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Political Determinants and Impact Analysis of Using a Cable System as a Complement to an Urban Transport System

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Abstract

The construction of cable-propelled systems, fully integrated to urban public transport systems, has become an innovative trend in recent years for some Colombian cities. The most prominent examples include the cities of Medellín and Manizales, where these infrastructures have been built and running for several years. In fact, it should be highlighted that Manizales hosted, during the first half of the 20th century, the longest cable system in the world, which operated for nearly 40 years and was a cornerstone in the development of the region. This historic cable enabled the transportation of large shipments of coffee to the Magdalena River, to be exported across the world.

In this paper we provide a thorough assessment of the current cable system in Manizales. We evaluate its costs in a comparative perspective against the impacts generated by the system, via time savings in daily travel. Due to its full integration with the public transport system, we also provide empirical evidence of the related passenger demand variability.

Upon the implementation of the first cable system, additional similar projects have been initiated. We provide insights into a cable system designed and being built for recreation, and describe the planning process for the most recent public transport cable system being designed. All these systems are evaluated from the supply-side, measuring accessibility, from the demand-side, modelling the complete urban transport system for the city, and from the political side, describing the determinants of the decisions that ultimately stimulate the implementation of these projects in sustainable mobility.

Based on the results obtained, we offer conclusions regarding the actual competitiveness of cable-propelled systems, arguing that they should be considered valid urban passenger transport solutions.

Keywords: Accessibility, impact of transport modes, cable propelled system, transport innovation.

JEL Classification: R41 and R42

Number of words: 6.204

1 Introduction

The city of Manizales is located in the centre-west region of Colombia, at 5.4º latitude north and 75.3º from Greenwich, along the prolongation of the Andean Mountain Range, at 2150 meters above sea level, and with a approximate population of 370.000 inhabitants. The city was planned and developed in response to an abrupt topography, which explains the discontinuous urban structure. In October 2009, a cable-propelled line was inaugurated in Manizales, as a complement to the Urban Collective Public Transport (UCPT) system. It was built, with the primary objective to connect the city`s Central Business District (CBD), with the inter-municipal transport terminal.

Territorial planning, for both urban and regional transport, has significantly veered towards ¨accessibility¨ during the last 50 years. This approach was initially introduced in the 1920`s, in the context of regional economic planning and area location theories (Batty, 2009). For the purpose of this paper, we define accessibility as a measure of the easiness in communication among human settlements and activities, using a certain mode of transport (Morris et al., 1978), (Zhu and Liu, 2004), however, we are aware of several other accepted definitions for this concept, with Hansen's (1959, 73) definition being a classical one: "… the potential of opportunities for interaction".

There are many different approaches to use an accessibility analysis as an evaluation tool for sustainability (Cheng et al, 2007; Vega, 2011), economic development (Rietveld and Nijkamp, 1993; Vickerman et al., 1999; MacKinnon et al., 2008), demography (Kotavaara et al., 2011), coverage analyses (Straatemeier, 2008), social cohesion (Schürman et al., 1997; López et al., 2008), operativity in modes of transport (Escobar and García, 2012), amongst others. Moreover, what remains clear is that accessibility analyses are increasingly becoming more important in the evaluation of infrastructure plans and projects (Gutierrez et al., 2010), as the improvement in accessibility levels is very often, one of the key criteria in these evaluations.

For the purpose of this research, we use operation speed data for the UCPT, measured via GPS systems. The operation speeds where calculated based on real monitoring data and reflect the true operational characteristics of the arcs that compose the network; a remarkable fact, considering that in some cases the operational speeds are estimated according to the path category (Burns, 2007); nevertheless, we are aware that in recent years, some accessibility research has been advanced, using only real vehicle speeds (Li et al., 2011).

Road network and speed data were loaded onto a GIS system. These GIS systems record a vast variety of data that, upon generating interactions, allow us to obtain a more detailed understanding of the accessibility characteristics offered by every single transport mode. One of the key advantages of GIS systems is that these allow us to understand the behaviour of the network (Gutierrez et al., 2010), thanks to the use of specific algorithms (i.e. minimal paths) (Zhang and Gao, 2009) that provide researchers with tools to simulate diverse network behaviours.

In this paper we evaluate the overall average accessibility conditions offered by the UCPT system before the implementation of the cable, and then compare these with the new conditions upon the implementation of the cable-propelled system. We evaluate costs, using a comparative perspective in regards to the system generated impacts, via travel time savings. On the other hand, we provide a brief historical summary of the key political determinants to the implementation of the system, and the changes in transported passenger numbers.

Our research efforts have been focused on the impact, in terms of average travel time, given the new cable-propelled line, in respect to the area and population percentages and number of housing units covered by the isochronous curves. The data processing was made using the Transcad® software, and fully taking into consideration the current and future physical characteristics of the UCPT system of the city of Manizales, in order to obtain the matrices with average travel times, generated by minimal paths, and the application of all technical foundations required for the evaluation of accessibility.

The structure of this paper is as follows: we provide a summary of our methodology for accessibility calculations, and describe our database in section 2. Section 3 offers an insight into the historical conditions, and political determinants of the cable-propelled system in the city. We present or results in section 4, and finally, our conclusions in section 5.

2 Methodology

The most fundamental components of our methodology comprise the generation of the pertinent georeferenced network and of the operation speeds for the arcs that withstand the UCPT system. Building upon these, we apply geostatistical techniques to obtain the prediction models for our key variable: average travel times, both ex-ante and ex-post.

2.1 Data collection

25 GPS tracking devices were installed in a rotating fashion, to a sample of 200 UPCT vehicles, so as to record satellite positioning data along a predetermined time interval. Using this approach, one can calculate the average operation speed for each of the arcs that compose the system. On the other hand we compiled qualitative data from public and media records, pertaining the planning and implementation process for the Manizales cable-propelled system.

2.2 Update of the georeferenced network

We analysed the current road network, as provided by the municipal administration, and complemented the supplied data with the fieldwork done using the GPS tracking devices. This allowed us to correct and validate geographical information.

2.3 Calculating operational speeds and instantaneous speed

In order to process the collected data, different calculation algorithms were required. Operational speed was determined for each network arc based on time data obtained directly from GPS tracking. We analysed three parameters: (1) vehicle speed for each data point interval for all *nth* arcs; (2) average operation speed for the *nth* arc; (3) operational speed for each *i* arc in a predetermined route.

2.3.1 Calculating instantaneous speed

The operational speed for each time interval between two points was obtained by applying

Equation 1. This parameter was used to establish speed variations in a particular arc, in order to determine the account for the operational stops when zero values are obtained, and to determine the duration of these stops.

