Geographical Accessibility in medium-sized Colombian cities considering private vehicle and cycling: Metrics and comparisons

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Abstract

Mobility is an issue for urban settlements worldwide due to the increase in population and migration from rural areas. The mobility paradigm has been the approach used in the last decades to tackle negative externalities related to congestion, road crashes, and pollution. It prioritizes travel time reduction and transportation network optimization for private motorized vehicles. On the other hand, the creation of liveable and sustainable urban spaces is the main objective of the accessibility paradigm setting the reach of opportunities first than the mobility itself. Geographical accessibility measures the travel impedance between all places in a city, assuming an equal value for each. Several studies have conducted accessibility measures in large cities in Latin America and the Caribbean region; however, few studies concentrated on the accessibility impact on medium-sized settlements despite 40% of LAC inhabitants. The research objective is to measure the geographical accessibility in the main medium-sized Colombian cities by comparing two modes of transport: private vehicles and cycling. Open-source software (**QGIS**) and programming language (**Python 3.X**) will be used to retrieve the road infrastructure network from Open Street Maps and calculate the travel time matrix and isochronous coverage curves. Operational speeds will be used in conjunction with road typologies to measure travel impedance. This framework allows us to conduct comparisons within cities and modes of transport (active and motorized vehicles) through the accessibility metrics built to promote a dialogue about accessibility challenges within medium-sized cities with similar geographies.

Materials and Methods

Choose the cities

Geographical accessibility
- Private vehicles
- Cycling

Metrics, indicators, and comparisons

1. Sociodemographic data:
- Urban boundary
- Census data

DANE

2. Road network, speeds, and altitude data:
- Driving
- Cycling

OpenStreetMap · NASA · Google Maps

3. Cycling speeds per slope: STRAVA Crowdsourcing data

STRAVA

4. Driving road network model validation (only for driving)

$$A_i^{\ddagger} = \frac{\sum_{j=1}^{n} C_{ij}}{n-1}$$

QGIS

5. Geographical accessibility calculations and isochronous curves construction

Results

Figure 1

Case study cities

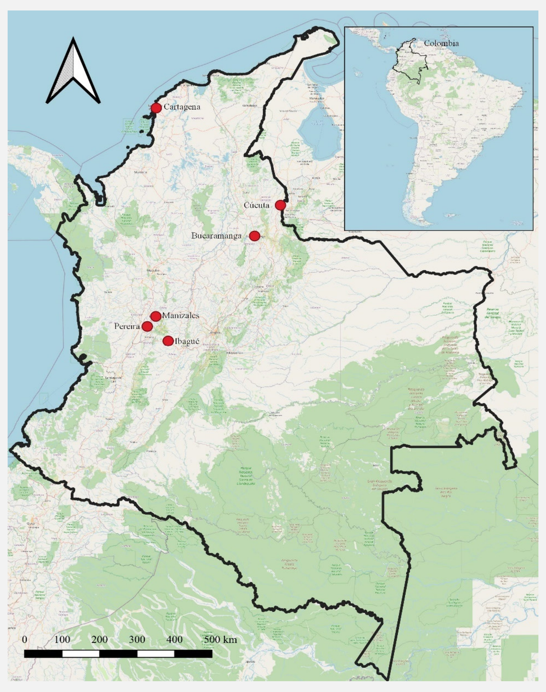

Table 1

Population and Area per city

City	Population 2021 (AM)	Area (ha)
Bucaramanga*	604 186 (1 210 530)	9302.51
Cartagena	926 747	8322.38
Cúcuta*	759 395 (986 015)	10 528.07
Ibagué	503 745	4793.87
Manizales	425 181	4226.67
Pereira*	404 270 (647 298)	5093.74

Table 2

Average speed (kph) for private vehicle

Typology	$\bar{x}$	σ	Cv
primary	27.56	0.68	2%
primary_link	23.70	4.00	17%
secondary	22.98	2.81	12%
secondary_link	27.06	8.25	30%
tertiary	18.99	1.31	7%
tertiary_link	22.00	3.91	18%
trunk	42.61	5.63	13%
trunk_link	31.16	5.04	16%
residential	13.01	0.53	4%
unclassified	16.77	1.25	7%

