Historical Analysis of Road Infrastructure Accessibility in Colombia

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SUMMARY

In the post-conflict context, the Colombian government has developed particular interest on the improvement of the national road network to generate access to areas typically affected by the armed conflict and to boost the national economy. As a reaction to this determination, it was considered necessary to develop an indicator of accessibility to the road infrastructure network, through a historical analysis of the Colombian road network from the 1940s to the present, to determine quantitatively the areas of the country that historically have had limited or no access to the national road network.

In this research, we defined accessibility as the distance from the point of interest to the nearest road within the national network, considering a cost factor based on the difficulty implied by the effects of the geomorphology and land cover for moving in space. To quantify an indicator that condensed this definition, an analysis using geographic information systems (GIS) was made. In this process, historical maps of the road network were digitized for the entire study period, and the cost surface that defined the difficulty of accessing the road network was obtained. We then developed an accessibility indicator for the whole country based on distance to the national road network from each point within the Colombian continental shelf, for every decade of the study period.

Furthermore, for every population center we computed their accessibility indicator obtaining a historical data series, classified by administrative regions, which reflected the evolution of road infrastructure in the country in most of its territory. According to these results, certain factors that were analyzed could explain the stagnation in the road development of the critical areas according to their geographical conditions, on which it was concluded that for some regions accessibility could not be defined solely according to the road network since this did not represent the main transportation mode amongst the regions. Finally, a discussion on the accuracy, extension and source of the historical data is given based on some incongruences found.

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1. INTRODUCTION

1.1. Motivation

Throughout its history, Colombia has presented different periods of violence and internal armed conflict. In the analysis of this phenomenon, a possible relation between the most affected areas by the armed conflict and the zones of low accessibility due to a road infrastructure deficit was found. Within the framework of the peace processes that are taking place in Colombia in recent years, the national government has been promoting the program *Vías para la paz*, with the objective to connect different areas affected by the armed conflict with the rest of the country. According to Wegener and Bökemann (1998), accessibility is the primary outcome of a transportation system and defines the competitiveness of a region; this is why improvements in transport infrastructure represent an increase in accessibility and the socioeconomic development of the region (Gutiérrez, Condeço-Melhorado, & Martín, 2010).

However, considering the state's willingness to invest in the development of new roads, it raises the question: where should they build them to maximize the impact on road coverage? In this context, it was considered relevant to conduct a historical analysis of accessibility to road infrastructure, using GIS tools, based on the characteristics of the Colombian geography (geomorphology and land cover) and available records of the national road network since the mid-20th century to the present. This analysis aims to show the development of the road network in the country and how it has affected accessibility at its administrative regions, to identify where the infrastructure development should be focused.

1.2. Accessibility

In this research, accessibility is defined as the cost distance (Dahlgren, 2008) to reach the nearest road of the national network from any point within the country borders. That is the ease of accessing the road network service with the lowest possible cost (Taylor & Susilawati, 2012). Considering the essential components of an accessibility analysis, the executed one has the singularity that the transportation network also corresponds to the destination points. Furthermore, this procedure has an aggregate value given that it considers the barriers that may represent a difficulty on the displacement of a person from any point to the nearest road; considering the terrain conditions (slope) and the land cover on the route to the road.

2. METHODOLOGY

2.1. GIS digitalization of historical information

To perform spatial analysis at a historical level, it was necessary to turn information available in sheets and books into digital geographic information. It is essential to point out that all the geographic information presented in this document is in the projection MAGNA-Colombia-Bogota (EPSG:3116), which corresponds to the official coordinate system of Colombia MAGNA-SIRGAS (IGAC, 2004). Additionally, this analysis will only take into account the continental shelf of Colombia, since the accessibility to the insular region cannot be quantified with an analysis of the road network.

Given that this research is focused on the study of road infrastructure development, the archives of the Agustín Codazzi Geographic Institute (IGAC) were consulted to retrieve maps of the national road network. Records from 1941 to 1990 and GIS data of the road network for the years 2006 and 2017 were available[1].

Since most of the retrieved information was printed, it was necessary to carry out a digitization process using ArcGIS, in which the roads were drawn as vectors of geographic information with the georeferenced map image as a guide. To exemplify this procedure, Figure 1 shows the map of the national road network of 1941 (Ministerio de Obras Públicas, 1941) and in Figure 2 the same map is shown but with digital content as a result of the digitization process executed in ArcGIS.

