Localization of the Elementary EducationSchools: an Application to Urban Municipal Schools of Cataguases/MG - Brazil

Ana Carolina Lima de Souza[1], Tiago Bittencourt Nazaré[2], Douglas Barbosa[3]

[1]*Student ofIndustrialEngineering, Faculdades Integradas de Cataguases-FIC/UNIS*
[2]*Master in Engineering systems management, Universidade Católica de Petrópolis-UCP*
[3]*Bachelor degreeof Industrial Engineering, Faculdades Integradas de Cataguases-FIC/UNIS*

Cataguases/MG, Brazil

Abstract

The present study aims to measure the capacity of urban municipal elementary schools of Cataguases/ MG – Brazil, considering the current legislation on the entitlement to free basic public education, withthe purpose of identify excess or shortage of vacancies. It makes use of the census tracts, population data, both reported by the IBGE, according to the 2010 Census. Information was collected from each school, provided from the Department of Education of the city. As such, Quantum Gis software was used to calculate the several indicators and spatial distribution of schools.

Keywords:*Location of schools, Quantum Gis, zoning, capacity.*

I. INTRODUCTION

According to [1], basic education is a citizen's entitlementand it is the State's duty to provide it with quality and for free.

Cataguases Municipal Department of Education manages 23 schools in the municipality, since from pre-school until elementary education. There are 18 schools in the urban area and 5 in the rural area.

For its efficient management, it is necessary develop a work that contains the supply and demand of enrollments in the municipal public schools. This way, a better application of public resourcesand an improvement in urban displacementwill be achieved.

It must be mentioned, according to [2], the number of primary school enrollments in 2017 fell by 0.41% compared to 2016 in Brazil. In elementary and midlle education, this reduction was observed for the fourth consecutive year. This fall is associated with the increase the number of private school, the policies of rectification of flow that has reduced the reprobations, and, above all, the decrease of the birth rates.

The objective of this study is to verify the current location of urban elementary schools in the city of Cataguases/MG - Brazil, using the *p*-median model. The intention with this analysis is to realize a school zoning, in order to detect excess or shortage of vacancies, allowing a more effective management of school capacity. In order to evaluate the spatial distribution of the schools, the free software Quantum Giswas used to calculate the centroids of the city's census tracts and the distance between them and each school analyzed.

II. LITERATURE REVIEW

A. Current legislation for Brazilian basic education

According to [1], the State's duty with public school education shall be fulfilled by guaranteeing compulsory basic education free of charge for the 4 (four) at 17 (seventeen) years of age.

Still according to [1], basic education is subdivided into early childhood education for children between 4 (four) and 5 (five) years of age, elementary education is beginning at 6 (six) years of age and lasting nine years, and midlle education with a minimum duration of three years.

After the extension of elementary education to 9 (nine) years of duration, [3] defines the new agegroupfor elementary education:from 6 to 10 years for the initial years and from 11 to 14 years of age for the final years.

B. Basics of localization

According to [4], the location of public sectors is related to an important scope of operational research. The problems of location are intended to indicate where an establishment should be located, in order to improve a decision variable. In several adversities, the data on capacity offered and necessity have to be reconciled.

Reference [5] establishes that the optimization of the location of service stations or facilities is based on defining a geographical spot for its operation in order to enhance its service, taking into account several exceptions, especially demand conditions.

According to [4] infrastructures such as ATMs, recycling collection centers, schools, etc., the fundamental coefficient is the ease of access in the place.However, for an emergency activity, the ambulance travel time to the place of occurrence is the primary coefficient.

Reference [6] reports that there are differences of purpose between the private and public sectors.As long as in the private sector, the purpose is to boost profits or reduce costs, in the public sector, the purpose is to increase the benefits available to the community, or to restrict the costs of the services provided.

1) **The p-median model:** According to [7], the most widespread mathematical model related to the problem of location of activities or service stations is the p-median model, which indicates points to find facilities with the purpose of reducing the distance between the users, gathered at each vertex or centroid, and existing facilities.

For school location, this model has the following premises:

- The entire school-age population residing in each census area is gathered in its respective centroid;
- All schools provide equivalent teaching conditions. With this, every student enrolls in the school closest to their residence. Since this school offers similar conditions to others, the decisive factor for choosing it is proximity. Reference [8] validated this hypothesis when analyzing the behavior of students from Nova Iguaçu/RJ;
- Schools located in the same sector serve the same area, being classified in only one with their unified capacities. In Cataguases there are 11 municipal urban schools of elementary education, installed in eleven distinct sectors, this premises being dispensable.

C. Related works

There are numerous works associated with the allocation of public resources that cover the field of education and linear mathematical programming. Most of these journals have as purpose to verify the location that the schools are located or to analyze how the school transport is carried out.