Equation 1 Operational Speed

$$v_i = \frac{3.6}{t}\sqrt{(y_2 - y_1)^2 + (x_2 - x_1)^2}$$

Where:
v_i = Speed in km/h,
x_1, y_1 = Coordinates for point 1 in meters,
x_2, y_2 = Coordinates for point 2 in meters,
t = time interval in seconds between data points.

2.3.2 Calculating average speed for a trip within an arc

The average speed for a trip within an arc was obtained using the relation between arc length and the difference in passing times between the beginning node and the ending node (see
Equation **2**).

Equation 2 Average speed for a trip within an arc

$$v_i^a = 3.6\frac{l_a}{t_2 - t_1}$$

Where:
v_i^a = Speed *i* in an arc *a* (km/h),
l_a = Longitude of the arc *a* in meters,
t_1 = Passing time in beginning node,
t_2 = Passing time in ending node.

2.3.3 Calculating average speed within an arc for a given period of time

The average speed within an arc for a given period of time is calculated using
Equation **3**. This speed was calculated for each road network arc that makes part of the UCPT system. We use this to establish impedances, and ultimately, calculating the minimum times matrix.

Equation 3 Average speed within a given arc

$$\overline{v_a} = \frac{\sum_{i=1}^{n} v_i^a}{n}$$

Where:

$\overline{v_a}$ = Average operational speed within arc *a*,

n = Number of registered speed data points within arc *a*, during a given time period.

2.4 Calculating Overall Average Accessibility

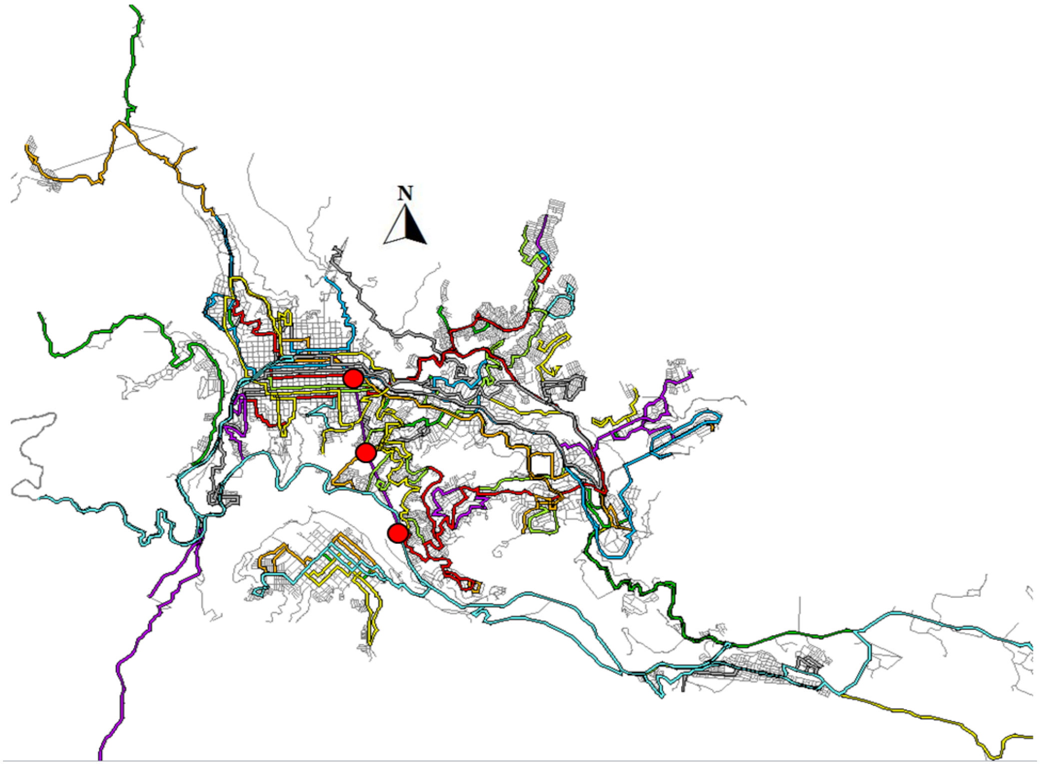
We calculate the overall average accessibility based on the average trip time vector (Tvi), which represents the average travel time from node *i* to all other nodes in the road network; this indicator tends to favour those nodes located towards the centre of a network, due to the fact that travel times from said nodes to all others are shorter, due to their geographical location.

In order to obtain the average trip time vector, we initiate by calculating the unimodal distance matrix. Hence, upon securing average operational speeds for each arc, we can elaborate the average minimum travel times matrix, through which average travel times between all nodes that make part of the studied network are minimized. The obtained average travel time vector (nx1) is related to the geographical coordinates (latitude and longitude) for each of the nodes; thus providing an ordering matrix (nx3), with which all average travel time isochronous curves are generated.

2.5 Description of the parameter obtention procedure in analysing accessibility for the UCPT system

The UCPT system of the city of Manizales is composed by 60 routes operated by regular buses, medium capacity buses, and micro-buses, and by one single route served by the cable-propelled system, as can be seen in Figure 1; the stations for the cable system have been highlighted in red.

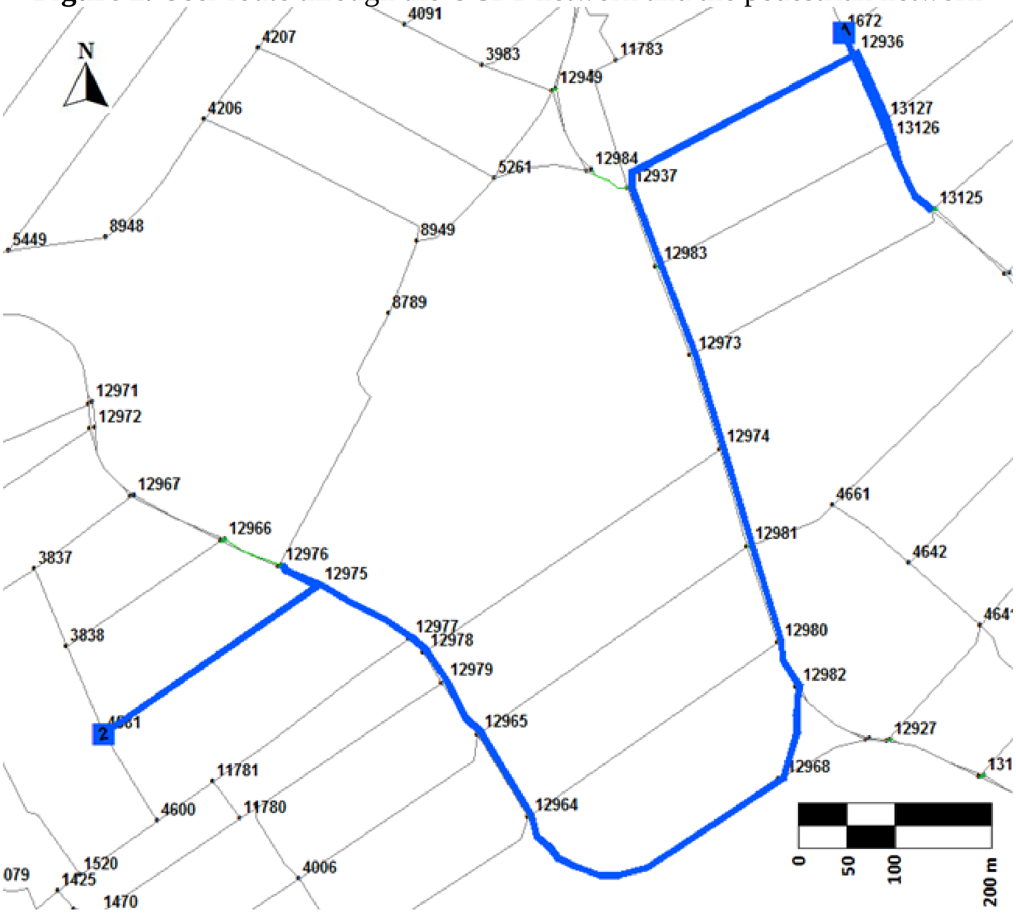
Figure 1. UCPT route network for the city of Manizales and cable-propelled line