The same process was carried out for all the maps of the national road network of the 20th century, and thus, GIS data of the road network across the country was obtained. In addition, the roads, as they are in the resulting layers, correspond to a schematic layout due to the quality and methodology of the old cartographic surveys and the scale used to represent the extension of the Colombian territory. The printed maps of the road network had an approximation to the location and length of the roads. However, the available data is still significant for this work, since it is a nationwide analysis. Additionally, the scale of the research prevented the consideration of the urban road network in the analysis.

[1] The records of the road network for the twentieth century were obtained in maps for the years 1941 (Ministerio de Obras Públicas, 1941), 1956 (Instituto Geografico Militar, 1956), 1960 and 1969 (IGAC, 1960, 1969); in books for the years 1971 (Ministerio de Obras Públicas, 1971), 1984 and 1990 (Ministerio de Obras Públicas y Transporte, 1984, 1990) and for what goes of the XXI Century it was possible to obtain GIS data for years 2006 (IGAC, 2018) and 2017 (Ministerio de Transporte, 2018).

Figure 1: National road network map for 1941 (Ministerio de Obras Públicas, 1941).

Figure 2: National road network map for 1941 — ArcGIS digitization

According to the available data, historically there have been a lack of roads in SE Colombia, which mostly belongs to the Amazonian region. However, this does not mean that there are no roads in that regions since it is certain that interurban roads were available, but marginalized. That is, they do not have connectivity to the national network and have no influence on the accessibility of these areas with the rest of the country.

The way in which the state manages land in administrative terms has changed over time. This is evidenced in the evolution of the internal administrative boundaries of the country throughout its history. In the analysis period, several changes occurred, like alterations in the delimitation of territorial entities and the creation of new administrative regions. We retrieved and analyzed the population censuses of Colombia for the analysis period to evaluate those changes. In each of the censuses analyzed, the population of the territorial entities was normalized with their area, and in this process, evidence of the changes in these could be seen (DANE, 1940, 1954, 1967, 1978, 1985, 1994, 2007). The official area, reported by DANE in each census, for each administrative region is presented in Table 1; This table also shows that for the years 1938, 1951 and 1964 some regions do not have an assigned value (-) because they had not yet been established as a territorial entity.

Table 1: Evolution of the regional area 1938 - 2005 (DANE, 1940, 1954, 1967, 1978, 1985, 1994, 2007)

ADMINISTRATIVE REGION	**AREA [km^2]**						
NAME	**1938**	**1951**	**1964**	**1973**	**1985**	**1993**	**2005**
ANTIOQUIA	65810	65810	62870	63612	63612	63612	63612
ATLÁNTICO	3470	3470	3270	3388	3388	3388	3388
BOLÍVAR	59560	59560	36915	25978	25978	25978	25978
BOYACÁ	64580	34424	67750	23189	23189	23189	23189
CALDAS	13370	13370	13070	7888	7888	7888	7888
CAQUETÁ	102990	102990	90135	88965	88965	88965	88965
CAUCA	30200	30200	30495	29308	29308	29308	29308
CESAR	-	-	-	22905	22905	22905	22905
CÓRDOBA	-	-	25175	25020	25020	25020	25020
CUNDINAMARCA	30236	30236	38383	24210	24210	25880	24210
CHOCÓ	46570	46570	47205	46530	46530	46530	46539
HUILA	20700	20700	19990	19890	19890	19890	19890
LA GUAJIRA	12240	12240	20180	20848	20848	20848	20848

