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Strategic location for the construction of a graphite trading warehouse in Mexico

E. Avila-Soler* • L. W. Rodríguez-Alvarado • J. Loyo-Quijada • M. Á. López-Ontiveros • S. M. García-Carranco

Universidad Autónoma Metropolitana, unidad Azcapotzalco, Ciudad de México, México

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Abstract: The investigation determined the location to build a graphite commercial warehouse (GCW), derived from the fact that the only place of production of the input is the state of Sonora, the above complicates satisfying the internal and external market of consumers due to the times and the distances. The methodology applied to determine the location for the construction of the warehouse was by means of a macro and micro analysis of location, both contemplate the diagnosis of variables through the methods of critical factors and center of gravity. The results allowed obtaining the order of alternatives for the GCW are Querétaro, followed by San Luis Potosí, Guanajuato, Tamaulipas, Aguascalientes, and Durango. The conclusion is that the GCW must be built in the location of georeferenced coordinates (20 ° 49´40.32 "N, 100 ° 18´32.38" W) or its equivalent (20.827, -100.308), specifically in the municipality of Marquez for have optimal communication channels and be a strategic point for the distribution of the product.

Keywords: Location, graphite, georeferenced, macrolocation, microlocation

*Corresponding author.
E-mail address: eas@azc.uam.mx (E. Avila-Soler).
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1. Introduction

Mining represented in 2019 the seventh position as a generator of foreign exchange in Mexico with a contribution of 2.4% of Gross Domestic Product (GDP) and, according to the firm S&P Global Market Intelligence, during 2018 it ranked 5th in attracting investments. The sector employed 379 people with practically no movement compared to 2018, with a participation of women of 15.7% and generated 3,153 new jobs. (Cámara de Mineria de México, 2020, Secretaría de Economia, 2020). However, this research focuses on the analysis of graphite, which occupies the ninth place of production worldwide and has a potential reserve of 3,100,000 tons of the amorphous type, located in the state of Sonora. (U.S. Geological Survey, 2020).

The graphite producing region in Mexico is located in the state of Sonora, specifically in the central coal deposits 150 km from Hermosillo in the San José de Moradillas and Ónavas, Peñitas and Ubalama mines. In the southeast in Álamos-San Bernardo, 42 km east of Navojoa and 9 km from La Colorada municipality, with a production of 9,000 metric tons in 2019. (Subsecretaría de Mineria- Secretaría de Economía, 2022; INEGI, 2017). Companies engaged in the business of mining graphite are: Grafitos de México S.A de CV, Minera Real de San Javier S. A. de C.V. y Grafito en la mina La Cumbre del Rincón. (Servicio Geológico Mexicano, 2018; USGS. Science for a Changing World, 2015).

Graphite is an allotropic form of carbon, a soft gray to black mineral with metalloid luster, specific gravity 2.23, hardness 1-2, crystallizes in the hexagonal system, stable and chemically inert at normal temperature, odorless, non-toxic, heat resistant, excellent conductor and unctuous to the touch. It is normally found in closed pit and underground mines in the form of foliate or massive grains and scaly aggregates. The origin comes from the metamorphism of organic material into schist and marble sediments. It should be noted that it is associated with other minerals such as: quartz, feldspar, micas, calcite, pyrite and iron oxides. In Mexico there are three types of graphite (scattered flakes, crystalline and amorphous streaks), the currently exploitable one is amorphous, due to its profitability, distribution, variety, smoothness and purity. (Berry et al., 1893, Grafito Soluciones, 2010)

Global graphite production in 2019 was 1,100,000 tons with potential reserves of 300,000,000 tons. The main producing countries are China (33%); Mexico (24%), Canada (16%), India 9 (%) and others (18%), together produce 95% of the world total. (U.S. Geological Survey, 2020).

