the population growth and the distance in years with respect to the horizon study.

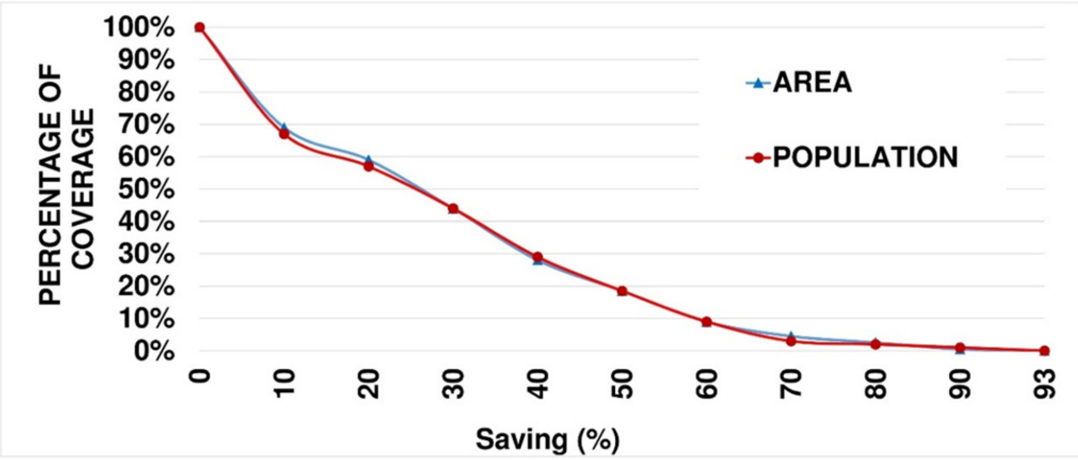

Figure 11. Percentage of savings perceived as variable for health facilities

4. Conclusions

As a general assessment, it is possible to affirm that the proposed interventions to the horizon 2031 on the road infrastructure network, improve the conditions of accessibility of the population towards the health care centers of the municipality, by covering more than 70% of the population in a time of up to 10 minutes.

On the other hand, the evaluation methodology allows locating areas with access difficulties, facilitating decision making in future road interventions, as well as the implementation of new equipment in order to benefit the affected population.

It is recommended to carry out, in future investigations, the intervention in health for the industrial sector destined in the municipality, considering that, it could be a potential focus of work accidents, which require to be attended.

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Competing Interests Statement

The authors declare that there are no competing or potential conflicts of interest.

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