Source: Own calculations.

We have taken the full road network and discarded the directionality of the arcs, since users can actually walk in any direction. Similarly, we calculated impedances for each arc, derived from the walking speed; thus, for the purpose of our study, walking is a possibility for all arcs except for those composing the cable-propelled line. After overlapping the road network used by the UCPT routes on the defined pedestrian network, we connected the precise locations for the public transport stops. In Figure 2 we can observe, for example, the representation for a user trip that begins at location 1 (node 1672), walks to the public transport stop at node 13125, boards the transport system, and then gets off at another public transport stop located at node 12976, and finally walks through the pedestrian network until reaching his destination at location 2.

Figure 2. User route through the UCPT network and the pedestrian network



Source: Own calculations.

The obtained value for the average travel time corresponds with the sum of all impedances deriving from the different times in each arc, a part of which is spent on public transport, while the other one is spent walking. We do take into consideration a waiting time value generated by the vehicle late arrival, as a function of the route frequency. On the other hand, we do not consider any waiting time during the UCPT system exiting stage. Finally, we calculate the minimal paths network in the UCPT system for all nodes against all other nodes. This matrix allows us to generate the accessibility models required for evaluating the insertion impact of the cable-propelled system.

3 Historical and political determinants of the cable-propelled project

3.1 Brief history of the project

The city of Manizales has experienced the implementation and operation of four different cable-propelled systems, which have all ceased to function (Reseña Histórica Cable…, 2011). Currently, one such system is active, and another one is under construction (see Table 1).

Table 1. Cable-propelled systems in Manizales (1915 to 2013)

Cable system	Length	Dates of operation	Status
Manizales - Mariquita	71.8 kms	1915 - 1968	Inactive
Manizales - Aranzazu	22.8 kms	1928 - 1942	Inactive
Manizales - Pueblo Rico	9.7 kms	1928 - 1935	Inactive
Manizales - Villamaría	2 kms	1927 - 1930	Inactive
Manizales - Los Cámbulos	2.1 kms	2009 – presently	Active
Los Cámbulos - Villamaría	0.7 kms	Under construction	n/a

Source: own construction from official city data

The Manizales – Villamaría cable line began losing demand as the railroad connecting those areas was introduced. Further, it was completely abandoned when the road between these urban areas was built (García and Correa, 1999). Between 1997 and 1998, an published study insinuated the possibility of rescuing this cable. It was titled "A Prefactibility Project for a Cable between Manizales and Villamaría", and constructed by the API consortium (*Asesor de Proyectos de Infraestructura*). Essentially, it proposed the construction of two terminal stations, at Fundadores and La Fuente, as well as eleven other regular stops.

We highlight three important points from this technical study, which differ from the actual situation of the existing cable. First, the project is framed as a cable intended for tourist purposes; second, the projected cable was framed as a the system operated under a concession; and third, the study proposed a system composed of three individual cable lines, totalling a length of 17.5 km together, and an estimated potential demand of 26,650 daily trips ("Manizales - Villamaría, Cable Vía. Proyecto de Prefactibilidad", 1998).

At the end of 1998 a new study entitled "Plan Director Cable-Vía Manizales" was published. It was sponsored by the Europa América Foundation and produced by the Spanish firm Guillen Associats SL from Barcelona. The study exhibits a quite different cable system from the one currently built, especially in the realm of what was under discussion at that time: three light rail lines (6.3 km) and eight cable-propelled lines (14.3 km), likewise, we find it relevant to highlight several specific statements from this document: "This economic study was performed based on the criteria that would determine the minimum number of trips that would provide a full return on the planned investment" ("Plan Director Cable-Vía Manizales", 1998, 17). Thus, we conclude that the financial model designed for this feasibility study determines the number of ideal trips, but does not determine the number of trips that would technically real. "The main conclusion of this economic analysis is that the project itself, in other words, excluding the external funding, would not be acceptable in terms of an average return expected by an investor" ("Plan Director Cable-Vía Manizales ", 1998, 40); hence, making it clear that the project would not be profitable from a purely economic point of view for whom ends up developing it, which is not the case for the party providing the resources to realize it.

The same key document recommends the design of a more profitable first stage of the project, and says: "The operation of the implemented cable-propelled line will provide actual data, which can be used to deflate the projections applied to other facilities." ("Plan Director Cable-Vía Manizales", 1998, 40), leading us to conclude that the actual implementation of the most profitable cable section, would be used as the actual feasibility study; thus costing several million dollars.

Despite the economic shortcomings, the lack of predicted passenger demand and other countless hypotheses against the feasibility of the cable shown in different studies, the official Decree 1072 was issued in April 2004, providing the ultimate green light to the project's implementation. In early 2006, the well-recognized Colombian transport firm Metro de Medellín, presented a general assessment of the preliminary feasibility for the construction of a cable-propelled system in the city of Manizales. This study initially noted four possible routes for the cable line ("Reseña Histórica Cable ...", 2011); one of which was finally chosen, and is currently operating.

The subsequent implementation stages ran quite smoothly. In December 2006 official contracting began, by March 2007 a proposal was received for its full design and construction, which was awarded to the consortium in April 2007. The process undergoes a technical economic adjustment in July 2007, and the final contract is signed in August 2007. Subsequently, the affidavit that certifies the start of the contract is signed in September 2007, and by January 2008 the architectural designs were delivered. Construction work began in March 2008, and finally, by October 30, 2009 the system was inaugurated ("Historical Overview Cable ..." , 2011).