Regarding the location of the facilities, the studies aim to indicate the best location for the next school buildings in order to reduce the distance traveled by the students. In this context, [9] exposes the tests according to the mathematical programs and the positions of the schools in several Brazilian cities. Similarly, [10] uses the p-median model for the installation of new public schools in the city of Vitória - ES.Reference [11] presents a structuring of the method used in previous studies.

Reference [12] analyzed the location of school facilities in Southampton, England, initially established at the central point of extensions determined by geographic distributions. The fall in birth rates has led to the occlusion of schools. In this way, this study differs from the ones mentioned above by the fact that its result was not the construction of new school buildings, but the closing of some, in view of the various remaining vacancies.

III. METHODOLOGY

For the development of this paper, bibliographical research was carried out, through books, scientific articles, journals and academic and governmental sites, from November 2017 to June 2018.

The methodology used was applied in order to produce sciences aimed at solving certain problems, and a quantitative approach that, according to [13], is a method that quantifies opinions and information to categorize and verify them.

Under this approach a case study was made with regard to the location of the urban municipal schools of elementary education in Cataguases/MG - Brazil, with the help of Quantum Gis software. According to [14] the case study has the purpose of analyzing an instance in reality and clarifying how and why it occurs, pointing out elements that collaborate for the effectiveness of the subject in question.

D. Obtaining the area of coverage of schools

The first step in the preparation of the study is to analyze the area of coverage of each school and the population distribution of the region where it is located. For this, the map of the city of Cataguases was obtained, according [15] it was fractioned in census tracts, which are small territorial units determined for cadastral control purposes, in which each enumerator collects the data of the sectors that are assigned to him.

Through the free software of geographic information system, Quantum Gis, the centroid of each sector was located, which is a representative point of its respective demographic center.

In the case study discussed, there are 116 census tracts, being considered only 100, comprising the urban area, as shown in the polygons of Fig. 1, with its due centroids.

The next step was to obtain the data referring to the last census, Census 2010, regarding the population in school band, how many children between 6 and 14 years of age live in each sector. This population demand was acquired through [16], where all data referring to the last census are available.

Assuming that the population of each sector increased in the same proportion up to the present day, the population estimate for the municipality, published in 2017, in [17], was used to calculate the estimated population of each sector. As the total population in the last census was 69,757 people and the estimate in 2017 was 75,025 people, there was an increase of 5,268 people, equivalent to 7.55% over the course of 7 years.
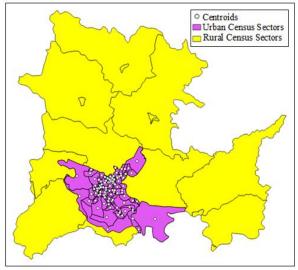
Fig. 1: Cataguases census sectors with the urban centroids

In this way, to obtain only the population of each sector, in the age group of 6 to 14 years, the population of each sector obtained in the Demographic Census of 2010 was multiplied by the estimated increase of 7.55%. Thus, Table 1 shows the population demand for each sector, after using the rounding criterion.

Next, with the Municipal Department of Education of Cataguases, data were collected referring to urban municipal schools of fundamental level, such as name, address, capacity and number of enrollments per school for the last 10 years.

With this, these 11 schools were located on the map of the city. And, using the Quantum Gis software, it was possible to draw each route of the itinerary centroid-school, being able to determine which census sector is closest to each school, that is, its area of coverage, based on the assumptions of the p-median. Fig. 2 shows the 11 areas of coverage, with the location of their respective schools.

With the 100 urban census sectors directed to their respective schools, establishing the area of coverage of each one as represented in Fig. 2 by the eleven distinct colors, it is possible to analyze the capacity of each school in front of the demand of each comprehensive area.

IV. RESULTS AND DISCUSSION

The work in question presents a methodology for the analysis of the location of municipal urban schools of elementary education in Cataguases/MG, Brazil.

The problem studied has 11 vertices, which correspond to the census tracts. The model used was that of the p-median, which assumes that the school chosen by the student is the one closest to his or her home.

E. Analysis of the excess or shortage of enrollments in each school

In order to obtain excess or shortage of places in Cataguases municipal urban schools of elementary education, each school was checked in isolation, with its proper area of coverage. Through the Quantum Gis software, the distance of each centroid for each school was calculated, in order to identify which census tracts each school understands.