MAGDALENA	53920	53920	46695	23188	23188	23188	23188
META	85220	85220	85770	85635	85635	85635	85635
NARIÑO	29910	32560	31045	33268	33268	33268	33268
NORTE DE SANTANDER	21490	20690	20815	21658	21658	21659	21658
QUINDIO	-	-	-	1845	1845	1845	1845
RISARALDA	-	-	-	4140	4140	4140	4140
SANTANDER	32070	32070	30950	30537	30537	30537	30537
SUCRE	-	-	-	10917	10917	10917	10917
TOLIMA	22990	22990	23325	23562	23562	23562	23562
VALLE DEL CAUCA	20940	20940	21245	22140	22140	22140	22140
ARAUCA	25830	25830	23490	23818	23818	23818	23818
CASANARE	-	30156	-	44640	44640	44640	44640
PUTUMAYO	26470	23820	25570	24885	24885	24885	24885
AMAZONAS	124340	124340	121240	109665	109665	109665	109665
GUAINÍA	-	-	78065	72238	72238	72238	72238
GUAVIARE	-	-	-	42327	42327	53460	53460
VAUPÉS	149850	149850	90625	65268	65268	54135	54135
VICHADA	102990	102990	98970	100242	100242	100242	100242

To capture the variation of regional boundaries in GIS, we used maps with the political-administrative division of the country presented in the censuses for the year of execution. Based on these documents, the layers of the regional distribution of Colombia in the 20th century (beginning in 1938) were made. As the guide map of this process was used the Departments' distribution GIS data retrieved from the National Geostatistical Framework (MGN) of 2016, available in DANE's *GeoPortal*, and the internal divisions were modified according to the map of each census. To illustrate the result of this process, Figure 3 shows the map of the administrative regions in 1938 (DANE, 1940) and Figure 4 the same map digitized in ArcGIS.

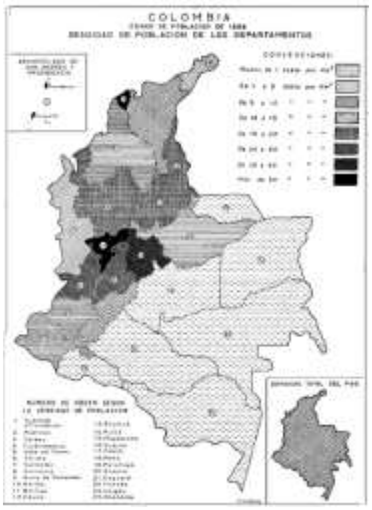


Figure 3: Political-administrative map with population density from 1938's census (DANE, 1940)

Figure 4: Political-administrative map 1938. Digitized with ArcGIS

2.2. Digital Elevation Model

Colombia is a country with a rugged territory, the Andean mountain range defines the geomorphology of a large part of the country, and it is divided into three mountain ranges that cross it from south to north. Additionally, there is a peripheral system made up of some mountains, where the highest peaks of the country stand at 5775 m.a.s.l.

To execute an analysis with the highest possible precision, it was necessary to obtain a digital elevation model (DEM) that would represent the conditions of the Colombian geomorphology.

The Earth Observation Data and Information System (EOSDIS) was consulted to retrieve the portion of the global digital elevation map (GDEM) ASTER[2] version 2 corresponding to Colombia (NASA, METI et al, 2009)(NASA, METI et al, 2009). To obtain the DEM used in this analysis the images were post-processed, the raster presented in Figure 5 and the model shown in Figure 6 was obtained as a result.

Figure 5: DEM ASTER V.2. from Colombia (NASA, METI et al, 2009)

Figure 6: Colombia's DEM (NASA, METI et al, 2009) 3D, ArcScene Layout.

2.3. Cost

As stated before, accessibility is quantified as the cost distance to the road network. To achieve this purpose, it is necessary to define a spatial cost factor. For this analysis, it is defined by the effects of land cover and the geomorphology on the difficulty of transporting to the road network.

According to IGAC (2013), the land cover is the morphological and tangible aspect that includes all the constituent elements of the earth's surface, whether of natural or cultural origin, which are observed and can be measured with aerial photographs, satellite images, and other remote sensors. Since the year 2000, in Colombia, land cover is classified according to CORINE (Coordination of information on the environment) methodology.

The CORINE Land Cover methodology (CLC) was implemented in the year 2000, but only in 2010 was achieved the consolidation of the land classification base map (period 2000-2002) with a 1:100,000 scale. In which was presented the classification with the CLC methodology in the national legend of land cover. To assign the cost factor, the land cover map was retrieved from the Colombian Environmental Information System (2010b).

