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PROGRAM FOR THE DELIVERY OF BASIC NECESSITIES OF A WAREHOUSE DURING THE COVID-19 PANDEMIC

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Abstract: The purpose of the research is to reduce the logistics costs of a warehouse supplier of products belonging to the primary consumer located in the central area of the State of Veracruz, Mexico. There is an increase in the number of stores to supply due to the quarantine. As a result, its high costs have been negatively affected. Therefore, the project focuses on minimizing the distances travelled in delivering its products, which will reduce costs. From applying vehicle routing with capacity (CVRP), a redesign of delivery routes is carried out weekly, proposing a new weekly delivery schedule of 22 routes and 162 destinations. Whit the CVRP application decreased 23.61% in the distance travelled even with an 8% increase in recipients. Thus, it reflects the fulfilment of the delivery objective to the current stores and those added by the warehouse. The research addresses two problems, first the costs incurred by the warehouse for the delivery of its products. The second is the increase in supply due to the initiative to prevent the spread of the COVID-19 virus, avoid the displacement of long distances to purchase products by the inhabitants and reduce those who attend the stores' Warehouse supplies.

1 Introduction

According to international organizations, all countries worldwide face various emergencies resulting from different risks in terms of scale, complexity, and global consequences. These can have profound political, economic, social, and public health repercussions, and their long-term consequences can sometimes persist for several years. These risks include *a)* infectious disease outbreaks; *b)* chemical and radiation contamination; *c)* armed conflicts; and *d)* consequences of climate change [1,2].

A pandemic is an epidemic disease that extends to many countries and affects almost all members of the region [3]. In Figure 1, the timing of some of the most deadly pandemics throughout history plasma, including the currently known as COVID-19.

541-542 Justinian Plague
1347-1351 Black Death
1520.Smallpox
1866.Cholera in London
1918 -1919 Spanish flu
1957 - 1958 Asian flu
1968 - 1970 Hong Kong flu
1981 – currently HIV
1991 Cholera in Latin America
2004 Avian flu
2019 - currently COVID-19

Figure 1 Chronology of pandemics [4-7]

1.1 SARS-COV-2 Virus

At the end of 2019, the SARS-CoV-2 virus appeared and brought thousands of deaths and changes in society. The SARS-CoV-2 virus is the virus that causes a respiratory disease called coronavirus disease 2019 (COVID-19). It is a virus of the great family of coronaviruses, a type of virus that infects humans. SARS-CoV-2 infection in people was first identified in 2019. This virus is thought to spread from one person to another in droplets dispersed when the infected person coughs, sneezes, or talks. It is also possible to transmit it by touching a surface with the virus and then putting the hands to the mouth, nose, or eyes, although this is less frequent. There are ongoing research studies on treating COVID-19 and preventing SARS-CoV-2 infection. Also called severe acute respiratory syndrome coronavirus type 2 [8].

Many coronaviruses cause respiratory infections, which can range from a simple cold to serious illnesses as the Middle East respiratory syndrome (MERS) and severe acute respiratory syndrome (SARS). Recently, COVID-19 was discovered, an infectious disease caused by a coronavirus; both were unknown until December 2019, when the first outbreak exploded in Wuhan (China). Today, COVID-19 has become a pandemic that has affected many countries in the world [9].

1.2 Impact of the SARS-COV-2 Virus on the word

The statistics classify the countries affected by COVID-19 (SARS-CoV-2) based on the number of confirmed cases as of February 23rd, 2021. China, where the outbreak is believed to have originated, has proved just over 89,800 cases of COVID-19. However, the ranking is led by the United States, with around 28.8 million confirmed positive cases. As for the Old Continent, the 47 European countries have registered infected citizens, highlighting Spain, Russia, the United Kingdom, Italy, and Germany. The first suspected cases were officially announced by the World Health Organization on December 31st, 2019, after the appearance of this new coronavirus about three weeks earlier in one of the markets of the Chinese region of Wuhan, from where it acquired its name [10].