In percentage terms, the Mexican graphite production that is exported is: the US (95%), Guatemala (2%) and Germany (2%), given its quality that competes with the Chinese and displaces it due to its low price. In the case of imports, they come from the US (60%), China (15.5%), Canada (9.5%), Brazil (8.8%) and Spain (4.8 %) (U.S. Geological Survey, 2020).

At present, the commercial presentation of the product is packed in paper bags of 23 kg or bulk is 300, 1,000 and 1,500 Kg. Nationally transported from the state of Sonora by truck to areas of consumption; they move to international destinations such as the United States by rail and to other countries by ship. (Dirección General de Desarrollo Minero, 2018).

The industrial use of graphite occurs in the elaboration of refractories, pencils, lubricants, batteries, cast iron, ballasts, plastics, ammunition, electrodes, manufacture of mechanical components, increase in the carbon content in steel, brushes for automotive engines and coatings (Comercioindustrial, s.f.; Grafito Soluciones, 2010; Subsecretaria de Mineria-Secretaria de Economía, 209)

In a report titled “Minerales para la acción climática: la intensidad mineral de la transición de energía limpia”, of the World Bank predicts a fortunate future production of minerals such as graphite, lithium cobalt could increase by 500% by 2050 to meet growing demand for clean energy technologies, the World Bank reported. He estimates that more than three billion tons of minerals and metals will be needed to also deploy wind, solar and geothermal energy as energy storage.

The problem detected in the study is the time and distance for sale and supply to the consumer of the raw material, the maximum distance of travel is 1,960 km with a period of time of 24 continuous hours, consequently, it would be advisable to build a Warehouse Graphite Marketer (GCW) in order to carry out the collection and sales functions in a strategic place in the Mexican Republic.

The analysis is justified, because it will generate benefits for suppliers, companies, consumers and additionally there are many methods to solve the problem of the location of the collection center, they are specified in various techniques, such as: the center of gravity method or Weber's method, the grid method, the centroid method, the Brown and Gibson model, the hierarchical preferences method, the weighted factor method, among others (Arsaniani, 2012; Ballou, 2004; Causado-Rodríguez et al., 2018; Urango et al., 2015)

The production of graphite in 2019 in thousands of tons worldwide was 1,119,241.00 national 1,591.00 with a contribution of world production 0.14. (Servicio Geológico Mexicano, 2020).

Investment in México from 2018 to 2019 in the mining sector was 4 thousand 657 million pesos with the participation of Canada (65%), the United States (17%), China (5%) and Japan (2%).

Graphite imports were 111,938,702.00 current dollars in 2019 with a share of 7.6 to the mining sector, Exports 82,411,191.00 current dollars and a 13.9% share to the mining sector. (Mexican Geological Survey, 2020).

The need for a new logistics facility lies in the industrial importance of this mineral.

In Mexico, only 7 companies that sell graphite are reported and they are: Bicar, Carbograf Industrial, Crisoles Industriales, Terium Crisoles, Grupo Roee, Macrein Carbon, High-quality abrasive products and graphite-producing mines, companies located in the State of Sonora (Boletin Industrial, 2022). In the year 2020, Mexico ranked 11th with a production of 8 thousand metric tons compared to the 650 of China number 1 (Statista, 2021) since the demand for graphite increased due to the fact that the main producer in the world China its production decreased due to the Covid-19 pandemic in 2019 and 2020 from 40 to 33% (U.S. Geological Survey, 2021).

Despite considerable uncertainty triggered by the COVID-19 pandemic in the second quarter of 2020, prices have risen steadily since the end of 2017 as demand for flake graphite from the lithium-ion battery industry coincided with Chinese environmental inspections. Sustained high prices have encouraged the development of flake graphite projects outside of China; During 2019 and early 2020, several projects completed feasibility studies, scoping, or resource upgrades (Acomet, 2021).

