Accessibility in the cities of Sao Paulo state

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1. Overview

1.1. Introduction

People with physical or mental disabilities are often the target of prejudice and discrimination, leading families who have someone in these conditions, to isolate themselves from society. Social inclusion programs are of great importance in the reintegration of these people, promoting dignity and the right to participate in democracy. However, for this process to be efficient, cities need to adapt their facilities and public transport to equalize access to the resources available to all.

1.2. Problem

This paper aims to answer the following question: which cities in the state of Sao Paulo have the highest accessibility index (ratio between venues with accessibility by the total number of venues) and what factors do they have in common?

1.3. Interest

I believe the result of this research is relevant, because if we know what are the common factors in cities with greater accessibility, the public and private sectors will be able to direct their efforts and resources more effectively in social inclusion programs, and also, If you have a disability, you can choose a more beneficial place to live.

2. Data

2.1. Data sources

Two data sets were required for this research: a table containing the cities of the state of Sao Paulo and information about their population, area, financial data on agriculture, industry, utilities, gross domestic product, human and municipal development indicators. in addition to their geographical positions, all from open sources (Table SP), and the second set, containing the result of searching for city locations through the API provided by FourSquare, each with its name, id, category, geographic position and whether it is accessible to wheelchairs (Table FS).

City	Population	Area KM2	Farming	Industry	Public administration	Public services	Taxes	GDP	GDP per capita	HDI-M	HDI-R	HDI-L	HDI-E	FMDI	Latitude	Longitude
Adamantina	33888	411.99	45201.02	138803.34	168908.81	621261.40	80366.51	1054541.08	31121.18	0.79	0.77	0.85	0.75	0.78	-21.686651	-51.076297
Adolfo	3469	211.06	33549.77	8059.45	21422.16	33338.63	3364.63	99734.63	28667.61	0.73	0.71	0.84	0.65	0.78	-21.235659	-49.644191
Aguaí	34919	474.55	87873.19	297084.21	121789.13	336929.46	99032.53	942708.52	27263.25	0.72	0.70	0.86	0.61	0.72	-22.059203	-46.979384
Agudos	35828	966.71	80476.44	800703.35	174721.09	672594.73	334526.09	2063021.70	57826.60	0.74	0.70	0.84	0.69	0.77	-22.471162	-48.987822
Alambari	5600	159.60	35578.26	7684.43	24265.69	28925.07	4113.25	100566.70	18245.05	0.71	0.68	0.80	0.66	0.70	-23.550338	-47.897971
Alfredo Marcondes	3923	118.92	5147.29	16134.31	19518.70	28834.32	13365.29	82999.90	21173.45	0.74	0.68	0.84	0.71	0.76	-21.952700	-51.413956
Altair	3994	313.01	137866.81	9244.01	20293.65	37987.09	4689.41	210080.96	52877.16	0.69	0.70	0.80	0.58	0.75	-20.523895	-49.060613
Altinópolis	15557	928.96	195155.50	22009.42	64684.57	221688.64	23401.18	526939.31	33869.35	0.73	0.73	0.84	0.64	0.80	-21.021364	-47.371200
Alto Alegre	4037	318.57	36909.22	12081.21	22009.11	32604.84	6853.25	110457.64	27293.71	0.70	0.68	0.82	0.62	0.75	-21.611707	-50.150075
Alumínio	17747	83.66	1269.67	902768.74	92240.80	376606.08	480691.90	1853577.18	105101.90	0.77	0.73	0.84	0.73	0.73	-23.520347	-47.257525

Table SP: first ten lines

Originally, the Sao Paulo state has 645 cities. Due to the lack of some relevant information, some were removed, leaving 633 cities.

Field	Description	Year
City	city of Sao Paulo state	
Population	number of inhabitants	2018
Area KM2	city area in Km2	
Farming	total value of production from agricultural activities	2017
Industry	total value of production from industrial activities	2017
Public administration	total value of production from public administration	2017
Public services	total value of production from public services	2017
Taxes	total value of production from taxes	2017
GDP	total value of production from gross domestic product	2017
GDP per capta	ratio between GDP and Population	2017
HDI-M	mean index over HDI-R, HDI-L and HDI-E	2010
HDI-R	human development index - income	2010
HDI-L	human development index - longevity	2010
HDI-E	human development index - education	2010
FMDI	municipal development index (2013)	2013
Latitude	latitude coordinates	
Longitude	longitude coordinates	