Latin America and the Caribbean are geopolitical regions that include more than 40 countries and territories from Mexico to Cape Horn. It can be subdivided into four areas based on their geographical location: South America, Central America, the Caribbean, and Mexico [11]. Latin America has become the region hardest hit by the COVID-19 pandemic. The economic crisis generated by the outbreak comes with limited progress on social indicators. Unemployment rates have risen dramatically across the region [12]. As of February 22nd, 2021, 20,747,458 cases of COVID-19 have been registered in Latin America and the Caribbean. Brazil is most affected by the pandemic in the region, with around 10.2 million confirmed cases. Colombia is in second place, with more than 2.2 million infected. Mexico, for its part, has registered a total of 2,041,380 patients. Among the countries most affected by the new type of coronavirus in Latin America are also Argentina, Peru, Chile, and Ecuador [13].

The Mexican Republic is divided into 32 states and is home to 126,014,024 people [14]. On February 23rd, 2021, the Ministry of Health presented its daily technical report on the progress of the pandemic caused by the SARS-CoV-2 virus in Mexico, in which it detailed the number of new infections of Covid-19 and the number of deaths is (1) number of confirmed positive cases per day in Mexico: 8,634; (2) number of confirmed deaths per day in Mexico by Covid-19: 1,273; (3) total number of confirmed positive cases in Mexico: 2,052,266, and (4) total number of confirmed deaths in Mexico by Covid-19: 181,809 [15].

The Covid-19 pandemic is not only an unprecedented health emergency, but it is an economic and social emergency, the magnitude and consequences of which are having a dramatic impact on the most vulnerable families. According to recent ECLAC projections, the 5.3% fall in GDP and the 3.4% increase in unemployment in Latin America will generate an increase in poverty by 4.4 percentage points (reaching 34.7% of the regional population), and extreme poverty of 2.6 points (reaching 13.5% of the regional population) and inequality.

Measures must be taken to mitigate the economic impact that the Covid-19 crisis is causing on families and avoid an increase in economic precariousness and vulnerability. International experience shows that, in times of crisis, it is essential that countries have strengthened social protection systems that provide adequate and timely responses to families through economic support measures that reduce the adverse effects on employment and that guarantee access to essential benefits [16].

According to the above, social enterprises play a critical role in supplying necessities to vulnerable people. Said companies are a model of innovative companies, which encourages creating these to help solve a social problem and not maximize profits [17]. The objective of this model is none other than to face the most pressing needs of humanity, especially poverty. Every social enterprise creates employment good working conditions and, naturally, addresses a specific social pathology, such as the lack of schools, health care, and food.

The present research solves a vehicular routing problem with capacity (CVRP) in a Warehouse that supplies stores located in localities belonging to the Las Montañas region of the State of Veracruz. The warehouse presents problems of increase in logistics costs due to a rise in the number of points to supply (distance travelled) and the lack of vehicles for delivery on a new route due to a full delivery schedule. That is why, through the application of the CVRP model, a set of routes are proposed that allow supply to localities located within the region called Las Montañas of the State of Veracruz and at the same time reduce the distances travelled for the delivery of products. by the route and therefore a decrease in the logistics costs of the warehouse, proposing a new aggregate delivery program.

The second section presents the research through which the authors solve the problem of delivery in different parts of the world. Section 3 sets out the contextual framework of the study, which is located in one of the regions of the State of Veracruz, Mexico, called the High Mountains. It presents its municipalities a level of marginalization from medium to very high, a situation that has brought with it the installation of social enterprises, which due to the penetration of the COVID-19 disease in the region, have had to establish strategies for more significant support to the population. In section 4, the methodology to follow is shown, for programming the Capacity Vehicle Routing Problem (CVRP) and the supply of data to it as a solution to the problem of increasing routes of a social warehouse; Section 5 presents the results obtained and their discussion, followed by the authors' conclusions and the bibliography that supports the research.