A future project is being carried out by Nouveau Monde Graphite which has announced the completion of a detailed engineering study on its planned coated spherical graphite processing plant in Canada and has started to procure equipment. The Matawinie Graphite Mine project has shown exceptional potential thanks to its large HIGH PURITY ORE RESERVE and our low-cost operating model, a skilled workforce, high quality infrastructure including paved roads and hydroelectric power, and a vibrant regional business ecosystem provide an enviable environment for real estate development (Nouveau Monde Graphite, 2021).

All this generates more opportunities for Mexico to continue with its exports.

Therefore, it is important to have a strategy for both storage and transportation that contributes to the reduction of costs and the delivery of merchandise to industrial zones is more effective.

The hypothesis of this article is that a GCW in a region and in a strategic municipality will have the level of service to satisfy the market of all regions demanding the right product, quantity, time, right moment, minimum cost, flexibility, reliability, and at the same time. It will contribute in the medium term to the economic profitability of the company and the economic development of the municipality.

The general objective of the research is to determine a proposal from a region and a municipality to build a GCW. The specific objectives are a) Carry out a Macrolocation. b) Carry out a Microlocation. c) Analyze the results with the Group of Experts and d) Generate the location proposal for the construction of the GCW.

This article was developed as follows: a first section with introduction, context of theoretical aspects related to the subject with the environment; a second section, with a methodological process and materials, in which the process of the critical factor methods and the center of gravity is presented in detail; a third section, presenting the results of the survey, selection, classification and evaluation of the information; a fourth section, in which a discussion and conclusions are presented, and, finally, the respective bibliographic references.

2. Materials and methods

The applied materials were documentary sources, such as statistical yearbooks of the elected states, state reports, databases of the Instituto Nacional de Estadística y Geografía (INEGI), scientific articles and literature on plant location and distribution methodology, as well as a table processor software for calculations and a coordinate converter GPS (Coordenadas, 2020) and use of Google Earth and a Work Team (WT) that had the experience in these cases to solve the methodology.

The WT is made up of 5 research professors from the Centro Integral de formación e Investigaciones de Ingeniería Industrial (CIFIII) of Universidad Autónoma Metropolitana, Azcapotzalco, all have between 10 and 35 years of experience in the sector.

The methodology procedure was divided into the following stages: a) The first one consisted of looking for information concerning the themes of graphite and location of facilities. b) The second was to purge the unnecessary information to apply the method. c) The third was to apply the method of locating a facility. d) The fourth was: the WT had to analyze the results of the applied method and lastly e) The WT generated the location proposal for the construction of the GCW.

The study considered various units of measurement such as: kg, km, metric tons, weights and coordinates GMS and decimals.

The variables found that according to the process were defined as: market, population, marital status, per capita income, normalization, certification, competitiveness, total and per capita GDP, trade agreements, municipalities, raw materials, taxes and legal considerations, geographic and meteorological conditions, water, electricity, environmental control, communication and transportation, labor, availability of land and community factors. (García & Valencia, 2014; Hardin, 1998).

The location to build the GCW consisted of a WT performing a quantitative analysis using the macro-location and micro-location tools.

The Macrolocation, it is defined as the location of the country or region, for this the critical factors method of selecting alternatives was applied, due to the information that could be collected. The steps to follow to apply this methodology are a) The WT develops a list of relevant factors (which affect the selection of the location). b) The WT assigns a weight to each factor to reflect its relative importance in the company's objectives. c) The WT develops a scale for each factor (for example, 1-10 or 1-100 points). d) The WT rates each location for each factor, using the scale from step 3. e) Multiply each rating by the weights of each factor and obtain the total rating for each location. For which applies in "Eq 1.":

$$S_j = \sum_{i=1}^{n=5} W_i * F_{ij} \tag{1}$$

$$i = 1,2,\dots,5, \qquad j = 1,2,\dots,5$$

Where: s_j is the global score of the alternative j, W_i is the weighted weight (W_i) of the factor i and F_{ij} is the score of the alternative j by factor i, $\sum_{i=1}^{n} W_i * F_{ij}$ is the sum total of the alternatives.