To quantify the cost of this parameter, it was associated with a cost factor between 1 and 10 to each third level coverage of the national legend (IDEAM, 2010a). As well, to assign the cost factor, it was taken into account the difficulty that each coverage implies into transport,

[2] ASTER GDEM is a product of METI (Ministry of Economy, Trade and Industry of Japan) and NASA (The National Aeronautics and Space Administration of the United States).

according to the available descriptions in the technical sheets of the Catalog of hedging patterns of the land (IDEAM, 2012); in which physical, environmental and legal safety factors were analyzed.

According to the criteria described above, the cost for each coverage is directly proportional to the difficulty of moving in space. For instance, the urban covers had the lowest cost factor (1 – 2) because there is infrastructure available on those, so, it means easiness for displacement. Likewise, natural barriers such as waterbodies or cliffs, got the highest associated cost, since displacement cannot be performed in those areas without the construction of infrastructure. On the retrieved shapefile of the land cover base map, each polygon got assigned the associated cost to its own cover. This layer was transformed into a raster file with the value of the related cost stored in its cells (Figure 7).

Figure 7 Land Cover associated cost (Raster)

On the other hand, to consider the effect of the rugged terrain was added a cost factor based on the geomorphology. The orography associated cost depends on the slope because it represents a barrier for displacement. Thus, it was obtained a raster of the slope [%] for the entire country (Figure 8), based on the DEM presented in Figure 5. To get the cost factor associated with the slope, was established the same scale as in the cost factor associated with land cover (1-10). However, in this case, the factor was determined by re-scaling the slope surface of Figure 8 by a logarithmic function whose limits were the extremes values of the cost scale, the result is illustrated in Figure 9.

Moreover, due to the conditions of the terrain (cliffs, canyons, etc.), the slope raster has values greater than 1000% that make accessibility impossible. A slope greater than 100% represents a high difficulty for the displacement. In this work, slope values higher than 200% (65°) represent the maximum difficulty in the displacement; therefore, it was assigned the maximum accessibility cost factor (10) to every place with a slope greater or equal.

Figure 8: Slope raster

Figure 9: Slope's associated cost factor raster

As stated before, the accessibility cost is defined by two variables: geomorphology factor, expressed by its slope, and a factor associated with the land cover or land use. To obtain a total cost factor, it is necessary to add the cost associated to those variables, and since for both, the factor is classified on a numerical scale between one and ten (1-10) it is possible to operate them directly (Dahlgren, 2008).

However, according to Hansen (1959), not all the variables that determine the displacement cost have the same value in the analysis, and according to the methodology presented in the analysis of El-Geneidy et al (2016), the quantification of cost to move in space could be developed with a weights criterion. For these reasons, the cost factor will be the result of a weighted sum of the components described initially.

Additionally, it was considered the statistical variability of cost parameters (mean value and standard deviation) at the national level, those values (Table 2) showed that the average cost associated with the slope is the lowest, and the effect of the land cover is six times greater than this. Consequently, it was decided to allocate 100% of the cost of slope and 50% of the cost for land cover to the total cost, that is, the total cost factor is defined by the following equation. Figure 10 presents the map of the total cost factor for Colombia, a result of operating the variables according to the total cost equation.

$$\text{Total cost} = \text{Cost}_{SLOPE} + 0.5\ \text{Cost}_{LAND\ COVER}$$

Table 2: Statistical values of the cost variables

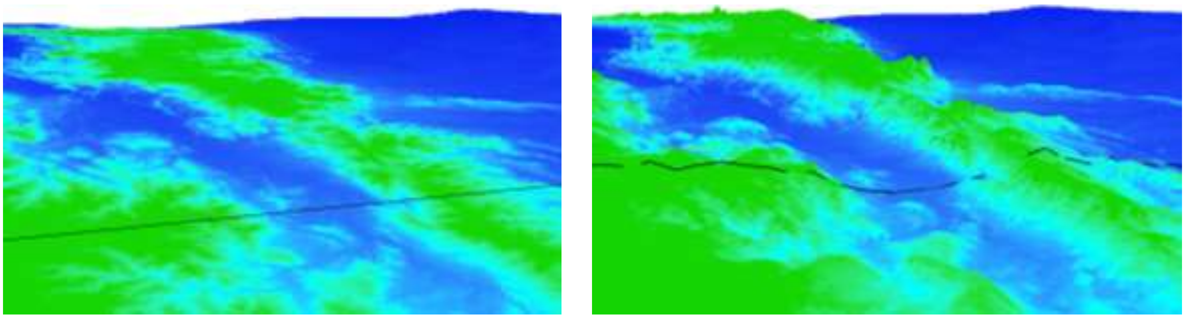
Variable	Mean	Standard deviation
Slope	1.17	0.84
Land Cover	6.58	2.91
Total Cost	4.46	1.67