3.2 Political dynamics influencing the process

Twelve years passed from the moment the first study was published, until the first line was opened in 2009. Interestingly, the city hosted seven different mayors during this time. Public policy decisions in cities are exposed to a variety of coordination problems, whose resolution depends directly on the interaction between actors at different institutional levels.

In order to understand these multi-level relationships, and their policy consequences, it is crucial to analyse two overarching ideas, as Procopiuck (2011) reminds us: (1) how these institutions are organized; and (2) how their agents act strategically in society in order to obtain resources and competencies that can be applied towards public policies in the long run. Moreover, in order to produce public policies at the local city level, government often have to coordinate efforts with regional, national and/or international institutions. Thus, coordination capabilities turn out to be important attributes in designing and implementing metropolitan-wide policies for certain urban services like transport, water supply, air quality protection, etc.

The case of Manizales is an interesting one, as not only do we observe a significant number of mayors and municipal administrations being directly involved in the project (see Table 2), but also a variety of institutional players, and governmental levels. After the pioneering cable-propelled systems implemented during the beginnings and mid 20th century, the idea was once again proposed in 1997, although purely as a tourist alternative for the city of Manizales. This happened during the period during which Mauricio Arias Arango was mayor, with the support of the traditional forces of the Department of Caldas: the Barco and Yepes political groups. As such, no major political groups could have been expected to oppose the project. The new cable-line was approved in 2004 by the city administration –then under mayor Nestor Eugenio Ramírez– who interestingly, was not part of the traditional political coalitions. Nonetheless, the project continued to gather support from both sides of the aisle; thus becoming a flagship project for the city ("Los planes de desarrollo, entre …, 2012"). Finally, its construction started (and finished) during the city government led by Juan Manuel Llano.

Table 2. City governments in Manizales (1992-2015)

Mayor	Period	Political Support
Jorge Eduardo Rojas Giraldo	2012-2015	Partido Conservador
Juan Manuel Llano	2008-2011	Partido de la U
Luis Roberto Rivas	2005-2007	Nuevo Partido, Salvación Nacional, Cambio Radical
Néstor Eugenio Ramírez Cardona	2002-2004	Independent
Germán Cardona Gutiérrez	1999-2001	Nuevo Partido, Salvación Nacional
Jorge Enrique Rojas Quiceno	1998	Non-traditional coalition opposing the Barco-Yepista coalition
Mauricio Arias Arango	1995 – 1997	Traditional coalition
Germán Cardona Gutiérrez	1992-1994	Traditional coalition

Source: own construction from official city data

The participation of the national government was also significant and important throughout the process. Not only is the national Ministry of Transport, the sole entity with the competency to regulate and supervise cable-propelled public transport services, but it is also this ministry which ends up generating the norms and technical specifications for the development of such projects. Moreover, a division within this ministry called Superintendencia de Puertos y Transporte (Regulating Agency for Transport and Ports), is entitled to supervise the service provision for the system. ("Reseña Histórica Cable ...", 2011). The participation from the national government is also crucial due to the financial resources available for the development of these types of projects. The National Development Plan for the 2002-2004 presidential period mentioned the specific task of studying the reconstruction of the Manizalez - Mariquita cable-propelled system, in order to strengthen the tourism cluster for the region (Plan Nacional de Desarrollo, 2003). Moreover, National decree 1072 (2004), dictates the need for technically appropriate studies being developed by a recognized entity with sufficient experience. As such, Infimanizales contracted with Metro de Medellín (first company in the world to successfully implement cable-propelled systems, as part of an integrated mass transport system), two significant studies: (1) a general diagnostic in 2005 for the potential construction of the first cable line; and (2) an advanced assessment on the construction of the terms of reference for the pre-construction studies of the first cable line in 2006.

Although the project enjoyed significant political support from various political groups and institutional levels, several academics did voice their opposition to its development. A group from the National University (Manizales), for example, publicly expressed their technical concerns towards the project during a presentation before the Manizales City Council in 2005; mainly, in regards to the lack of passenger demand to achieve an appropriate return on the investment, according to available projections. Nonetheless, the project was a clear flagship initiative by the city government led by Juan Manuel Llano, and it was ultimately pushed through, and paid via public subsidies. Although most of the administrative and operational information continues to be confidential, it is still not completely clear whether the city government is having to provide a monthly subsidy to the cable; the authors of this paper have reason to believe this is the case, according to the projections made, but have found no access to the official records, in order to validate the claim. Likewise, a study published in 1999 by the same university clearly states that such cable-propelled systems require costly maintenance that would not fit the goals of the

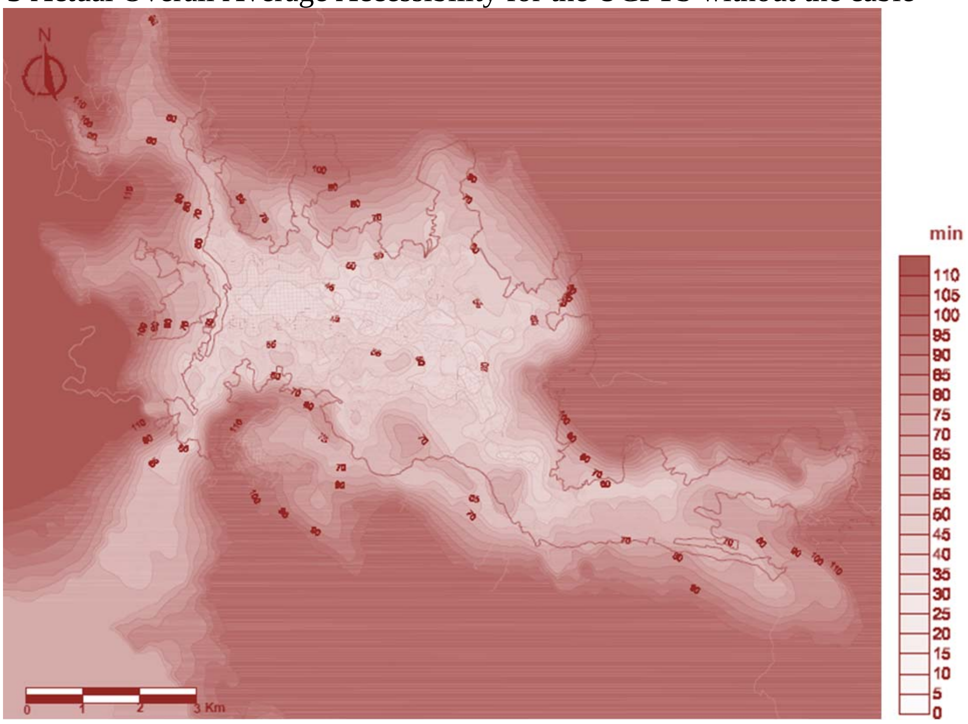
UCPTS of a mid-size city like Manizales (Cable Vía Manizales. Una vieja solución…, 1999).