The criterion of the method for taking a decision on the recommendation is based on the score top marks in considering the results of quantitative systems also see more detail Table 1 (Chase et al, 2000).

Table 1. Weighted and global ratings of the alternatives by their factors.

Factors	Alternatives				
	W_i	1	2	3	4
Commercial	W_1	W_1F_1	W_1F_1	W_1F_1	W_1F_1
Labor	W_2	W_2F_2	W_2F_2	W_2F_2	W_2F_2
Operational	W_3	W_3F_3	W_3F_3	W_3F_3	W_3F_3
Economic	W_4	W_4F_4	W_4F_4	W_4F_4	W_4F_4
Social	W_5	W_5F_5	W_5F_5	W_5F_5	W_5F_5
Total	$\sum W_i$	$\sum A_1$	$\sum A_2$	$\sum A_3$	$\sum A_4$

The meaning of the table values is: W_n, is the weight of the factor that affects the selection of the alternative. W_nF_n, it is the multiplication of the weight of each factor weighted by the score of alternatives for each of the factors of relative importance in the objectives of the company and $\sum A_n$ is the total sum of the alternative evaluated.

The Microlocation, It is defined as the municipality where the GCW will be physically located, the tool applied was the center of gravity (Causado-Rodríguez et al., 2018) detected that if real georeference coordinates were not applied, they used to give wrong results when defining the exact municipality, (see details under discussion) and the process was as follows: a) The search for the updated map of the alternative state favored by the method with all municipalities. b) The WT proposes five municipalities, considering the most remote places in terms of distance and viability of transport and communication. c) The search for the official real coordinates in INEGI of the chosen municipalities. d) The population is searched in INEGI of each municipality and e) The method is applied in "Eqs. 2 and 3":

$$C_{Xi} = \frac{\sum_{i=1}^{n} C_{Xi} * W_i}{\sum_{i=1}^{n} W_i} \qquad C_{yi} = \frac{\sum_{i=1}^{n} C_{Yi} * W_i}{\sum_{i=1}^{n} W_i} \tag{2 and 3}$$

Where: C_{xi} represents the horizontal coordinate of the location i. C_{yi} represents the vertical coordinate of the location i. W_i, the weight of the location i in this case the number of inhabitants (Render & Heizer, 2014).

3. Results

The results obtained are described below.

3.1. Macrolocation

The macrolocation in this study considered the alternatives: Querétaro (Q), San Luis Potosí (S), Guanajuato (G), Tamaulipas (T), Aguascalientes (A) and Durango (D) and the assignment of ratings by the WT evaluated the affectations of distance, time and accessibility for all the weights of the factors (commercial, labor, operational, economic, social) and each of the respective alternatives, as detailed in the following paragraphs. The commercial factors evaluated for the regions were: a) Competition (Com). b) Taxes and legal considerations (TlC) and c) The threats of the company in the region (TCR), Weaknesses of the (WCR), opportunities (OCR) and strengths (SCR) of the company in the region. The total scores obtained from the alternatives were 44, 43, 41, 39, 38 and 31, with Q being in first place followed by S, G, A, T and D, see details in Table 2.

The reason for the behavior of Table 2, shows that the state of Q has the number of productive units in the country, which will be able to with perfect competition and is an industrial zone that represents opportunities and strengths for the market and allows to attack at the same time the threats and weaknesses of the company, which is a disadvantage for the other alternatives.

The labor factors evaluated in the regions were: a) The labor infrastructure (LI). b) Labor relations (LR). c) Social security (SS). d) Proximity to housing (PH) and e) Salaries and incentives (SI). The total scores obtained from the alternatives were 44, 44, 43, 42, 41 and 34, with Q and S in first place, followed by G, A, T and D, see details in Table 3.

Table 2. Ratings of the alternatives by their commercial factors.