Table SP: features description

City	Venue	Venue ID	Venue Latitude	Venue Longitude	Venue Category	Accessible
Adamantina	Verdurão	4ef606028b81ef98cf8bf3d5	-21.685683	-51.079293	Gastropub	No
Adamantina	Aroma Café & Cia	4b95623bf964a520b99f34e3	-21.685990	-51.073928	Café	No
Adamantina	Restaurante e Pizzaria Cartola	4b817ebef964a5202caa30e3	-21.688155	-51.074865	Restaurant	No
Adamantina	Via Sabor Panificadora	4de7ed7b45dda9e8a3385432	-21.682576	-51.079105	Bakery	No
Adamantina	Chiquinho Sorvetes Adamantina	5291672511d2ec25cc40d5e3	-21.687580	-51.074467	Ice Cream Shop	No
Adamantina	Bar do Sashimi	4ba40a38f964a520a97a38e3	-21.688654	-51.079062	Bar	No
Adamantina	Sorveteria Cherry	4b9cc3a2f964a520707a36e3	-21.688062	-51.073470	Ice Cream Shop	No
Adamantina	La Olimareña	5494af82498e89679c1197cb	-21.691706	-51.074619	Ice Cream Shop	No
Adamantina	Sorveteria Água Na Boca	4efa1705b63446a50b0c1bab	-21.683935	-51.074804	Ice Cream Shop	No
Adamantina	Cartola Cachaçaria Chopp Grill	4dd711deae60680f14fe71e3	-21.686943	-51.070068	Nightlife Spot	No

Table FS: first ten lines

Field	Description
City	city of Sao Paulo state
Venue	venue name
Venue ID	venue ID on FourSquare
Venue Latitude	venue latitude coordinate
Venue Longitude	venue longitude coordinate
Venue Category	venue category
Accessible	is venue accessible for wheelchair? Yes or No

Table FS: features description

Regarding the API, there were some restrictions due to the "personal" account: up to 100 locations could be searched per city within a 1000 m radius, avoiding territorial overlap, as some cities have an area smaller than 4 Km2 (Table SP Description). In addition, only 5000 daily consultations could be made to gather accessibility information. As a result, it was necessary to repeatedly create and delete the FourSquare API access credential in order to obtain all the required information.

	Population	Area KM2	Farming	Industry	Public administration	Public services	Taxes	GDP	GDP per capita	HDI-M	HDI-R	HDI-L	HDI-E	FMDI	Latitude	Longitude
count	633.00	633.00	633.00	633.00	633.00	6.330000e+02	6.330000e+02	6.330000e+02	633.00	633.00	633.00	633.00	633.00	633.00	633.00	633.00
mean	69272.99	385.96	56807.39	593318.06	272422.28	1.881461e+06	5.228281e+05	3.326837e+06	33371.74	0.74	0.72	0.84	0.68	0.76	-22.14	-48.63
std	479742.88	320.37	65832.88	2762611.36	1760898.45	1.922045e+07	5.014366e+06	2.849975e+07	28005.27	0.03	0.04	0.02	0.05	0.06	1.18	1.73
min	810.00	3.61	0.00	1197.71	7998.20	7.340020e+03	5.862400e+02	2.786437e+04	8711.80	0.64	0.59	0.78	0.52	0.59	-25.01	-53.06
25%	5567.00	159.60	17948.44	9686.14	25063.31	4.205689e+04	5.708110e+03	1.273613e+05	19730.86	0.72	0.69	0.82	0.64	0.72	-23.08	-50.00
50%	13654.00	283.14	36620.69	53813.77	55295.69	1.345454e+05	2.291148e+04	3.442632e+05	26537.35	0.74	0.72	0.84	0.68	0.77	-22.19	-48.60
75%	41262.00	512.58	72377.53	310085.12	165449.08	5.997348e+05	1.208201e+05	1.323520e+06	37374.78	0.76	0.74	0.85	0.71	0.81	-21.18	-47.29
max	11753659.00	1978.80	580210.27	59119808.83	42958613.89	4.746460e+08	1.225262e+08	6.992884e+08	357342.06	0.86	0.89	0.89	0.82	0.90	-19.94	-44.32

Table SP Description: statistics about Sao Paulo cities

2.2. Feature engineering

After some manipulation of the data, a column named “Venues” and "Accessibility" was added to the SP dataset, obtained by counting establishments containing the item "wheelchairAccessible" in their attribute list, divided by the total of establishments in the same city.