Figure 10: Total cost factor map (1.5 – 15.0)

2.4. Accessibility Indicator

Dahlgren (2008) postulates that the most straightforward accessibility analysis consists of calculating the Euclidean distance between the points of origin and the points of destination. However, when executing a general accessibility analysis, that is not the best tool to be used, since the entire surface of a country cannot be represented in a single plane. For this reason, the distance must be calculated considering at least the effect of the geomorphology.

To illustrate the principles developed in this section, a straight road was drawn between two points of the DEM, traversing the central and eastern mountain ranges, and its length was calculated on the plane and the surface. The exercise illustrated in Figure *11* supports the importance of considering distance on the surface when executing an accessibility analysis.



a. Euclidean distance case. A road on a plane. (**Length: 207.93 km**)

b. Surface distance. Road projected on a surface (**Length: 219.24 km**)

Figure 11: Graphics comparison of Euclidean distance (a) and Surface distance (b)

Hence, accessibility was quantified with an indicator defined by the cost distance to the road network, which was calculated using the ArcGIS path distance tool, that considers the effects of displacement cost and the geomorphology.

The applied tool calculates the distance from an origin feature to all points within spatial limits defined by a geographical layer. The calculated distance depends on an elevation model to consider the effects of the surface on the total value. Additionally, it considers the difficulty of moving in space by calculating a cumulative cost factor to increase the distance defined for each point. The inverse value of path distance will be the accessibility indicator in this study. Therefore, since this tool calculates the distance to the study points, the high values of the indicator represent high accessibility and vice versa.

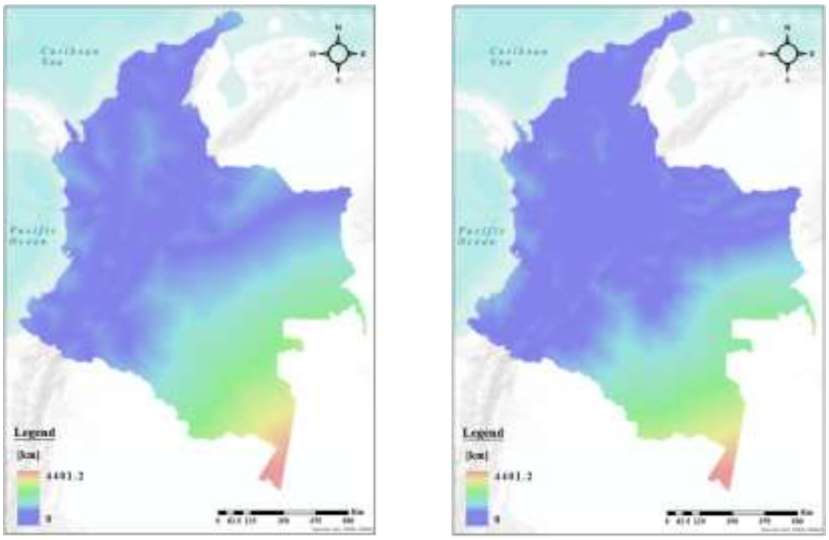
Path distance tool calculates, for each cell, the smallest cumulative cost distance from or to the origin and considers the effects of the surface on the distance calculation. To obtain the lowest cost distance to the points of origin of the analysis, the tool calculates through an iterative process the route between cells that results in the lowest cumulative cost (ESRI, 2017).

Path distance creates a raster in which each cell stores the accumulative cost distance to the source at the lower cost. The algorithm used represents the cells as a link /node, that is, it considers a node at the center of each cell and each node is connected by links to the adjacent nodes (contiguous cells). The cost distance between two cells (a, b) is calculated as the product between the surface distance between the two nodes and the average cost between them.

$$\text{Cost distance}_{\text{ab}} = \text{Surface distance}_{\text{ab}} * \frac{\text{Cost}_{\text{a}} + \text{Cost}_{\text{b}}}{2}$$

To assign the total value of each cell, the tool accumulates the cost distance of the movement between each node within the route to the point of origin. Also, to execute path distance, several inputs are required: the layer of the analysis origin, which in this case is the road network for each decade; a layer with the surface on which the distance will be calculated, like a DEM and the cost surface, defined in section 2.3.

