Geographical Coverage of the Higher Education Offer and its Relationship with Social Equity Case

Study: Manizales University Campus

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Abstract

Higher education is essential for the economic and social development of a country, generating social mobility in the different regions, mitigating the inequality and inequity that exist in the countries. In this sense, Manizales has focused its vision of the city in strengthening and developing as the main university city of the country, promoting different policies of support in research and academic offerings among the 6 main universities of the city, benefiting the nearly 50 thousand registered students. Therefore, it is essential to measure the geographic coverage, through the comprehensive accessibility, that higher education has in general and that of each university in particular, in order to find the current panorama of the city and its relationship with the population and the different socioeconomic strata.

Keywords: Higher education, comprehensive accessibility, Manizales university campus, equity
1 Introduction

The social and economic development of a country goes hand in hand with the growth and quality of higher education [29]. In economic terms, the scope and perspective of higher education may reflect the development expectations of a country [17], however one of the most frequent topics in higher education is the access opportunities and the inequity that exists in it, given that people from lower socioeconomic levels have a barrier in terms of income, due largely to aspects such as the quality of prior education, which does not allow them to pass the admission exam, causing a minimum percentage of students who graduate from high school in these socioeconomic levels to enter the university, also the limited quotas in public higher education institutions and the high cost of enrollment in private higher education institutions [1, 14].

On the other hand, geographic accessibility, which helps us to measure the territorial coverage of higher education in a given region, has become an extra restriction that people must overcome to access higher education, so improving coverage has become a fundamental aspect in the regions, driven by public policies [30]. Accessibility is a concept that has been used for decades in various topics such as urban planning, land use and transport, as well as city planning [2, 23]. It was Hansen (1959) who defined accessibility as the potential of interaction opportunities possessed by a person or group of people, which can be evaluated through the road infrastructure network and using a particular mode of transport [7, 11, 15]. Accessibility over the years has been addressed from different approaches, perspectives and types of measures, among which is the comprehensive accessibility, that measures the potential opportunities of an area with respect to certain establishments and through it can be obtained coverage and area of influence that facilities such as hospitals, universities, shopping centers and many more have [9, 12, 16]. In recent years, various methodologies for calculating accessibility have been used to evaluate the coverage of higher education in various regions such as Ireland [4, 29, 30] and England [13].

1.1 Manizales University Campus

Manizales (see Figure 1), capital of the department of Caldas in Colombia, has a high cultural, vocational and quality level focused on the development of higher education, represented in the multiple universities and institutions of technical and technological education accredited present across its territory, accounting with about 46 718 students [20], more than 10% of the total population in the urban area, which reaches in its metropolitan area joined with the municipality of Villamaria 419 000 inhabitants according to the projections of the National Administrative Department of Statistics [5]. For this reason, the municipal government has taken measures to promote this city vocation through the creation of the University System of Manizales, SUMA, which is an agreement between the six most important universities in the city (see table 1), which have an offer of 121 undergra-
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duare and 175 postgraduate programs, which allows continuous support in various
topics such as research through the various research groups and contribution of
resources, as well as academic offer and mobility that allows the students to take
courses at any of the universities that are part of the agreement and also a joint
vision in the university projection model of the city [19, 28].

![Geographic location of Manizales and its Universities.](image)

Table 1. SUMA Universities, Number of campus, undergraduate and postgraduate
programs. Source. Authors with information from
Manizalescampusuniversitario.com

<table>
<thead>
<tr>
<th>University</th>
<th>Number of Campus</th>
<th>Undergraduate Program</th>
<th>Postgraduate Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>National</td>
<td>3</td>
<td>11</td>
<td>29</td>
</tr>
<tr>
<td>Caldas</td>
<td>6</td>
<td>43</td>
<td>59</td>
</tr>
<tr>
<td>Autonôma</td>
<td>3</td>
<td>21</td>
<td>33</td>
</tr>
<tr>
<td>Manizales</td>
<td>1</td>
<td>20</td>
<td>32</td>
</tr>
<tr>
<td>Católica</td>
<td>1</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Luis Amigó</td>
<td>1</td>
<td>11</td>
<td>7</td>
</tr>
</tbody>
</table>