City	Population	Area KM2	Farming	Industry	Public administration	Public services	Taxes	GDP	GDP per capita	HDI-M	HDI-R	HDI-L	HDI-E	FMDI	Latitude	Longitude	Venues	Accessibility
Adamantina	33888	411.99	45201.02	138803.34	168908.81	621261.40	80366.51	1054541.08	31121.18	0.79	0.77	0.85	0.75	0.78	-21.686651	-51.076297	44.0	0.022727
Adolfo	3469	211.06	33549.77	8059.45	21422.16	33338.63	3364.63	99734.63	28667.61	0.73	0.71	0.84	0.65	0.78	-21.235659	-49.644191	5.0	0.000000
Aguaí	34919	474.55	87873.19	297084.21	121789.13	336929.46	99032.53	942708.52	27263.25	0.72	0.70	0.86	0.61	0.72	-22.059203	-46.979384	23.0	0.000000
Agudos	35828	966.71	80476.44	800703.35	174721.09	672594.73	334526.09	2063021.70	57826.60	0.74	0.70	0.84	0.69	0.77	-22.471162	-48.987822	20.0	0.100000
Alambari	5600	159.60	35578.26	7684.43	24265.69	28925.07	4113.25	100566.70	18245.05	0.71	0.68	0.80	0.66	0.70	-23.550338	-47.897971	3.0	0.000000
Alfredo Marcondes	3923	118.92	5147.29	16134.31	19518.70	28834.32	13365.29	82999.90	21173.45	0.74	0.68	0.84	0.71	0.76	-21.952700	-51.413956	5.0	0.000000
Altair	3994	313.01	137866.81	9244.01	20293.65	37987.09	4689.41	210080.96	52877.16	0.69	0.70	0.80	0.58	0.75	-20.523895	-49.060613	1.0	0.000000
Altinópolis	15557	928.96	195155.50	22009.42	64684.57	221688.64	23401.18	526939.31	33869.35	0.73	0.73	0.84	0.64	0.80	-21.021364	-47.371200	4.0	0.000000
Alto Alegre	4037	318.57	36909.22	12081.21	22009.11	32604.84	6853.25	110457.64	27293.71	0.70	0.68	0.82	0.62	0.75	-21.611707	-50.150075	0.0	0.000000
Alumínio	17747	83.66	1269.67	902768.74	92240.80	376606.08	480691.90	1853577.18	105101.90	0.77	0.73	0.84	0.73	0.73	-23.520347	-47.257525	5.0	0.000000

Table SP: new columns

The entire process of extracting, transforming and storing (ETL) data can be accessed on my Github at this link.

3. Exploratory data analysis

3.1. Understanding the Data

Exploration of the data shows that almost all establishments are food grade. It makes sense due to limitations in the search radius as such locations are smaller and larger (Figure 1), As well as establishments that have accessibility (Figure 2).