Factor	Alternatives					
	D	A	G	S	T	Q
Com	5	6	7	8	6	8
TIC	6	6	6	6	6	6
TCR	5	5	6	5	5	6
WCR	5	6	5	6	5	6
OCR	6	8	9	9	8	9
SCR	4	8	8	9	8	9
Total	31	39	41	43	38	44

Table 3. Qualifications of the alternatives by their Labor factors

Factor	Alternatives					
	D	A	G	S	T	Q
LI	7	7	7	7	7	7
LR	8	9	9	9	9	9
SS	7	9	9	10	10	10
PH	5	8	9	9	8	9
SI	7	9	9	9	7	9
Total	34	42	43	44	41	44

The reason for the behavior of Table 3 shows that the Q and S regions are industrial zones, which had to improve the conditions of their workers, in the sense of protective equipment, labor conditions and regulations, social security for the worker and family, the proximity to the home to the workplace and the salaries and incentives for motivation due to the shortage of specialized labor.

The operational factors evaluated for the regions were: a) The availability of raw materials (ARM). b) Labor (LA). c) Raw material costs (RMC). d) Working conditions and ergonomic factors (WCEF) and e) Access to transport and communications (TCA). The total scores obtained from the alternatives were 46, 46, 45, 45, 40 and 31, with Q and S in first place, followed by G and T, A and D. See detail in Table 4.

The reason for the behavior of Table 4 shows that the Q and S regions are manufacturing industry areas and have taken care of having within reach what is required for their internal and external processes and procedures such as: the quantity and at the moment the supply of raw materials, availability of specialized labor, profitable costs of raw materials, have the working conditions and ergonomic factors to mitigate work accidents and occupational diseases and have control of transport and communication access to the facilities.

The economic factors evaluated for the regions were: a) Logistics transport service costs (LTSC). b) The availability of the investment market and production factors (AIMPF). c) Economic stability (ES). d) Market conditions (MC). e) Public debt (PD) and f) Public security (PS). According to the total rating of the remaining alternatives, the status of Q occupies the first place, followed by G, T, S, A, and D. See detail in Table 5.

Table 4. Qualifications of the alternatives by their operational factors.

Factor	Alternatives					
	D	A	G	S	T	Q
ARM	7	9	9	9	9	9
LA	5	8	9	9	9	9
RMC	7	8	9	9	9	9
WCEF	6	7	9	9	9	9
ATC	6	8	9	10	9	10
Total	31	40	45	46	45	46

Table 5. Ratings of the alternatives by their economic factors.

Factor	Alternatives					
	D	A	G	S	T	Q
LTSC	6	6	6	6	6	6
AIMPF	6	10	10	10	10	10
ES	5	6	7	8	10	9
MC	5	8	9	9	9	10
PS	5	7	9	9	9	10
PD	9	8	7	6	4	5
Total	36	45	48	48	48	50

Table 5 shows that the state of Q is the most industrialized with economic stability, which is why it is possible to mitigate the costs of transport and logistics services due to its infrastructure of communication routes that connects all destinations in the country. This state also has the availability of the investment market and factors of production. It has market conditions in all sectors and its capitalization allows it to be flexible with the inflation outlook and the availability of mortgage debt.

The social factors evaluated for the regions were: a) The population (POP). b) Employment (EMP). c) Poverty (POV). d) Armed conflicts (AC) and e) Pollution (POLL). The total scores obtained from the alternatives were 34, 31, 29, 28, 23 and 21, with Q coming in first place, followed by S, G, T, A and D. See detail in Table 6.

The reason for the behavior of Table 6 shows that the state of Q has public and private investment, which has been concerned with addressing societal problems such as: generating social benefits to the population, generating sources of employment, economic development for reduce poverty, have no armed conflicts and have programs to mitigate pollution levels.

The global ratings of the factors (commercial (CO), labor (LA), operational (OP), economic (EC) and social (SO)) are: 31.65, 39.29, 42.32, 43.45, 42.34 and 44.74. The alternatives to apply are: 1) Q, 2) S, 3) T, 4) G, 5) A and 6) D. See detail in Table 7.