In addition, the Territorial Planning Plan (POT) 2017 – 2031 of the city, which
unites as a planning and vision guide for the city over the next fifteen years,
proposes "... positioning and consolidating Manizales as a university city and leader
in education in Colombia, supporting the expansion approach of several universities
and educational centers ... " [24], which indicates a commitment of the city's
governmental institutions to develop the model focused on higher education. For
these reasons, it is important to measure the geographical accessibility through the
This research seeks to evaluate the coverage of the city of Manizales in terms of university facilities certified by the national Ministry of Education that also make part of the Manizales University System, through the calculation of the comprehensive accessibility to each of them and measuring the overall scenario. Then the population coverage will be evaluated taking into account the different socioeconomic strata and evaluating the equity in terms of geographic accessibility to the city's universities. In Manizales, studies have been made using territorial accessibility, taking into account a fraction of the universities [31], hospitals [8], eco-parks [9], among others.

2 Materials and Methods

To develop the research, the methodology shown in Figure 2 was followed, which consists of 5 main stages. On the first stage, the georeferencing of the universities of Manizales that belong to the SUMA agreement was made. Secondly, the validation of the transport network was done and was used on the third stage to calculate the comprehensive accessibility of the universities analyzed in the city. On the fourth phase, geo-statistical methods were used to obtain the isochrone accessibility curves for each studied university and finally a comparison was made between the coverage, the population and the socioeconomic strata within the city. In the following sections, each stage is addressed more specifically.

Fig 2: Methodology for investigation.
2.1 Manizales Universities Georreferencing

On this stage of the investigation, the GIS ArcGis 10.4.1 software is geo-referenced in the universities under study, in this case those belonging to the SUMA convention in Manizales, which has 6 affiliated universities, which can be seen in the table 1 and georeferenced in Figure 1.

2.2 Road Transport Network Validation

For the calculation of the integral accessibility, it is necessary to have the transport network of the city built in GIS software according to the graph theory, which among its diverse rules defines that the transport networks are composed by arcs, which are equivalent to the roads, and by nodes, which are equivalent to road intersections [10, 27]. In addition, the network must have various attributes such as length, speed of operation and travel time by arc. For Manizales, the transport network updated and validated, built and georeferenced in the ArcGis software, was obtained thanks to previous investigations where velocity data were also obtained thanks to global positioning devices (GPS) [22, 31]. For the calculation of the length of the arcs, the "Calculate Geometry" tool of the ArcGis software was used, where the arc travel times were also calculated, relating the length and the speeds of each arc.

2.3 Integral Accessibility

For the calculation of the integral accessibility, the following steps are followed. In the first instance, the node of the transport network closest to the different sites of the analyzed universities must be related. Then, the optimal route of all the nodes of the transport network is calculated to each of the nodes closest to the university headquarters in the TRANSCAD 7.0 software [9]. This optimal route is equivalent to minimizing the travel time between nodes through the Dijsktra algorithm [6]. Then, the vector of travel times for each university and the general scenario is calculated using equation 1.

\[ \overline{Tv_i} = \frac{\sum_{j=1}^{n} tv_{ij}}{n} \] (1)

In this case, \( n \) corresponds to the total number of seats that each university has, so the average vector of times for each university is obtained. In the case of the general panorama of higher education in the city, the sum of the travel times of all the universities is made and divided by 15, the total number of campuses for the 6 studied universities.

2.4 Geo Statistic Model

Using geo-statistical models it is possible to construct the isochronic curves of integral accessibility for each of the universities analyzed from the vector of travel
times [21. The method used is ordinary Kriging with a linear semi-variogram as a structuring equation [26]. This model has been widely used as a predictor in transport models, becoming the most frequented geo-statistical model by various researchers in this subject [18, 22, 32].