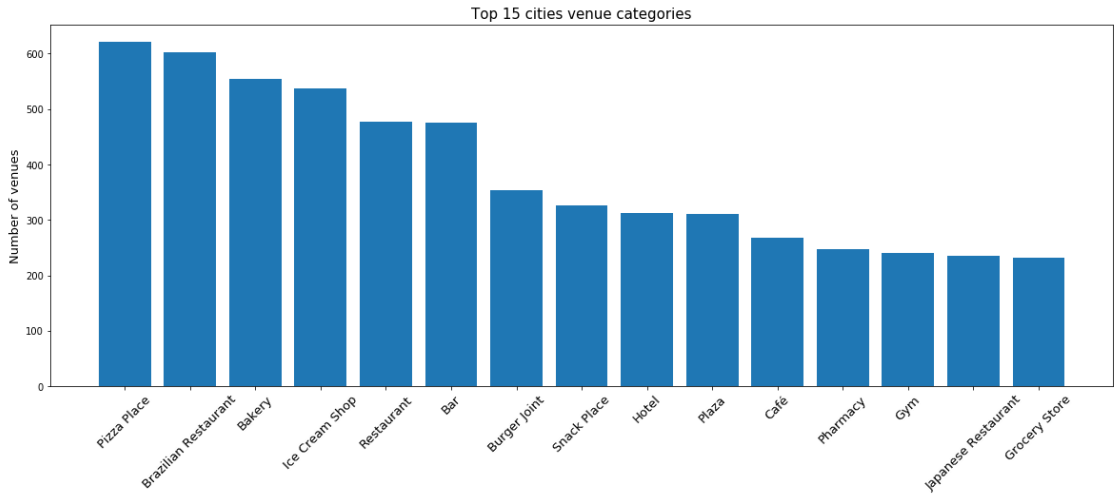


Figure 1

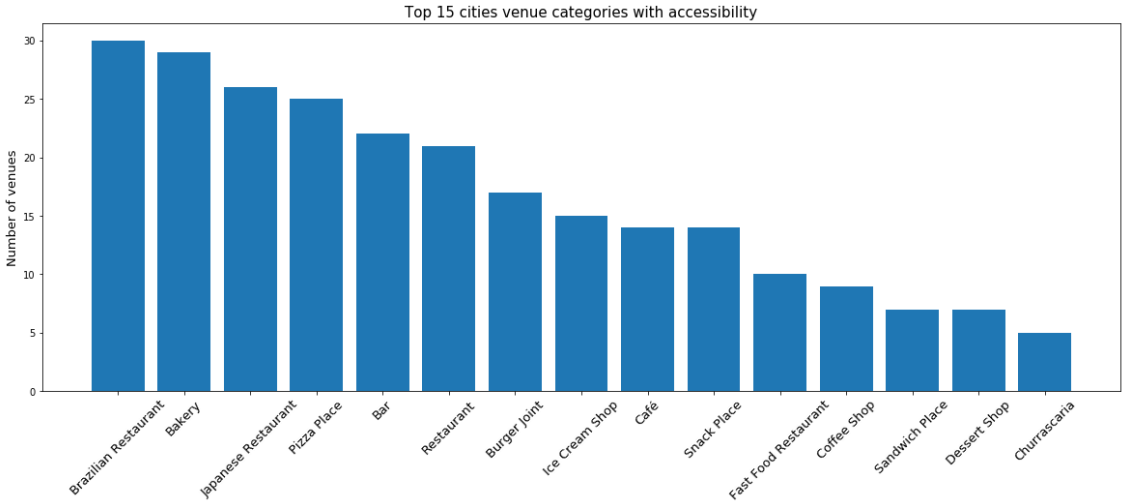


Figure 2

With regard to cities that have the highest percentage of establishments with accessibility, it is interesting to see that some have reached 100% (0.1) (Figure 3).

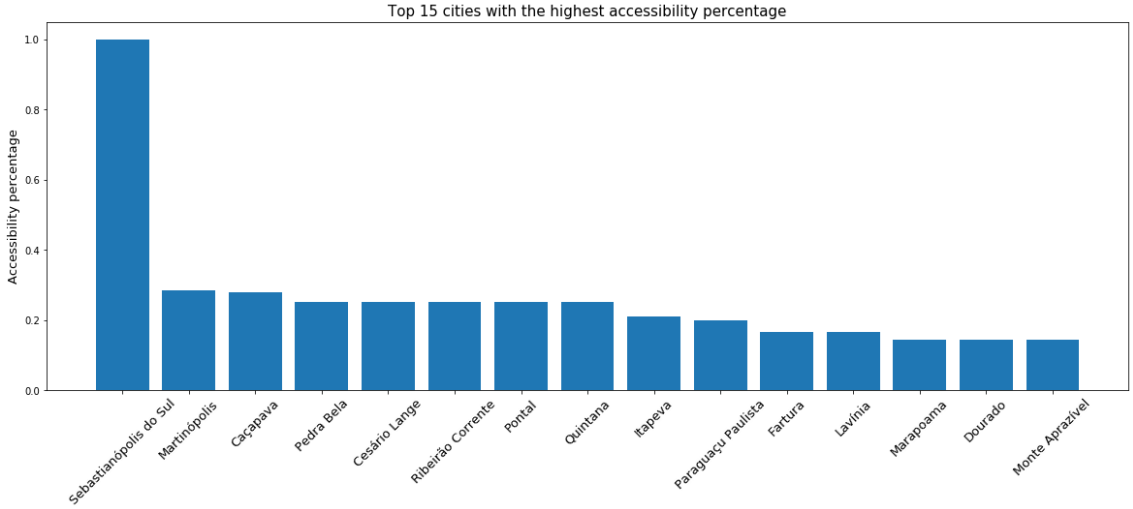


Figure 3

The distribution of the number of establishments per city indicates that, normally, the average is around 15 per city (Figure 4), just as the distribution of the percentage of establishments with accessibility averages 1% (0.01) (Figure 5).