The accessibility indicator was obtained through this tool and by executing it with the files of the road network for each decade, it was possible to illustrate the evolution of this factor at the national level throughout the analysis period. Figure 12 shows the result of executing this tool with the road network of the boundary years of the study period (1941 - 2017).



a. Path distance 1941 b. Path distance 2017

Figure 12: Accessibility map (a) 1941 y (b) 2017. Path distance result.

The path distance value is bounded between the cost distance limits for the 1940s since it represents the period with the least accessibility. As shown in Figure 12, it takes values from 0 to 4401.2 km. Now, as stated before, the accessibility indicator is calculated as the inverse of the path distance value.

$$\text{Accessibility indicator } [-] = \begin{cases} \dfrac{1000\ [\text{km}]}{\text{path distance [km]}}, & \text{path distance} > 1 \text{ km} \\ 1000, & \text{path distance} \leq 1 \text{ km} \end{cases}, \qquad (0.23 - 1000)$$

Then, since the lowest path distance value is 0, the highest accessibility value is 1000, and it represents that the service can be obtained almost instantaneously. Likewise, as the highest path distance value is 4401.2, the lowest accessibility value is 0.23, and it represents the point with the lowest accessibility to road infrastructure at a historical level in the analysis period.

3. RESULTS

The main objective of this study was to quantify the accessibility to the national road network for each decade from 1940 to the present. Consequently, section 2.4 illustrates the system to reach the indicator from the path distance raster.

As the Colombian territory has an extension of more than one million square kilometers of which, according to the DANE (2016) only about five thousand correspond to population centers. This means that people have been concentrated in a small portion of the territory, and it is on this fraction that the accessibility analysis executed must be focused. For this reason, it was assigned the respective accessibility indicator value to each of the 7,579 population centers within the continental shelf for each decade of the study period.

To assign the accessibility value to the population centers was taken the value of the indicator developed on the centroid of these. The annexed table shows the results of the accessibility value for each administrative region, in which the minimum, maximum and average values of the indicator are listed.

The regional average accessibility value was calculated with a weighted average of the indicator value in the centroid of each population center by its area.

$$\mathrm{Mean}_{Regional_{Accessibility}} = \frac{\sum_{i=1}^{n} \mathrm{Accs}_{\mathrm{population\ center_i}} * \mathrm{Area}_{\mathrm{population\ center_i}}}{\sum_{i=1}^{n} \mathrm{Area}_{\mathrm{population\ center_i}}}$$

According to the results presented in the annexed table, in most administrative regions, accessibility to the national road network increased, due to the appearance of new infrastructure. However, in regions such as Vaupés, Guainía, and Cauca, the accessibility variation between 1941 and 2017 does not follow the trend. Likewise, historically both Vaupes and Guainía, together with the Amazon, present the lowest average accessibility values of the whole country. However, the geographic context of these must be considered, since most of their territory is made up of jungle and natural areas, on which it is not possible to develop a road network. It means that it is necessary to execute a more profound analysis to quantify the accessibility of the most isolated areas of the country, in which should be analyzed other transportation modes beyond just the road infrastructure.

4. CONCLUSIONS

Although the development of an accessibility indicator to road infrastructure applied to the historical context of Colombia, specific executed procedures reduced the accuracy of the proposed analysis, due to the lack of available information and inconsistencies in the official retrieved data. Therefore, the primary error source of the accessibility indicator was the mismanagement of historical information handled by the state entities.

The total length of the roads in the historical analysis had inconsistencies in since in some periods the total amount decreased from one decade to another. Additionally, the roads data available at this time still do not consider the entire inventory of roads in the country; therefore, the accessibility results obtained in the most recent decade are underestimated.