2.5 Population and socioeconomic analysis

Finally, a coverage analysis is made through the intersection of the isochrone accessibility curves constructed in the previous stage and the neighborhood polygon of the city of Manizales, which has information regarding the socioeconomic stratum, population and density of each city neighborhood.

This polygon was obtained thanks to previous research and for its update the projections given by the DANE were used, obtaining the population for 2017 of the studied area [5]. Socioeconomic strata are a classification made in Colombia, which divides neighborhoods according to economic capacity and housing environment, measuring from 1 to 6 where 1 corresponds to the lowest stratum and 6 to the highest stratum. In addition, the low strata, which are considered 1 to 3, are frequently benefited with government subsidies [25]. Thus, the analysis of population and area coverage for each university and the general scenario can be made as well as an analysis by socioeconomic stratum that will allow finding disparities in access to higher education [25, 31].

3 Results and discussion

3.1 Accessibility and Inhabitants Coverage per University

First, the results of the isochronous curves of integral accessibility and their population coverage will be analyzed in the particular case of each University (Figure 3 and Figure 4).

Fig 3: Inhabitants Coverage per University.
In this case, the Autónoma University and University of Caldas have a coverage of 100% of the city’s population for average times of 40 minutes or less, while the same coverage is reached in times of 45 minutes or less for the Catholic University and Luis Amigó University. Finally, the National University and University of Manizales cover 100% of the population in average times of 50 minutes or less, resulting in analyzed universities with longer travel time to cover the entire population. These data can be explained due to the location and number of campuses that the Universities have. The University of Caldas is the one with the largest number of campuses and buildings, distributed throughout the city and located on its main arterial roads. The Autónoma University has a privileged location of its campus, because it is in the area of the city with better global accessibility which indicates that travel times to and from this point are, on average, better than to the rest of the city [22]. On the other hand, the Catholic University and Luis Amigó University have only one campus each, located on the most important main artery of the city, which connects the city in the west-east direction.
Finally, the National University has three campuses, two of them located in the economic heart of the city, which makes their access to them fast compared to the third located in the eastern part of the city, near the airport ‘La Nubia’, which makes access for the population that is westward difficult. Finally, the University of Manizales is located in the west of the city, which causes that people living in the eastern part have a higher travel time, similar to the National University, with its third campus.

3.2 Accessibility and Inhabitants Coverage per University, socioeconomic stratum analysis

Figure 5 shows the analysis of population coverage of each university taking into account the socioeconomic strata. In this, it can be seen that the Autónoma University has a very similar coverage in all strata, except for stratum 3. On the other hand, for the University of Caldas a more marked inequity is observed. In this case, stratum 5 reaches 100% population coverage in 15 minutes or less while stratum 1 is covered entirely by the isochronous curve of 35 minutes or less. For stratum 2 and 3 this value rises 5 minutes more and reaches 40 minutes or less of average travel time for 100% of the population, this is equivalent to moving 20 minutes more for stratum 1 and 25 minutes more for the stratum 2 and 3 with respect to stratum 5. The Catholic University and Luis Amigó University have similar population coverage in relation to socioeconomic strata where stratum 5 has better accessibility compared to stratum 2 and 3, which must spend twice as long for the entire population to access the mentioned universities regarding stratum 5, which spends an average time of up to 20 minutes or less. Regarding the University of Manizales, it is highlighted that stratum 4 has the best coverage, being the only one where stratum 5 does not have the best accessibility, however, back to stratum 3 it takes more time to travel to access this university. On the other hand, for the National University the best coverage are for stratum 5 and 6, those with a high socioeconomic level, while strata 1 and 2 have the most unfavorable accessibility. This indicates an inequity in the coverage of higher education, referring to access through road infrastructure.
3.3 Accessibility and Inhabitants Coverage, Manizales Higher Education