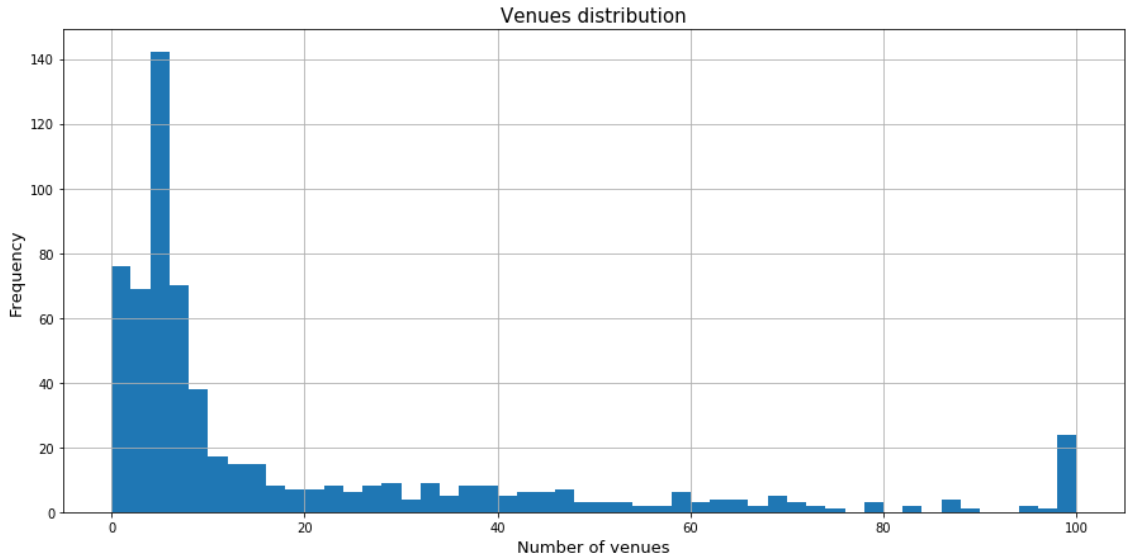


Figure 4

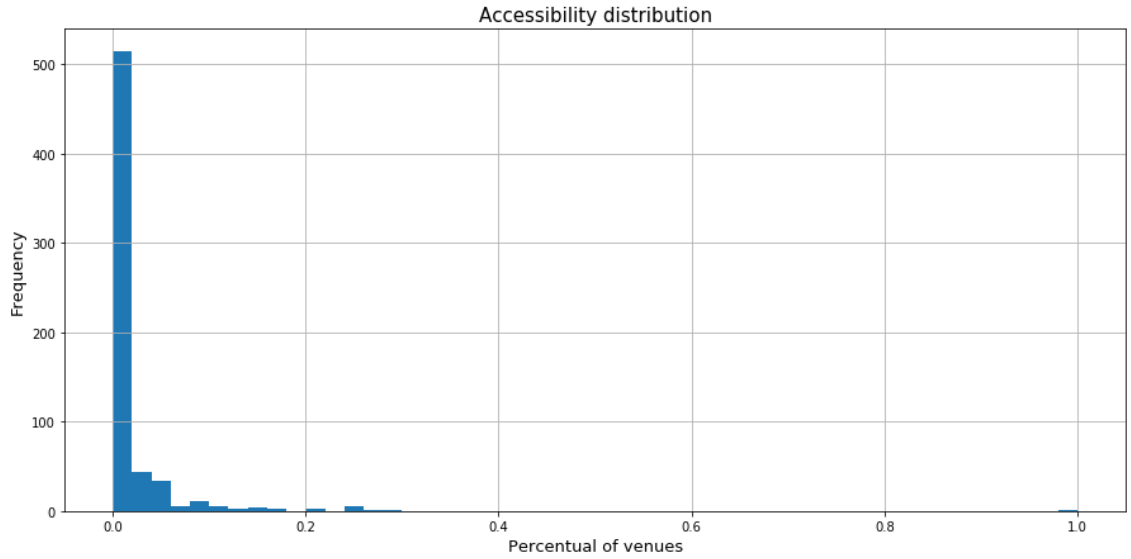


Figure 5

According to the data, given the sample collected from information about establishments, accessibility is almost nonexistent. However, the goal is to focus on cities with the highest percentage of adapted establishments and try to find what they have in common, which can be mathematically viable through a heat map on the correlation between city attributes (Figure 6).