Furthermore, given that before the year 2000 Colombia did not has a standard methodology for classifying land coverage, it was not possible to obtain comparable records of land classification before this year and, therefore, the distribution of the period 2000 – 2002 had to be used for the entire analysis. This means that, it was assumed that the distribution of land use at the macro level was static over time, which, according to Hansen (1959), is a very large imprecision, because just as human behavior is dynamic, the interaction with the medium means that the use and classification of this also fluctuate over time. Consequently, considering that the cost factor is one of the main variables of the accessibility indicator, and the land cover plays a significant role in this one, having carried out the historical analysis with a single land coverage distribution may have represented error propagation related to this variable.

The same scenario arose with the population centers since only the recent record was used to quantify the historical analysis in specific points of the country. Although it was possible to adapt the regional limits according to the historical record, there is no record of the geographical variation of the population centers, even though the area of these has increased over time. It is an error source in the results due to the methodology used to obtain the average accessibility for each administrative region.

Finally, as stated, the main obstacle to accomplish a robust accessibility analysis at the national level, for the case of Colombia, lies in the difficulty of obtaining accurate information on the entire national territory of the different factors necessary in the analysis.

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CONCTACT INFORMATION

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ANNEXES

Table 3: Results by administrative region

ACCESSIBILITY INDICATOR																								
ADMINISTRATIVE REGION	**1941**			**1956**			**1960**			**1971**			**1984**			**1990**			**2006**			**2017**		
	Max	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**
AMAZONAS	0,94	0,23	0,25	0,8	0,23	0,25	0,81	0,23	0,25	0,98	0,25	0,28	0,98	0,26	0,28	0,98	0,26	0,28	0,98	0,26	0,28	0,98	0,26	0,28
ANTIOQUIA	1000	3,14	32,48	1000	2,89	96,33	1000	2,95	101,75	1000	3,6	130,48	1000	3,6	138,42	1000	3,6	146,3	1000	3,9	183,55	1000	4,19	225,04
ARAUCA	40,03	1,8	4,39	16,89	1,8	3,65	16,89	57,71	3,65	1000	1,8	5,01	1000	2,36	7,88	1000	3,12	29,48	1000	19,36	337,05	1000	22,75	345,41
ATLÁNTICO	1000	14,33	104,81	1000	32,06	402,21	1000	36,09	243,73	1000	50,51	498,08	1000	40,96	766,9	1000	40,96	766,89	1000	140,17	917,36	1000	51,6	1000
BOLÍVAR	1000	3,85	29,3	1000	4,35	46,73	1000	4,47	48,92	1000	4,64	60,87	1000	4,83	62,25	1000	4,83	62,26	1000	21,65	82,26	1000	9,63	110,86
BOYACÁ	1000	2,98	26,34	1000	7,62	52,26	1000	2,36	37,6	1000	21,78	396,19	1000	21,78	420,95	1000	22,89	449,88	1000	24,95	1000	1000	24,32	1000
CALDAS	1000	8,15	142,51	1000	13,73	272,3	1000	13,73	265,26	1000	40,48	365,62	1000	34,53	472,76	1000	37,33	517,44	1000	160,97	556,67	1000	44,49	692,4