Table 1: Demand for centroids (students aged 6-14)

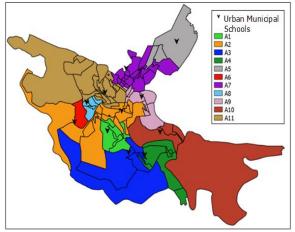| Sector	Population	Sector	Population	Sector	Population	Sector	Population	Sector	Population
S1	10	S21	16	S41	13	S61	15	S81	14
S2	15	S22	14	S42	14	S62	11	S82	16
S3	18	S23	16	S43	15	S63	19	S83	17
S4	13	S24	16	S44	17	S64	19	S84	16
S5	13	S25	29	S45	13	S65	19	S85	16
S6	17	S26	17	S46	16	S66	18	S86	19
S7	15	S27	16	S47	16	S67	19	S87	20
S8	12	S28	13	S48	16	S68	14	S88	14
S9	17	S29	13	S49	17	S69	13	S89	15
S10	15	S30	13	S50	19	S70	21	S90	19
S11	13	S31	22	S51	16	S71	14	S91	19
S12	11	S32	18	S52	17	S72	14	S92	19
S13	12	S33	12	S53	16	S73	15	S93	17
S14	14	S34	9	S54	14	S74	14	S94	14
S15	12	S35	11	S55	10	S75	13	S95	15
S16	14	S36	14	S56	13	S76	15	S96	22
S17	21	S37	15	S57	15	S77	14	S97	22
S18	13	S38	14	S58	16	S78	16	S98	15
S19	12	S39	15	S59	15	S79	13	S99	9
S20	16	S40	21	S60	15	S80	10	S100	13

Fig. 2: Area of coverage of each school in Cataguases

With the area of coverage of each school defined, the demands of each were calculated, defined by the number of school-age children residing in all sectors contained in each area.

With this, the pertinent data were confronted with the number of children aged between 6 and 14 years of each area of coverage with the appropriate capacities of each school, which were informed by the Education Municipal Secretary.

After this comparison, it is possible to determine the excess or shortage of places for each school. Thus, as shown in Table 2, if the number of enrollments is lower than the demand, the school has a shortage of places. If it is larger, there are excess vacancies and resources can be reallocated to the most deprived areas.

Table 2 shows the eleven urban municipal schools of elementary education in the city, the census sector where each one is located, the colors referring to the respective areas of comprehension of each school for a better understanding and the situation of the current scenario in relation to the capacity offered and school demand.

Thus, among the schools with excess vacancies

that comprise areas with reduction of children aged between 6 and 14 years, it is possible to establish which schools can be closed or reduced, reallocating their demands. On the other hand, it is possible to analyze possible extensions regarding schools that have a shortage of places or the construction of a new school to meet the remaining demand.

V. CONCLUSIONS

The objective of the present study was to evaluate the location of the municipal urban schools of elementary education in the municipality of Cataguases/MG - Brazil. The method used for this was the p-median model, which indicates that the student chooses the school closest to his or her home, due to the cost of transport, safety, time to travel, among others.

In order to carry out the practical study, data were obtained from the IBGE, such as digitized maps and census tracts, and data from the schoolpopulation by census section, as well as school information at the municipal education department. Quantum Gis software simplified the location of schools and centroids, the calculation of distances and assisted in the display of information and results.

Based on the analysis of the capacity of each urbane municipality school the elementary education in the city, it was verified that the capacity offered by the municipal network is enough to supply the existing demand.

It is worth noting that the excess of vacancies predominates in the current scenario of the city, with a capacity of 2,221 places for an estimated demand of 1,537, only the schools Professor Antônio Amaro and Monsenhor Solindo exceed the capacity offered.

In this way, corrective measures can be implemented, such as the relocation of some students to neighboring schools with remaining vacancies, the closure of schools located in areas with low demand and difficult access, and the transfer of some human,

Table 2: Current scenario of municipal schools in Cataguases/MG - Brazil

Sector	Municipal School	Enrollment	Demand	Scenario
S11	Professor Antônio Amaro	238	300	SHORTAGE
S21	Monsenhor Solindo	120	317	SHORTAGE
S26	Manoel Dutra Siqueira	85	62	EXCESS
S35	Professora Carmelita Guimarães	168	110	EXCESS
S41	Professora Darcília Guimarães	144	76	EXCESS
S50	Enedina Prata	192	104	EXCESS
S55	Flávia Dutra	448	255	EXCESS
S64	Professora Maria José Peloso	120	19	EXCESS
S67	Prefeito José Esteves	170	83	EXCESS
S89	Lysis Brandão da Rocha	416	106	EXCESS
S91	José Soares Gonçalves	120	105	EXCESS
TOTAL		2221	1537	EXCESS

material and / or financial resources to schools with a shortage of places.

Finally, a study is suggested to evaluate alternatives of changes with the purpose of proposing an ideal school scene for the city.

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