4 Results

4.1 Accessibility in average travel times

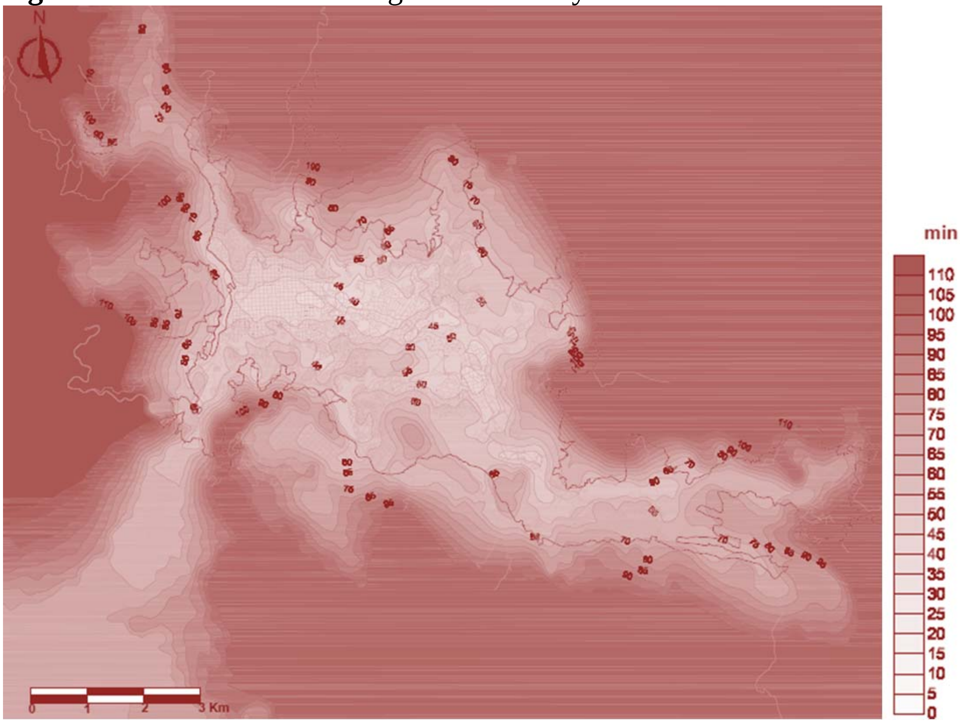
Our analyses in evaluating accessibility yielded the results shown in Figures 3 and 4, where we observe isochronous curves for average travel time in minutes, expressed as the Actual Overall Average Accessibility for the UCPTS without the cable, and Actual Overall Average Accessibility for the UCPTS with the cable, respectively. The curves represent the overall average accessibility time in minutes, detecting that areas with better accessibility conditions correspond to the areas of the city centre. In order to better detail the impact produced by the new cable infrastructure, we overlap isochronous curves to population data, number of homes and covered area for each case (ex-ante/ex-post the cable); thus obtaining the results presented in Figures 5, 6 and 7.