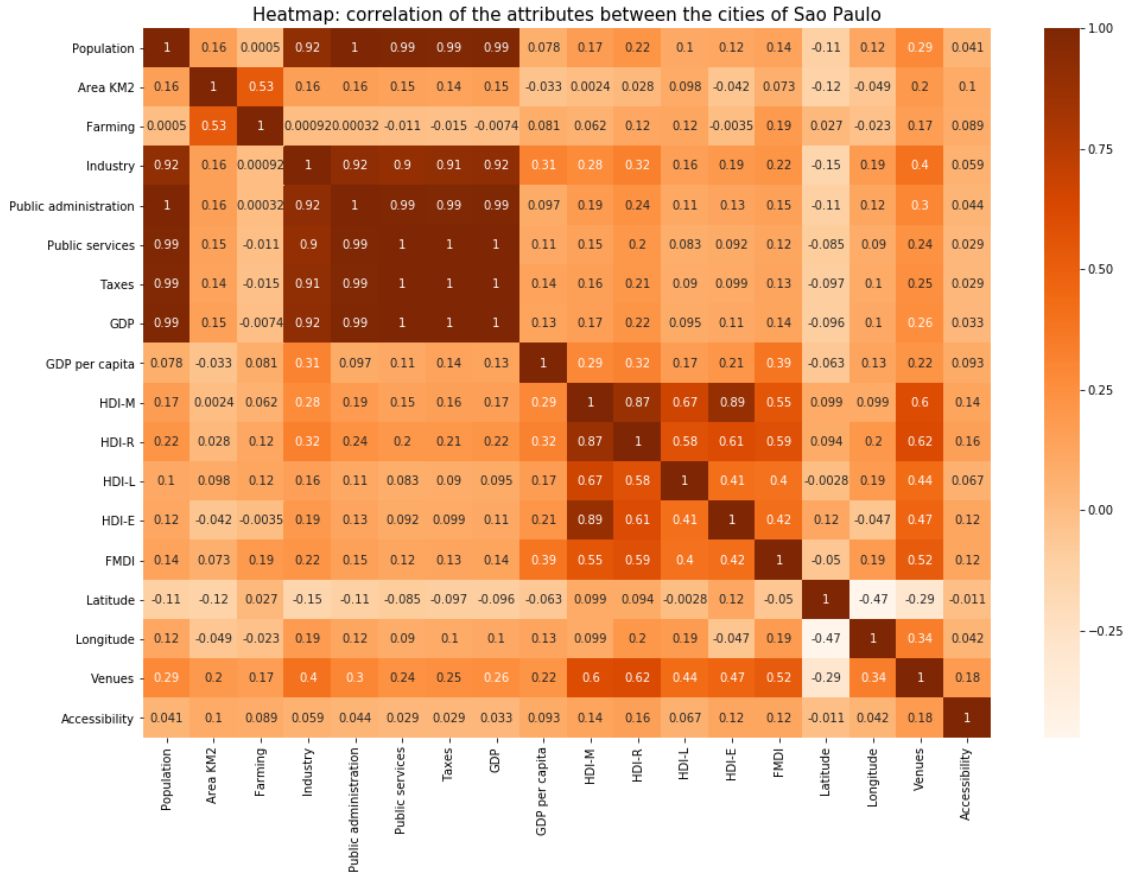


Figure 6

Looking at the map, it makes a lot of sense to correlate domestic productions and utilities with the population. In addition, the number of establishments seems to have a strong relationship with the level of human development, but no major correlation with the accessibility attribute.

When the same map is generated only with the data set where cities have a non-zero percentage, accessibility does not yet seem to be related to some other attribute (Figure 7), as the distribution of values is not favorable for this type of data. analyze. Thus, some segmentation may be useful.