Figure 6 shows the isochronous coverage curves for the global analysis of higher education in Manizales, including the 6 universities belonging to the SUMA agreement. There you can see how 12 of the 15 campuses of the universities are covered by the average time interval between 8.99 minutes and 15 minutes, this is equivalent to about 29% of the population (122 084 inhabitants). While the University of Manizales is outside of this coverage because it is in the time interval between 15 and 20 minutes, which has an influence of 159 266 inhabitants. In this last interval is also the headquarters of Arts of the University of Caldas, the most western headquarters of the mentioned university. Finally, the La Nubia campus of the National University, previously mentioned as the headquarters located in the eastern part of the city, is covered by the isochronous curve between 20 and 25 minutes, which has a population coverage of 75 568 inhabitants. In this case, the analysis of population and area coverage, figure 7, shows us how 67% (282 788 inhabitants) of the population reaches all higher education institutions analyzed in an average time of 20 minutes or less, while the area for this same time the percentage is 35% (2 067 ha).
Likewise, for average times of 30 minutes or less, coverage in population and area reaches 93% (388 280 inhabitants) and 77% (4 530 ha) respectively, indicative of the good coverage that the city has in terms of higher education. Finally, the entire population is covered for average times of 40 minutes or less, while for the entire area of the city this time is 50 minutes or less because the population is concentrated in urban areas closer to institutions of higher education, while there are areas that have an area within but do not have a population register. Figure 8 shows the population coverage according to the socioeconomic stratum in the global analysis of higher education in Manizales where it is observed that as stratum 5 has coverage of 93% of its population for an average time of 15 minutes or less followed by stratum 6 which reaches 65% coverage for the same time.

Fig 5: Inhabitants Coverage analysis per socioeconomic stratum.

Fig 6: Isochrones curves of Integral Accessibility, global analysis of higher education in Manizales.
On the other hand, for this same length of time, the population coverage reached for the other strata is 2% for stratum 1, 24% for stratum 2, 26% for stratum 3 and 41% for stratum 4, evidencing the disparity in coverage between the strata, where the high strata are benefited. On the other hand, the entire population in stratum 5 is covered by average times of 20 minutes or less, while for strata 4 and 6 such coverage is reached for times of 30 minutes or less. For the medium-low and low strata, the entire population is covered for longer times of up to 35 minutes for stratum 1 and 40 minutes for stratum 2 and 3.

4 Conclusions

In Manizales there is a good coverage for higher education in terms of geographic accessibility, because the entire population reaches all the studied institutions of
higher education in average times of 40 minutes or less. In addition, about 85% of people reach coverage in 25 minutes or less, having a good indication of the geographic coverage of higher education in the city.

In terms of equity in access to higher education institutions in Manizales, it is observed that the upper strata have better accessibility, while the lower strata are those covered by isochronous curves of travel time with greater average time, existing inequality in access with respect to socioeconomic level. It is important to close this gap so that coverage does not become an additional impediment for people from lower strata when entering higher education, and this analysis should be complemented with coverage through public transport, bicycle and walking, which are the most inclusive modes of transport and that generate greater sustainability in a city.

In the particular case of coverage analysis for each university, it can be observed that the University of Manizales has a lower accessibility compared to the other Universities due to its location in the western part of the city. Likewise, the Autónoma University and University of Caldas are the ones that represent the best coverage due to the location in the area with the best global average accessibility and the number of sites they have, respectively.

It is important to emphasize that this study should be complemented by taking into account an accessibility analysis based on accumulated opportunities, taking into account the different admission methods of the universities and the cost of their enrollments in order to know which areas of the city are the ones that really have the possibility of accessing higher education institutions and in what percentage they do so. With this, policies can be created in order to mitigate the inequity in access to higher education.

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References


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