Figure 3 Actual Overall Average Accessibility for the UCPTS without the cable



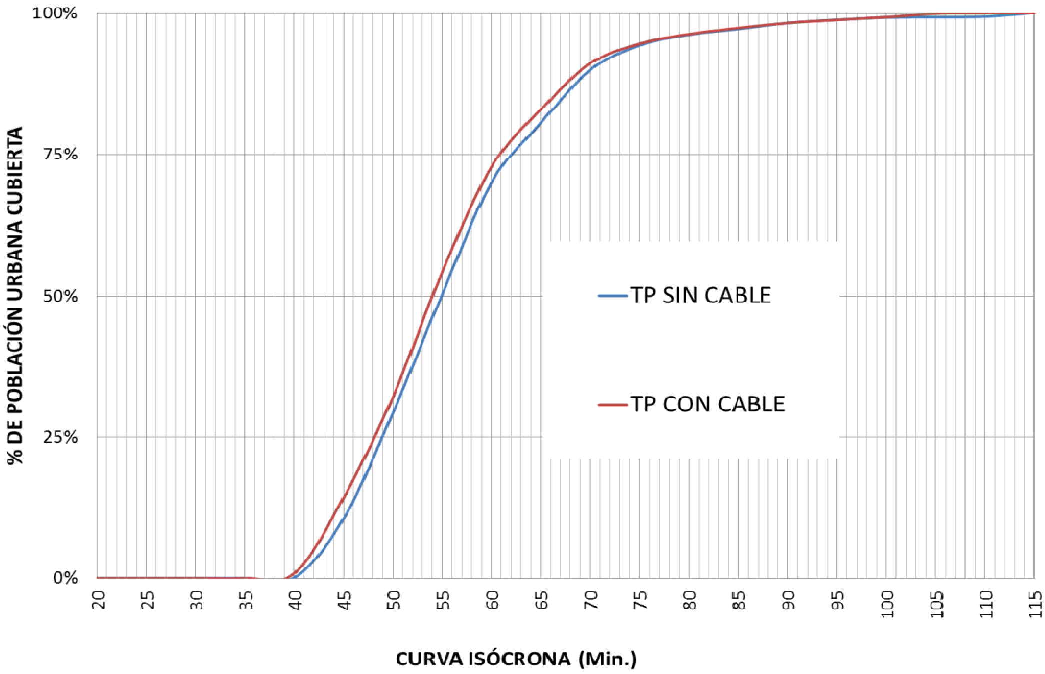
Source: own construction

Figure 4 Actual Overall Average Accessibility for the UCPTS with the cable



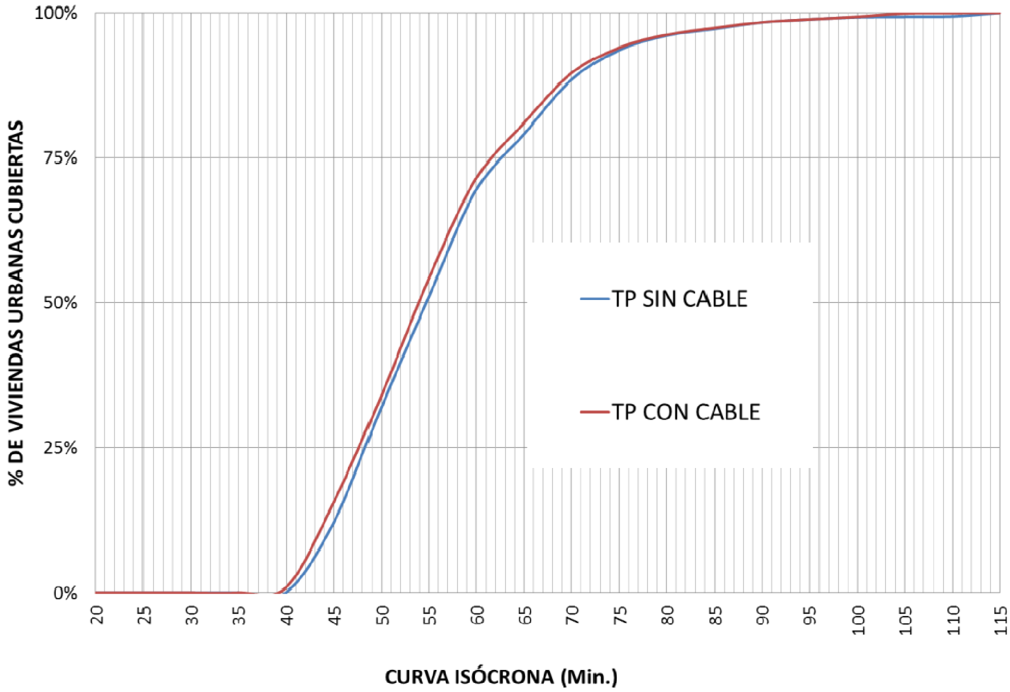
Source: own construction

Figure 5 Comparison between the % of urban population covered by the isochronous curves of the UCPTS with, and without the cable



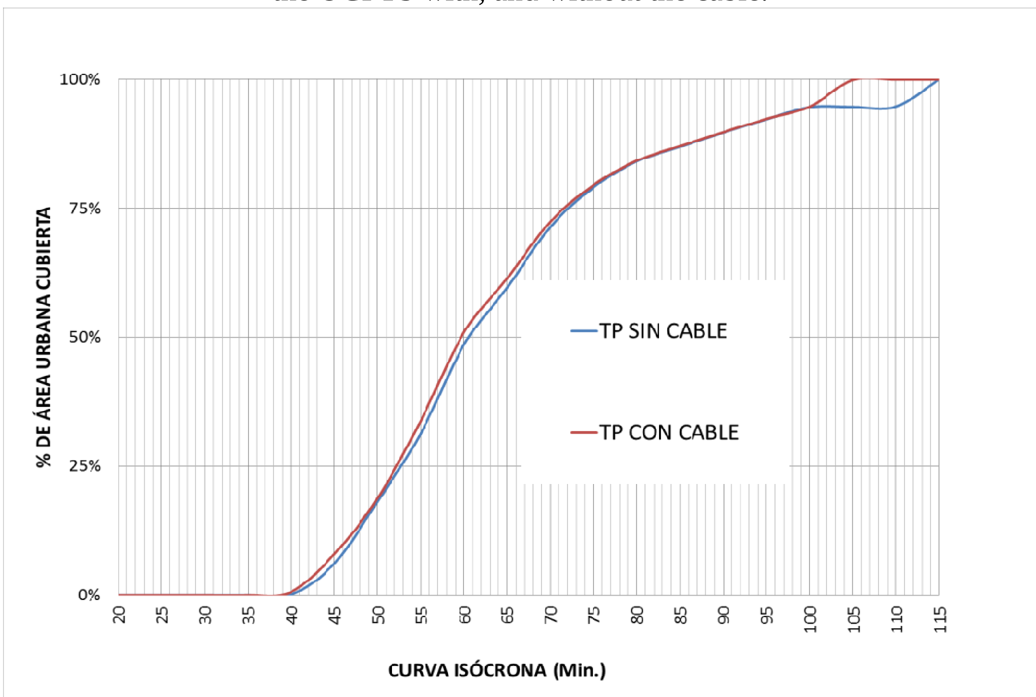
Source: own construction

Figure 6 Comparison between the % of urban housing units covered by the isochronous curves of the UCPTS with, and without the cable



Source: own construction

Figure 7 Comparison between the % of urban area covered by the isochronous curves of the UCPTS with, and without the cable.



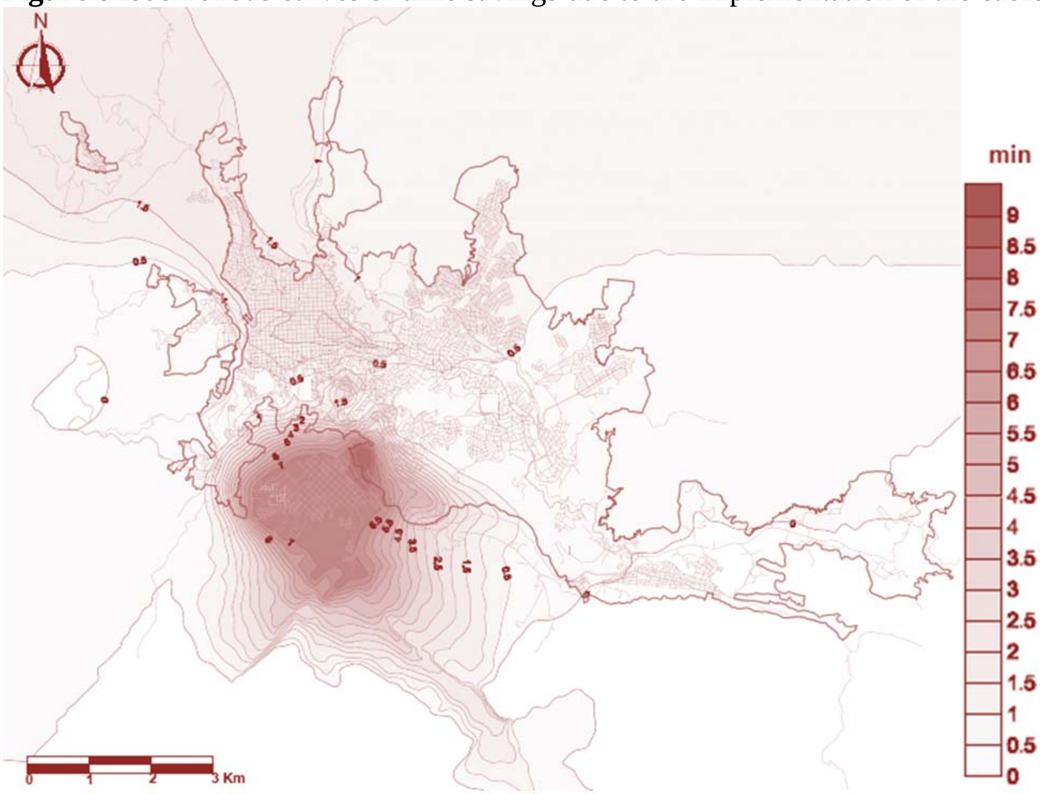
Source: own construction

We observe, for both cases (ex-ante and ex-post cable system), that the curves for population coverage (Figure 5) and the number of housing units covered (Figure 6) are very similar. The only notable variations come for the curve exhibiting the urban area covered (Figura 7), given the existence of significant areas that are not yet urbanized and are mostly in the periphery of the city. We detect that the impact on the population and the number of housing units covered, for a similar coverage percentage is about one minute.