Speeds are expressed in kilometres per hour (kph)
$\bar{x}$: Average
σ: Standard deviation
Cv: Coefficient of variation

Figure 2

Cycling speeds (kph) and slope group (%)

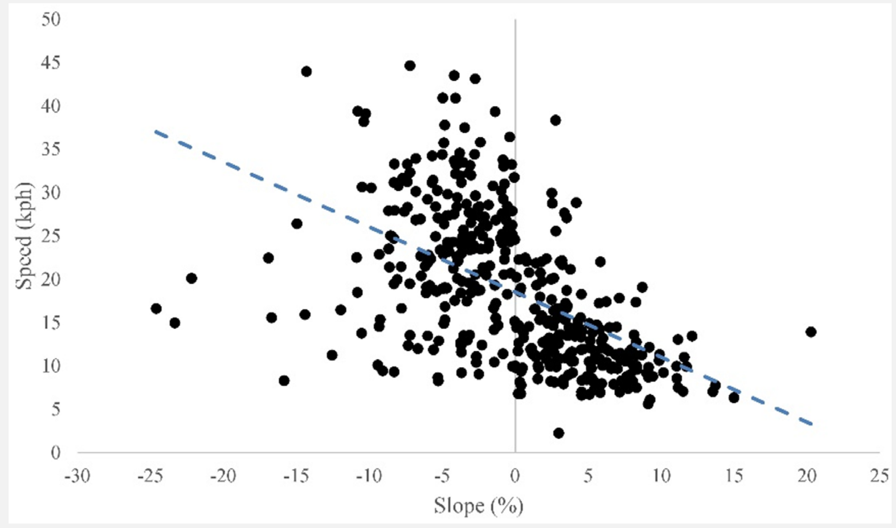

Figure 3

Geographical accessibility isochronous curves for cycling and driving per city

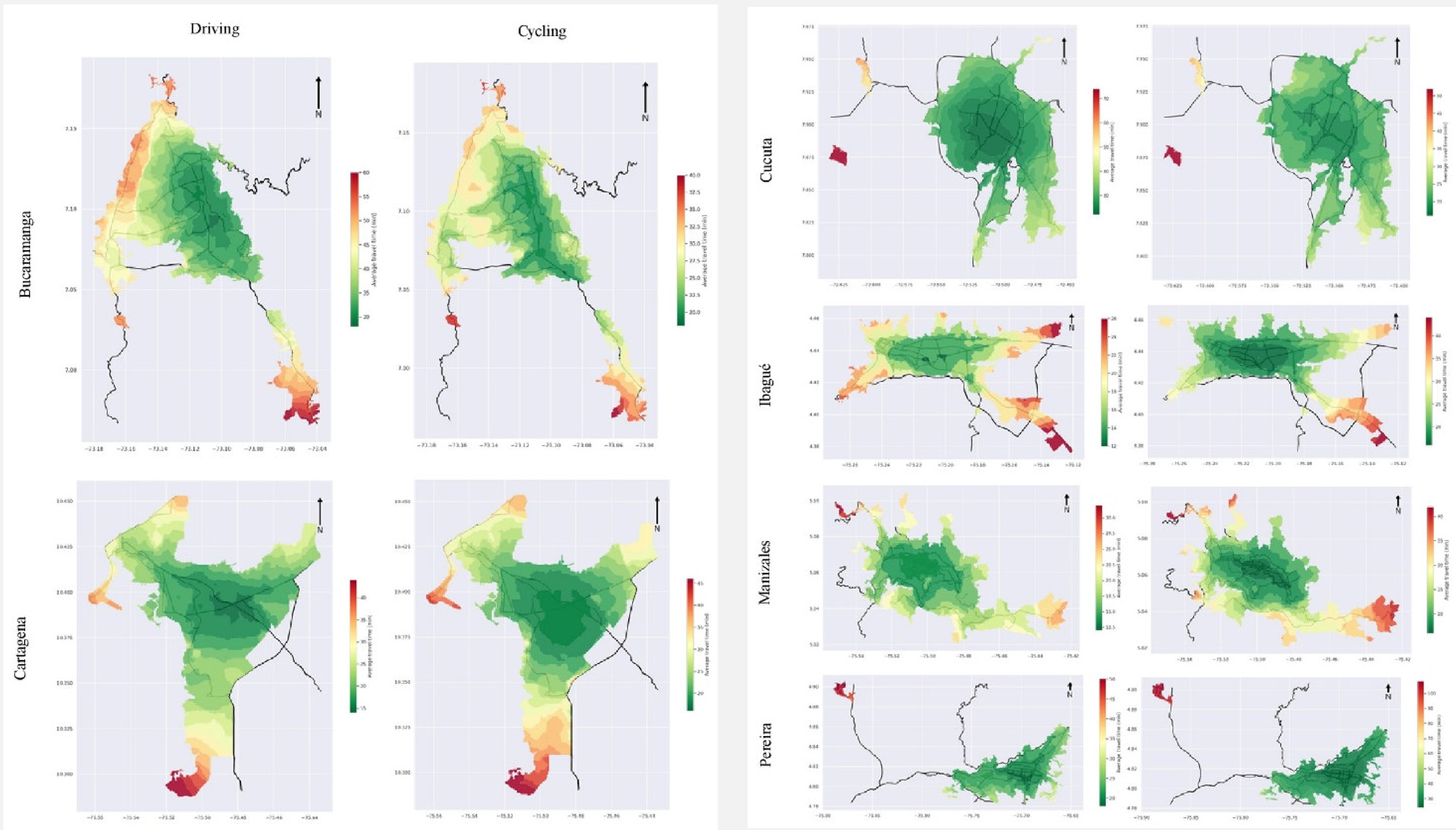

Table 3

Metrics and indicators for driving and cycling geographical accessibility per city

Indicators	Bucaramanga		Cartagena		Cucuta		Ibague		Manizales		Pereira	
	Driving	Cycling	Driving	Cycling	Driving	Cycling	Driving	Cycling	Driving	Cycling	Driving	Cycling
Population	30.92	46.40	30.24	31.85	31.61	45.84	20.18	31.35	22.68	30.10	34.32	58.77
Area	31.40	47.38	31.34	33.35	31.75	46.34	20.44	31.94	23.44	31.26	34.18	58.97
Housing	30.82	46.31	30.34	31.96	31.53	45.76	20.16	31.31	22.63	30.01	34.21	58.49
Male	30.96	46.45	30.25	31.85	31.63	45.85	20.19	31.38	22.69	30.12	34.34	58.80
Female	30.88	46.36	30.23	31.85	31.60	45.83	20.16	31.33	22.67	30.08	34.31	58.74
SES 1	32.46	48.08	30.87	32.40	31.99	46.30	21.10	32.77	22.89	30.51	35.41	60.56
SES 2	31.38	46.65	29.72	31.34	31.60	45.73	20.45	31.70	22.81	30.19	34.57	59.42
SES 3	30.86	46.62	29.38	31.05	31.16	45.43	19.45	30.17	22.56	30.07	34.05	58.00
SES 4	29.51	44.76	29.64	31.69	30.50	44.60	19.59	30.21	22.66	30.06	33.45	57.08
SES 5	29.37	44.88	32.57	35.22	30.28	44.17	19.50	30.33	22.03	28.65	33.22	57.27
SES 6	29.81	44.31	37.25	40.39	30.53	44.94	20.11	31.77	22.37	29.17	33.05	56.04

SES: Socieconomic strata
Travel times are expressed in minutes

Conclusions

This research calculated and compared geographical accessibility for six medium-sized Colombian cities considering private vehicles and cycling. This study reaches 4.7 million people near to 9.2% of the total population. We use open data, code, and software to develop a framework to calculate geographical accessibility for every city or zone worldwide. This could be replicable in any context if the data is available, especially sociodemographic.

References

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