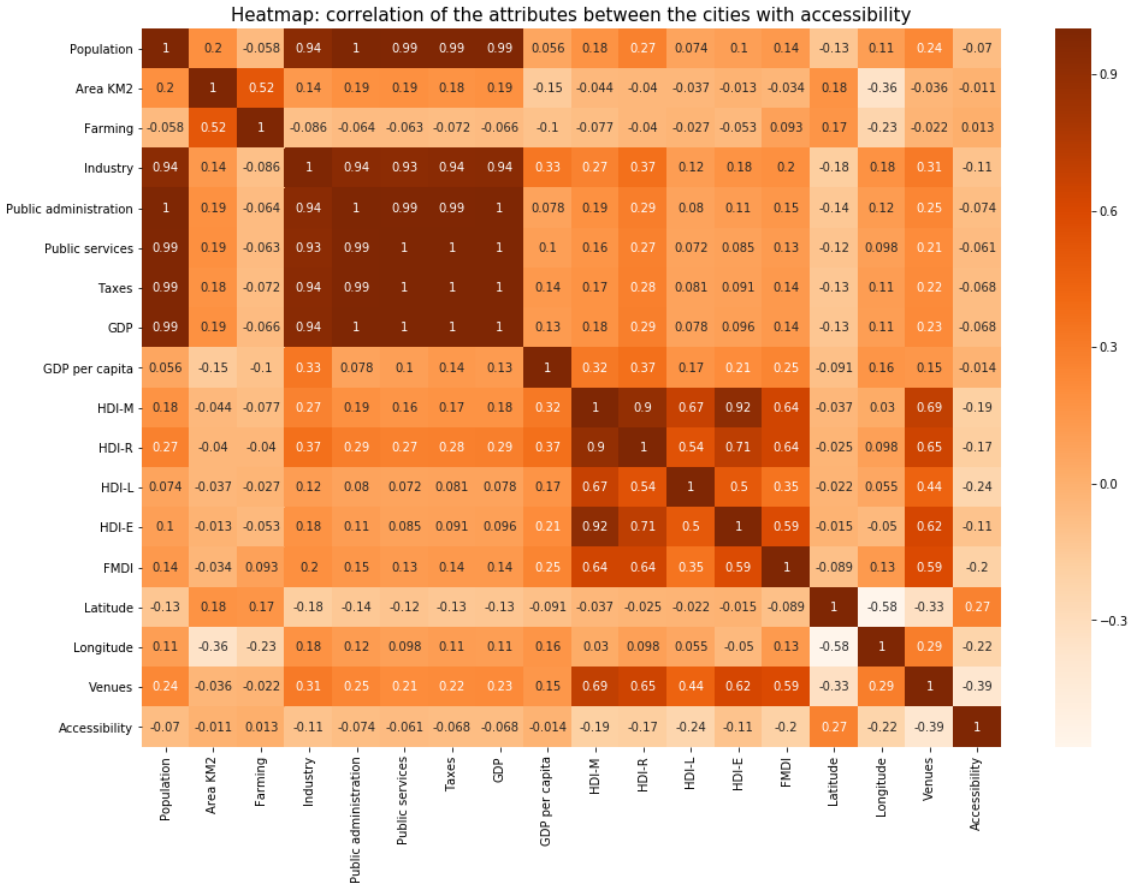


Figure 7

3.2. Clustering groups

Using the K-means clustering technique, the data was segmented into 5 groups, 0, 1, 2, 3 and 4. After division, the average of each attribute was added to a new table to facilitate comparison between the values of each group, ordered by "accessibility" in descending order (Table Stats).

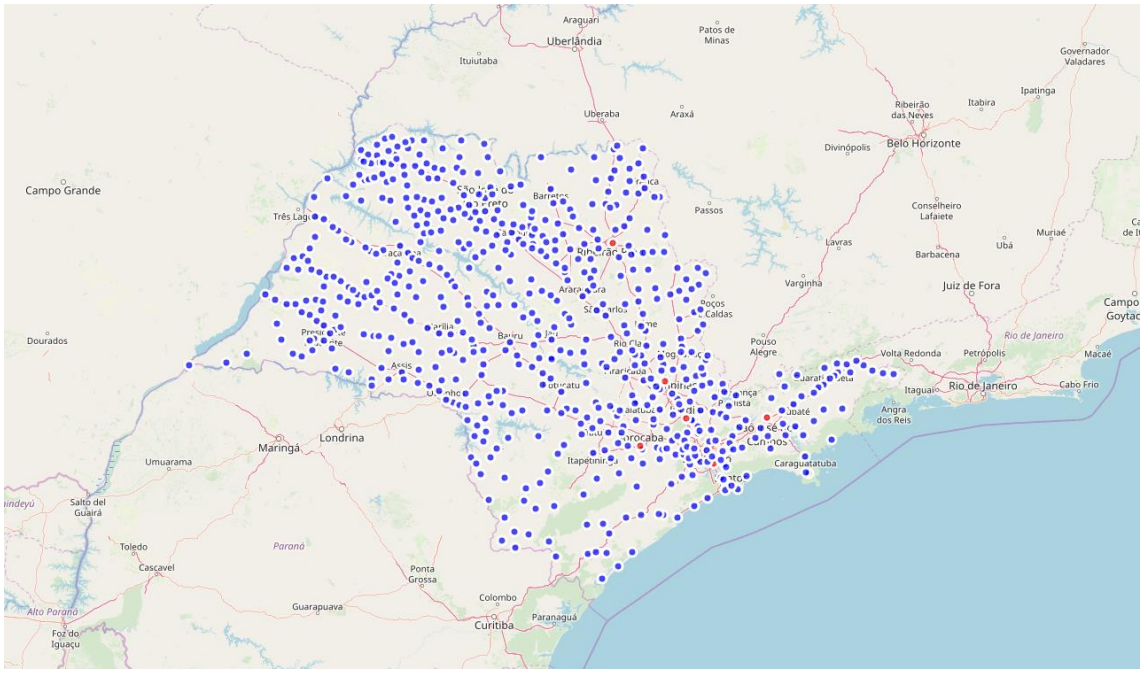
Group	Population	Area KM2	Farming	Industry	Public administration	Public services	Taxes	GDP	HDI-R	HDI-L	HDI-E	FMDI	Latitude	Longitude	Accessibility
2	5.720751e+05	479.430000	45191.221429	9.921091e+06	2.329664e+06	1.860665e+07	5.629350e+06	3.653195e+07	0.810000	0.855714	0.754286	0.847143	-23.025386	-46.896097	0.041429
3	2.533366e+05	442.492105	54581.175789	2.804005e+06	1.014292e+06	5.892823e+06	1.828582e+06	1.159428e+07	0.766053	0.851579	0.729474	0.832368	-22.964559	-47.264531	0.035283
1	1.175366e+07	1521.110000	37648.700000	5.911981e+07	4.295861e+07	4.746460e+08	1.225262e+08	6.992884e+08	0.840000	0.860000	0.720000	0.850000	-23.550650	-46.633382	0.030000
4	8.555592e+05	310.975000	34544.632500	7.001294e+06	3.541547e+06	3.728857e+07	1.219937e+07	6.006532e+07	0.787500	0.850000	0.720000	0.847500	-23.348081	-46.813357	0.022424
0	2.580204e+04	379.716346	57277.582281	1.928739e+05	1.037183e+05	3.653354e+05	8.702385e+04	8.062291e+05	0.711767	0.834460	0.671955	0.756072	-22.065719	-48.751255	0.013258