Another way to appreciate the impact of the cable insertion into the urban structure of the city of Manizales is presented in Figura 8, which shows the difference between the isochronous curves ex-ante and ex-post the cable; finding that a large portion of the interior city perimeter the gains in overall average access time did not exceed 90 seconds, with the adjoining town of Villamaria being the most benefited one. There, gains of up to nine minutes in average travel time were recorded. Although some initial studies dating back to 1998 argue for the feasibility of the cable, due to the potential time savings (the main argument being that the most congested routes would see a flow decrease resulting in more efficient circulation) ("Manizales - Villamaría, Via Cable Project Feasibility", 1998, 30), our research proves that the time savings are negligible.

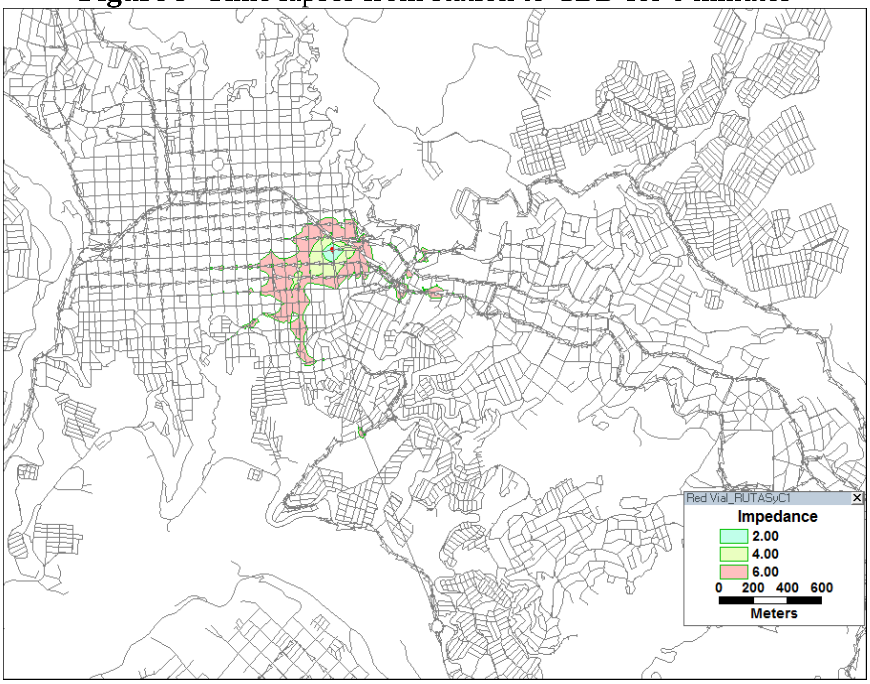
Finally, we also evaluate the impact on transport infrastructure by the insertion of the cable system, by generating time lapses from a fixed point. In Figures 9 and 10 we see how far users can get in six and 12 minutes respectively. This refers to taking the UCPT system from the cable station in the CBD. We note that through the public transport network, where there are bus stops, accessible areas are generated for a certain time value, an effect that can also be appreciated around the cable system stations.

Figure 8 Isochronous curves of time savings due to the implementation of the cable



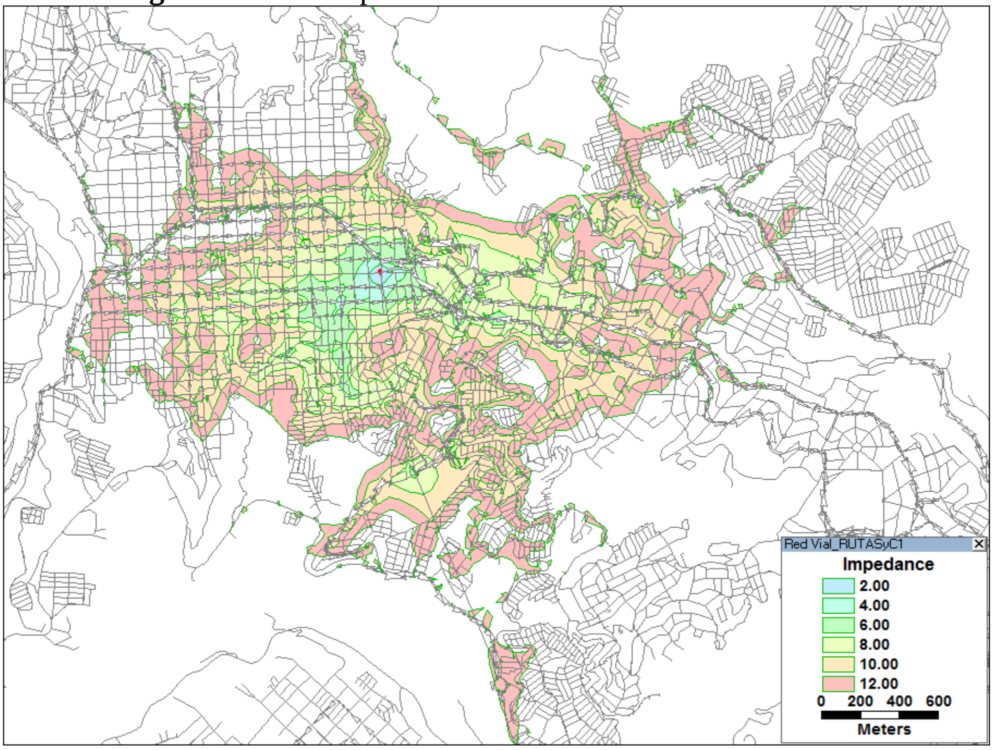
Source: own construction

Figure 9 Time lapses from station to CBD for 6 minutes



Source: own construction

Figure 10 Time lapses from station to CBD for 12 minutes.