Table 6. Ratings of the alternatives by their social factors.

Factor	Alternatives					
	D	A	G	S	T	Q
POP	5	6	7	9	8	10
EMP	4	5	8	9	7	10
POV	5	7	8	8	7	9
AC	2	0	1	0	1	0
POLLI	5	5	5	5	5	5
Total	21	23	29	31	28	34

Table 7. Weighted and global ratings of the alternatives by their factors.

Factor	Alternatives						
	W	D	A	G	S	T	Q
CO	0.30	31	39	41	43	38	44
LA	0.15	34	42	43	44	50	44
OP	0.12	31	40	45	46	45	46
EC	0.30	36	45	48	48	48	50
SO	0.13	21	23	29	31	28	34
Total	1	31	39	42	43	42	44

Source: Own elaboration, obtained from qualifying team, 2020.

The reason for the behavior of Table 7 shows that it is the place that presents the best conditions for the GCW in terms of commercial, labor, operational, economic and social conditions. It should be noted that the other alternatives with lower scores are not bad options, that is, if option 2 is chosen, 3 in the economic profitability will decrease in percentage terms, but they can still be considered due to some contingency of option 1.

3.2. *Microlocation*

The microlocation determines the municipality in coordinates of the highest profitability and minimum unit cost. The calculation required the WT to select 5 municipalities of the 18 and at the same time specify the real coordinates of the state plan and the existing population (W_i) of each of them.

In the selection of 5 municipalities, the WT considered the criteria of the furthest distances and potential consumption areas, being the following: Jalpa de Serra (JS), Tolimán (TO), Tequisquiapan (TE), Q and Amealco de Bofil (AB) and the population in inhabitants was: 26,902. 28,274. 70.742. 878,931 and 61,259 respectively. The center of gravity method yields the values in Tables 8 and 9.

The factors assigned to the centers of gravity C_{Xi} and C_{Yi} were through converting the physical location of the municipalities from coordinates degrees, minutes and seconds to decimals and are: JS (21° 13' 1" North and 99° 28' 28 West), To (29° 55′ 0.12″ North, 99° 55′ 59.88″ West.), Te (20° 31′ 14″ North, 99° 53' 45″ West), Q (20° 35′ 27.6 ″ North, 100° 23′ 27.6″ West) and AB (20° 9′ 36.94″ North, 100° 6′ 34.49″ West). (Geohack, 2022)

Table 8. Coordinates and population by the center of gravity.

Alternative Places	C_{xi}	C_{yi}	W_i
JS	21.2164	-99.4748	26,902
TO	29.9071	-99.9332	28,274
TE	20.5222	-99.888	70,742
Q	20.5931	-100.392	878,931
AB	20.1881	-100.144	61,259
Total			1,066,108

Source: Own elaboration, obtained from the qualifying team, 2020.

Table 9. Calculation of coordinates by the center of gravity.

Alternative Places	$C_{xi}W_i$	$C_{yi}W_i$
JS	570,764	-2,676,071
TO	845,593	-2,825,511
TE	1,451,781	-7,066,277
Q	18,099,914	-88,237,641
AB	1,236,703	-6,134,721
Total	22,204,755	-106,940,222

Source: Own elaboration, obtained from the qualifying team, 2020.

The results of the center of gravity C_{Xi} and C_{Yi} are represented in sexagesimal degrees, an online calculator (PLANETCALC, 2022) was used for their conversion into degrees, minutes and seconds, considering nine digits for greater precision, see "Eqs. 4 and 5".

$$C_{Xi} = \frac{\sum_{i=1}^{n} C_{Xi} * W_i}{\sum_{i=1}^{n} W_i} = \frac{22{,}204{,}755}{1{,}066{,}108} =$$

$$20.827 \text{ ó } 20°49´40.32" \tag{4}$$

$$C_{Yi} = \frac{\sum_{i=1}^{n} C_{Yi} * W_i}{\sum_{i=1}^{n} W_i} = \frac{-106{,}940{,}222}{1{,}066{,}108} =$$

$$-100.308 \text{ ó } 100°18´32.38" \tag{5}$$

The coordinates for the construction of GCW were obtained in degrees, minutes and seconds (GMS) and decimal and are (20 ° 49'40.32 "to the N, 100 ° 18'32.38" "to the W) or (20.827, -100.308), corresponding to the address of the municipality of Márquez, Q, which complies with the georeferential conditions and accesses for the commercialization of graphite, see in detail in Fig 1.