2 Literature review

Relevant investigations have been carried out on the subject of transportation, among which we can mention the researchers [18], Méndez et al., the present authors' results referring to research carried out on CVRP using commercial software. The first procedure considers alternative restrictions that grow polynomially with nodes and solve the new problem. For the second approach, using a metaheuristic such as the Memetic Algorithms, based on evolutionary computing techniques, focuses primarily on applying to a real problem of infectious waste collection in the city of Rio Cuarto, offering an optimal result based on the two options presented.

In the same area, the researchers [19], Suarez-Chilma, et al. address a vehicle routing problem in mountain cities. The main factor is the topography of the terrain in the mountains. The authors propose a multiobjective mathematical model, which determines a route with an adequate balance between the cost of transport and the environmental impact, concluding with the presentation of the model in a retail distribution channel of an Andean city in Colombia in mountain settings, giving as an answer that the shortest route is not necessarily the best.

Continuing with the investigations, the one carried out by [20], Rocha et al. shows a bibliographic review about the history, typologies, and methods of solving the Vehicle Routing Problem (VRP). Then, explaining the different variations that have arisen, referring to the other primary categories of VRP, the proposed solution methods, and their trends, emphasizing the main methods such as CVRP, concluding with their significant impact on solutions to problems of the big industries.

In Cavallin et al. [21], the research presents the problem of vehicle routing with capacity restrictions (CVRP) to a case of reverse logistics that deals with the collection of recyclable material in an urban environment. To find optimal solutions in reduced instances for this, they establish analytical examples, where the variation of the optimal solutions is shown as a function of the weights used for each objective. Likewise, the researchers [22], Prado-Torres et al. propose solutions close to the optimum concerning vehicle routing problems due to their high complexity according to the number of nodes or clients to minimize operating costs or maximize the number of clients served. With an emphasis on applying Clarke Wright's heuristic routing method, the implemented techniques reveal a lower cost routing to each client.

Researchers [23], Xiao et al. present a study on fuel consumption, which adds to the problem of generating routes for trained vehicles (CVRP) to expand traditional CVRP studies to minimize fuel consumption. They were applying a mathematical optimization model to characterize the FCR considering CVRP (FCVRP) formally. The experiments show a reduction in fuel consumption of 5% on average. Likewise, the researchers [24], González-Hernández et al. present a work based on the problem of vehicle routing trained and the location of a distribution center for a group of clients, the same problem that is solved with two software: Octave and Matlab to make a comparison of speed and reliability of the solution.

Vehicle Routing Problems are a class of problems that study the distribution of goods or services between a warehouse and end-users (customers). The goal of classic VRP is to allow multiple customers to create the lowest possible routes at the lowest cost, starting at the depot and ending [25].

3 Conceptual framework

3.1 Description of the study area

The State of Veracruz is located in the Mexican Republic see Figure 2; it is located along the Gulf of Mexico. It is a coastal strip of 720 km of coastline, representing 6.5% of the national total. With an area of 72,815 km^2, it is the eleventh State of the Mexican Republic in extension and represents 3.7% of the total surface of Mexico [26].

Figure 2 Location of the State of Veracruz [27-28]

Monitoring the panorama of the coronavirus (COVID-19), the Ministry of Health (SS) reports in its emission 316 dated February 8th, 2021, that, in the State of Veracruz, 104,124 cases of contagion have been studied of Covid-19, of which 40,851 were negative. The number of confirmed cumulative cases is 52,355 (+113 new) in 209 municipalities. Forty-one thousand nine hundred ninety-two people recovered outpatient and/or in hospitals, although 3,010 still require medical surveillance. Regarding deaths, there is a record of 7,353 (+ 25 new) in 194 districts and 10,918 suspected of illness [29].