Table Stats: comparative means of each group

Group 2 presents the highest accessibility percentage (4.2%), drawing attention to 2 factors that have an average above the other groups: production with industry (Industry) and educational development index (HDI-E). Other factors such as municipal development index (FMDI) and taxes (Taxes) are among the largest. Below is the table with the cities participating in this group (Table SP G2):

City	Population	Area KM2	Farming	Industry	Public administration	Public services	Taxes	GDP	HDI-R	HDI-L	HDI-E	FMDI	Latitude	Longitude	Accessibility	Group
Sorocaba	644397	450.38	33773.57	7980161.19	2565990.08	15269981.38	6002952.21	31852858.43	0.79	0.84	0.76	0.85	-23.501667	-47.458056	0.11	2
Santo André	690551	175.78	843.52	5196161.76	2469773.28	16248943.03	3554958.82	27470680.40	0.82	0.86	0.77	0.87	-23.657339	-46.532250	0.06	2
Jundiaí	400549	431.21	112983.03	8240604.97	1915874.44	23137051.65	7821438.84	41227952.95	0.83	0.87	0.77	0.89	-23.188786	-46.884512	0.04	2
São Bernardo do Campo	803771	409.53	7202.98	9186786.28	3008065.43	24370060.27	8108274.41	44680389.37	0.81	0.86	0.75	0.84	-23.708034	-46.550674	0.04	2
Paulínia	100915	138.78	26024.70	17671369.71	976756.40	11451592.82	5220746.25	35346489.87	0.80	0.86	0.73	0.80	-22.763039	-47.153221	0.02	2
Ribeirão Preto	669180	650.92	119098.04	5305064.63	2781989.58	23253567.10	3856123.83	35315843.18	0.82	0.84	0.74	0.87	-21.178333	-47.806667	0.02	2
São José dos Campos	695163	1099.41	16412.71	15867490.19	2589198.54	16515347.97	4840954.50	39829403.91	0.80	0.86	0.76	0.81	-23.180501	-45.887296	0.00	2

Table SP G2



Map of the cities of the state of Sao Paulo: group 2 in red, others in blue

4. Discussion

For particular and ethical reasons, I will not address political issues or accessibility laws, but will limit myself only to statistics. About 23% of the population claims to have a disability [1], in addition to finding problems in adapting to establishments [2], have difficulty transporting them to these locations, as only 4.7% of the country's streets have access ramps [3].] and over 90% of municipalities do not comply with the Public Transport Adaptation Act [4]. Most of the establishments that have adaptations are food category, eliminating or hindering several other categories, such as gyms, schools, libraries, leisure centers, among others. Adding the lack of options between the adapted categories and the difficulty of reaching these places, social isolation is almost inevitable. As noted earlier, social reintegration programs are important but need greater efforts for people with special conditions to enjoy this feature.

5. Conclusion

Clearly, the conclusions of this paper may be incomplete or biased due to limitations by data sources. In any case, the sampling of the results contributes to the low level of adaptation of the establishments to the wheelchair users, and also shows some positive correlation with cities that have great industrial power and cultural development, indicating that greater investments should be made in these attributes.

6. Future directions

This study is the basis for others that are better designed and with fewer limitations. However, as a conclusion paper, the intentions were not only to generate something for the completion of the course, but something useful that could reflect something positive in society.

7. References

A: https://agenciadenoticias.ibge.gov.br/agencia-noticias/2012-agencia-de-noticias/noticias/16794-pessoas-com-deficiencia-adaptando-espacos-e-atitudes

B: https://32xsp.org.br/2018/12/04/pessoas-com-deficiencia-em-sao-paulo/

C: https://noticias.uol.com.br/cotidiano/ultimas-noticias/2012/05/25/porto-alegre-se-destaca-em-estudo-do-ibge-com-quase-25-de-ruas-adaptadas-para-cadeirantes.htm

D: https://g1.globo.com/economia/noticia/88-dos-municipios-que-tem-transporte-por-onibus-descumprem-lei-de-acessibilidade-diz-ibge.ghtml