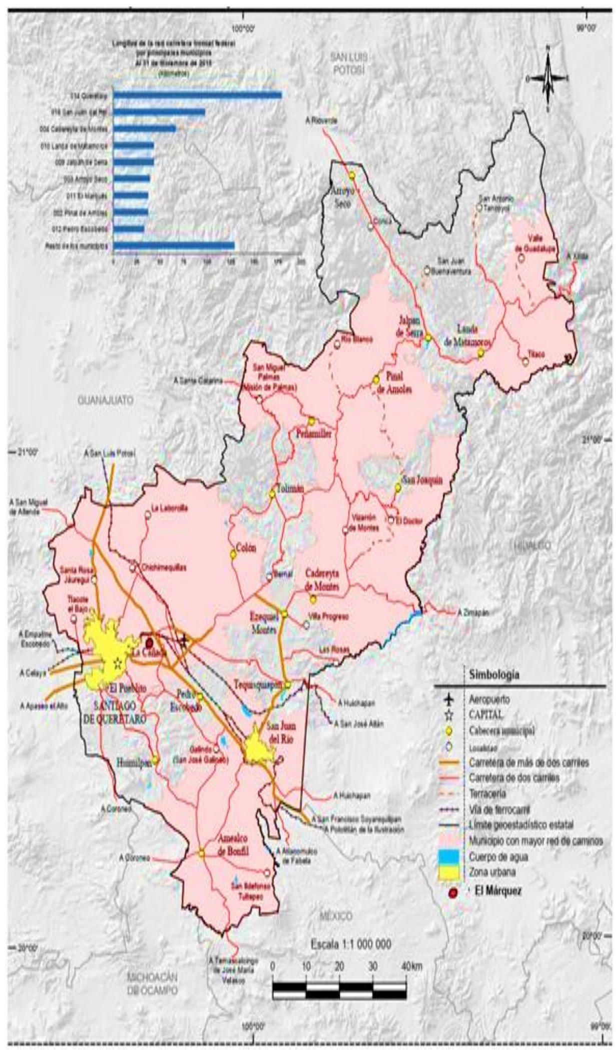

Figure 1. Geographic location of the warehouse.

4. Discussion

The study allowed the application of the selected methodology, except for a modification that was made in the center of gravity method, because by not introducing the real georeference information, the intended place was obtained, but without precision of the location, as mentioned. One of the subsequent studies, considering the above, the objective of the research was achieved. Below are other comparative and baseline studies in which they also applied the methodology and obtained similar results in other needs.

Rodríguez Sánchez et al. (2016) mentions that he founds the location in a study to reassign the population belonging to the family doctor's offices, minimizing the total distance that patients must travel to them. The method used demonstrated easy and quick access to primary care services as a relevant aspect in the effectiveness of the health system and the planning and satisfaction of patients with the service provided with the center of gravity method. The result was the proposal of an improvement to the relocation of the areas according to the distribution of the population assigned to these worst located clinics, minimizing the distance to travel to these services, based on the use of a computer tool.