CAQUETÁ	806,39	0,57	9,73	1000	0,59	9,32	1000	0,59	9,5	791,85	0,83	21,07	1000	0,8	19,01	1000	0,8	21,01	1000	0,82	30,2	1000	0,82	45,89
CASANARE	-	-	-	182,79	2,77	11,99	-	-	-	-	-	-	1000	3,18	69,44	1000	3,18	74,18	1000	10,01	226,01	1000	10,54	271,96
CAUCA	1000	3,17	54,65	1000	2,51	41,06	1000	2,51	41,07	1000	2,49	42,44	1000	2,5	43,19	1000	2,5	44,27	1000	2,7	54,95	1000	2,91	59,52
CESAR	-	-	-	-	-	-	-	-	-	1000	13,99	123,21	1000	23,26	264,36	1000	24,09	289,67	1000	25,44	1000	1000	29,54	413,49
CHOCÓ	1000	2,03	21,88	1000	1,96	11,08	1000	1,96	14,18	1000	2	18,96	1000	2,1	20,37	1000	2,11	20,5	1000	2,67	22,03	1000	2,65	22,61
CÓRDOBA	-	-	-	-	-	-	1000	8,33	95,32	1000	8,68	87,65	1000	8,68	96,77	1000	8,68	106,98	1000	11,21	218,9	1000	15,63	230,49
CUNDINAMARCA	1000	7,39	113,62	1000	14,58	636,67	1000	14,66	699,89	1000	14,61	760,73	1000	17,58	385,69	1000	15,75	395,65	1000	64,53	610,28	1000	22,93	584,83
GUAINÍA	-	-	-	-	-	-	1,36	0,49	1,09	1,36	0,49	1,1	1,87	0,49	1,12	1,87	0,49	1,12	2,07	0,6	1,83	2,07	0,6	1,81
GUAVIARE	-	-	-	-	-	-	-	-	-	-	-	-	1000	2,08	12,43	1000	2,08	12,37	1000	2,1	15,93	1000	2,19	16,09
HUILA	1000	11,41	116,07	1000	11,97	204,99	1000	11,97	207,59	1000	26,53	311,97	1000	22,91	305,06	1000	28,59	339,11	1000	50,08	459,95	1000	23,23	463,94
LA GUAJIRA	1000	2,06	12,65	1000	14,84	235,33	1000	21,69	277,42	1000	16,59	164,01	1000	20,16	210,09	1000	20,16	275,61	1000	48,65	442,86	1000	28,96	798,96
MAGDALENA	1000	7,2	78,2	1000	11,35	94,94	1000	10,66	126,5	1000	11,25	114,43	1000	14,04	125,2	1000	14,16	128,79	1000	19,23	830,96	1000	30,06	503,46
META	1000	1,67	9,8	1000	2,11	24,96	1000	2,11	25,23	1000	2,94	58,36	1000	2,94	65,67	1000	2,94	74,4	1000	3,44	101,6	1000	4,05	201,79
NARIÑO	1000	2,86	36,72	1000	2,2	43,52	1000	2,24	47,38	1000	2,24	57,02	1000	2,22	56,86	1000	2,22	57,09	1000	3,13	140,07	1000	2,85	65,55
NORTE DE SANTANDER	1000	7,05	128,6	1000	11,96	256,22	1000	15,1	322,91	1000	10,78	377,46	1000	26,13	424,01	1000	18,25	410,09	1000	19,38	1000	1000	17,82	1000
PUTUMAYO	1000	1,76	13,5	1000	1,74	19,12	1000	1,36	10,96	1000	1,87	22,91	1000	1,87	23,56	1000	1,87	23,8	1000	1,87	27,34	1000	1,89	26,98
QUINDIO	-	-	-	-	-	-	-	-	-	1000	89,71	679,77	1000	89,71	956,91	1000	89,71	956,91	1000	90,85	1000	1000	85,46	1000
RISARALDA	-	-	-	-	-	-	-	-	-	1000	10,65	416,24	1000	10,65	516,5	1000	16,53	657,62	1000	31,34	691,89	1000	24,77	571,52
SANTANDER	1000	5,88	82,75	1000	8,13	161,66	1000	10,12	138,16	1000	12,59	290,76	1000	13,34	442,58	1000	13,38	399,98	1000	22,66	608,82	1000	22,15	468,63
SUCRE	-	-	-	-	-	-	-	-	-	1000	5,25	61,73	1000	5,64	70,95	1000	5,64	70,65	1000	39,57	304,12	1000	18,1	213,74
TOLIMA	1000	5,35	108,12	1000	9,82	160,49	1000	9,82	223,22	1000	25,87	384,45	1000	25,93	533,8	1000	25,93	613,72	1000	52,42	1000	1000	62,44	652,56
VALLE DEL CAUCA	1000	3	72,95	1000	2,87	273,07	1000	2,88	268,81	1000	2,91	256,79	1000	2,91	257,59	1000	2,91	262,08	1000	4,18	699,74	1000	3,12	204,79
VAUPÉS	1,87	0,38	0,86	3,03	0,41	1,11	3,03	0,41	1,14	1000	0,5	2,04	1,34	0,51	0,86	1,34	0,51	0,86	1,35	0,51	0,84	1,39	0,51	0,86
VICHADA	292,27	2,55	12,71	34	2,35	10,76	152,47	2,55	12,52	1000	2,55	13,08	1000	2,55	17,52	1000	2,55	17,52	1000	5,61	163,94	1000	5,25	158,7