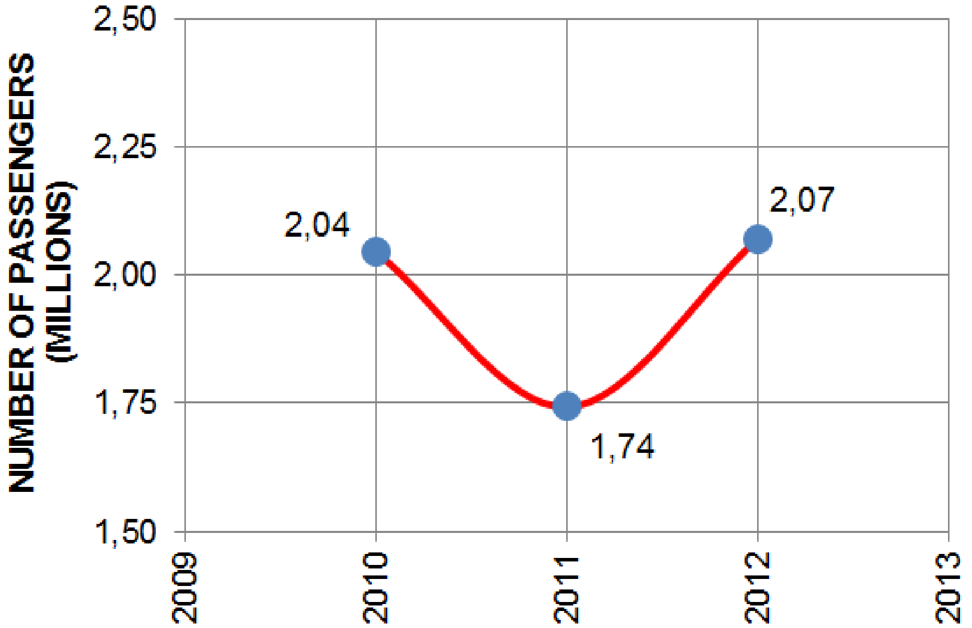
Source: own construction

4.2 Divergence in passenger mobility

The 1998 studies forecast about 8839 passengers per day for the Manizales - Villamaría cable ("Plan-Way Cable Manizales", 1998). However, the actual cable system has not lived up to these standards; Figure 11 shows the number of passengers that have actually been mobilized through the cable system for each year of operation. Between the first and second year of operation, we find a decrease of approximately 15 per cent (Comptroller General of the Municipality of Manizales, 2012), and estimate a new increase from this lower boundary for the second and third years of around 19 per cent. The first audit report of the Comptroller of the city of Manizales provides evidence that the system was far from reaching its equilibrium point (minimum number of passengers for the transportation system to be financially self-sustainable). During the first half of 2010, approximately 180,000 passengers were mobilized per month, while the equilibrium point required about 245,000; hence, showcasing a deficit of 65,000 passengers per month. Contraloría General del Municipio de Manizales, 2010). The initial demand projection for the cable was to mobilize about 17,000 people a day, with an equilibrium point of 8500 users (Concejo de Manizales, 2012a), a situation that has not been fulfilled so far.

Calculating average daily passenger numbers, we would get values between 4775 and 5672 per day, however, there have been months of the year with reported numbers of up to 4200 (Periódico La Patria, 2012) and others of 5600 (Periódico La República, 2010). Similarly, there have been some seasons, like that of the Manizales Fair, when the system mobilizes up to 9100 passengers per day (Asociación Cable Aéreo, 2013). Thus representing about 2.2 per cent of the daily trips in the city (DANE 2011).

Figure 11 Number of passengers mobilized by the cable system annually



Source: own construction from (Contraloría General del Municipio de Manizales, 2012; Asociación cable Aéreo 2012)

All of the above show a harsh reality: the cableway system is not financially self-sustainable. Therefore it must be constantly via governmental subsidies. However, there are some actions currently under study that would potentially positively impact these accounts, such as setting up commercial spots within the stations trading system stations (which should have been implemented from the very conception of the idea). For that goal, around 2400 m2 of the CBD station are said to be undergoing adequation soon.

Moreover, it is expected that the overall picture changes when the additional cable line (currently under construction) begins operations. Although it is being built without sufficient background studies in terms of mobility, the Asociación Cable Aéreo expects this new line will supply around 8000 new passengers per day to the system (Concejo de Manizales, 2012b); an extremely optimistic figure that is not supported by any judicious study on the subject.

5 Conclusions

Supply-side models, as applied in this study, are an option that continues to gain more adepts, mainly due to the fact that they lack a subjective influence from some of the parameters included in other models. This strategy allow us to obtain indicators for any infrastructure inserted in the urban context, and generally in any area of analysis, and thus to evaluate the cost-benefit of it, from the accessibility point of view.

This transport system was designed to carry an investment of US $ 20 million, ie 9.5 million per kilometre, however, the final investment went up to U.S. $ 28.5 million, leading to an expense of US $ 13.6 million per kilometre. Furthermore, the national government did not provide funding at the end, although it had offered it initially. (Periódico La República, 2010).

In terms of average travel time for a trip, the investment represents a reduction of 3.4 per cent. This translates into an investment of 8.45 million US dollars to improve by 1 per cent the average travel time of the population; quite an alarming figure, especially considering that in 1998, the projections shared with the public mentioned an investment per kilometre of around US$3 million ("Plan Director Cable-Vía Manizales", 1998, 40; "Manizales - Villamaría, Cable-Vía. Proyecto de Prefactibilidad", 1998, 34; Gutiérrez, 1999). The above assessment does not consider issues such as the environmental benefits, the tourist attraction gains, the possible traffic reduction due to the changes in the modal distribution, among other considerations that can be analysed, yet, it systematically and rigorously evaluates a high impact parameter for all inhabitants, such as overall average accessibility in the analysed territory.

In terms of the optimization of resources, a similar analysis could demonstrate that actions to improve the city traffic light system or designing a greater public transport control on itineraries, or even a low scale improvement of the road infrastructure could generate more significant cost-benefit relations. We highlight the use of GIS in this research. Although it has for decades been applied as a tool in various fields of knowledge, such as for instance, the location of public libraries (Higgs et al., 2012), we use it in this paper as an essential tool to find the shortest paths; it clearly has other countless applications.

From a social standpoint, we recognize that people require access to the typical and daily activities of any society. Greater inclusion, thus, depends on greater accessibility, which makes a strong case for the provision of adequate public transport systems (Farrington and Farrington, 2005). However, this must also be done in a financially responsible fashion. Evidence was found in previous studies on the financial risks that the construction of this cable could bring, for example, the 1998 study says: "If the demand for the service eventually does not reach the guaranteed level, the municipality must cover the revenue shortfall. The best way to overcome this risk is to ensure accuracy in calculating average daily traffic, through rigorous traffic studies, which include accurate origin-destination matrices" ("Manizales - Villamaría, Cable-Vía. Proyecto de Prefactibilidad", 1998, 3). This triggers questions not only about the ultimate decision to execute the construction, but also about the studies used to justify the passenger demand calculations. At that point, the origin-destination matrices were already outdated for 10 years.

When deciding about which actions to take in improving accessibility and urban quality of life, via the intervention of the road network, the tool we hereby offer constitutes a valuable resource. It is true that the implementation of environment-friendly transport systems like the cable could help mitigate the environmental drawbacks of the very unsustainable car-centred model in many of our cities, while also offering a vital transport mode for special hilly terrains. However, it is absolutely crucial that we are able to analyse ex-ante, with real modelling data, what the actual cost-benefit relation will be ex-post.

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