Dedy Oktrianto and Siswanto (2017), comment in their study that the province of East Java in Indonesia is the second with the largest industry and that in 2016 approximately 549,750 tons of industrial waste were produced, of which around 58% or approximately 320,499 tons are treated. Waste treatment takes place outside the East Java Province. In the case of untreated hazardous waste, it must be kept in a suitable place so as not to pollute the environment. The objective of this investigation is to determine the hazardous waste site in East Java. The method used to select the location is the center of gravity method based on minimum transportation cost. After the selection of the best location, the design of the warehouse and the identification of risks were carried out. The calculation results showed the location with the coordinates (-7.34962; 112.68251). The storage area was 4.94784 hectares. The risk identification was on the following 5 aspects: Fire, Explosion, Reactivity, Environmental health problems and contamination.

Zeferino (2020), He mentioned how he determined the appropriate location of a research institute, which represented a multi-criteria problem that requires a scientific approach for decision-making. The research center intends to carry out state-of-the-art research activities and provide the necessary skills to accelerate and optimize rail car manufacturing in South Africa. Therefore, the selection of a suitable and conducive location capable of effectively achieving these aforementioned objectives is a problem that requires a scientific justification for the allocation of the weights and biases. This objective was achieved by determining the suitability of possible location alternatives using the factor classification technique (FR) and center of gravity (CoG). The CoG revealed that any location within longitude 28.28 and latitude −25.75 (with a Cartesian coordinate position of 5053.62; 2718.69) is suitable for the research institute, while the result from the weighted / FR score matrix revealed that location J3 with a weighted score of 72.6% is the most suitable location for the research institute with a longitude of 5053.62 and a latitude of 2718.69.

Causado-Rodríguez et al. (2018) He mentions in the article that he prepared and that he was able to determine the location of an organization's place of operations through the application of a new method that includes the recalculation of coordinates and qualitative factors, which represent restrictions for its location. Therefore, the location methods are essential when facilitating the location of a productive site, such as the center of gravity method, by which it is possible to find the location of the site for a company; However, this method is 100% quantitative and only takes into account aspects such as demand and location coordinates, of the productive site, it concludes that I achieve the optimal location of the place of operations of an organization.

It is of great importance to design logistics networks considering the logistics costs that minimize the operation through operational strategies in production, storage and distribution of organizations.

Benefits are generated for the graphite sector in the short, medium and long term by having operational and distribution strategies, since it is an essential mineral in several industrial sectors.

The impact of the logistics network lies in several aspects:

- Impact logistics and environmental network contributes to the reduction of transportation costs and in turn reduces the environmental impact generated by the transport of merchandise. In Mexico, public and freight transport causes 80% of the pollution in the country, due to the fact that they use obsolete technology and there are no controls to regulate their emissions. (Leon, 2016)
- Impact on reducing uncertainty in deliveries and delivery management (availability, decision time, cost), customer quality service, logistics distribution costs, reduction of technology problems, use of record backups.
- Economic impact, opening another facility will increase economic growth with the generation of direct and indirect jobs, from 2015 to 2019 there was a loss of 4.8% of jobs in the Mexican mining sector (Servicio Geológico Mexicano, 2020).
- Social impact will generate occupational health and safety, (private) asset security, community development, clean energy, research and development, support for communities.

A new company will generate competitiveness with the 7 existing ones in the commercialization of graphite, benefiting the company-client relationship and costs due to its location in the State of Mexico (two in Tlalnepantla and one in Aculco), Monterrey (Nuevo León), Pachuca (Hidalgo), Puebla, Mexico City (Boletin Industrial, 2022).

5. Conclusions

The objective of the study was fulfilled, it consisted of a) determining the region and municipality where it was proposed to build a GCW, b) bringing the input closer to the market of suppliers in the various northern, central and southern regions and c) reducing the times, costs and a business expansion.

The Q status is the best alternative that allows you to comply with the best conditions favorable to commercial, labor, operational, economic and social factors. Additionally, other alternatives were obtained in case of contingencies.

The coordinates (20 ° 49'40.32 "to the N, 100 ° 18'32.38" "to the W) or (20.827, -100.308)) locate the GCW in El Márquez Q because it meets the conditions of highest profitability and minimum cost unitary.

Conflict of interest

The authors have no conflict of interest to declare.

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