Marginalization is a multidimensional and structural phenomenon originated, ultimately, by the economic production model expressed in the unequal distribution of progress, in the productive structure, and the exclusion of various social groups, both from the process and from the benefits of the developing. Marginalization is associated with the lack of social opportunities and the absence of capacities to acquire or generate them, but also with deprivation and inaccessibility of goods and services essential for well-being. The marginalization index is a summary measure of nine socioeconomic indicators that make it possible to measure forms of social exclusion and that are lag or deficit variables. They indicate the relative level of deprivation in which necessary contingencies of the population are subsumed. Marginalization is divided from its concept to obtaining the index it represents into 1. Education: illiteracy and population without completed primary school; 2. Housing: inhabited private homes without drainage or sanitary service, inhabited private homes without electricity, inhabited private homes without piped water, inhabited private homes with some level of overcrowding, and inhabited private dwellings with dirt floors; 3. Population distribution: localities with less than 5,000 inhabitants, and 4. Monetary income: the employed population that receives up to two minimum wages. The entities are stratified into five groups to identify geographic nuclei with similar marginalization, attributing to each one a degree of marginalization among the five, which are: deficient, low, medium, high, and very high [30,31].

The state of Veracruz is made up of 10 regions: (1) Huasteca Alta; (2) Huasteca Baja; (3) Totonaca; (4) Nautla; (5) Capital; (6) Sotavento; (7) Las Montañas; (8) Papaloapan; (9) Los Tuxtlas, and (10) Olmeca [32,33]. In Table 1, the region and the degree of marginalization with respect to the number of municipalities that make up each is observed:

Table 1 Degree of marginalization by region and number of municipalities in the State of Veracruz [34]

No.	Region	No. Of municipalities	Very high	High	Medium	% very high	% high	% medium
1	Huasteca Alta	15	1	5	9	6.67%	33%	60%
2	Huasteca Low	18	7	9	2	38.89%	50%	11%
3	Totonaca	15	6	5	4	40.00%	33%	27%
4	Del Nautla	11	0	6	5	0.00%	55%	45%
5	Capital	33	4	11	18	12.12%	33%	55%
6	Leeward	12	0	0	12	0.00%	0%	100%
7	Las Montañas	57	17	17	23	29.82%	30%	40%
8	Papaloapan	22	1	2	19	4.55%	9%	86%
9	Los Tuxtlas	4	0	1	3	0.00%	25%	75%
10	Olmeca	25	2	5	18	8.00%	20%	72%

This research will focus on the region of Las Montañas see Figure 3, which is located in the central area of the State of Veracruz, with an area of 6.053 km^2 representing 8.4% of the state territory. Therefore, it occupies the fifth place by its territorial extension. With 1,4 million inhabitants, it covers 18,3% of the state population, which makes it the most populated in the State. The territory of this region comprises 57 municipalities located at the confluence of the Sierra Madre del Sur, the Neovolcanic Axis, and the coastal plain of the South Gulf. The Mountains make up the most significant number of municipalities among the State's ten regions. Due to their territorial size, Tezonapa, Paso del Macho, Comapa, Zongolica, Tlatetela, Carrillo Puerto, Omealca, and Huatusco stand out, representing 41% of the region. Similarly, the National Population Council (CONAPO) lists 17 of the 57 municipalities in the area as very highly marginalized and 17 as highly marginalized [35].

Figure 3. Region of Las Montañas [36].

Because of the above, within the region, there is the presence of so-called -social enterprises that allow a continuous supply of necessities to low-income people and whose localities to be supplied are challenging to access. In this document, a study is carried out of one of these companies, located in Las Montañas region, for confidentiality reasons will be called warehouse from now.

The warehouse is a company dedicated to the wholesale grocery trade. Among the activities carried out are the management of orders, reception, review, and authorization of entry of products, planning and control of inventories, and the planning, scheduling, and consolidating deliveries to 151 stores located in different regional communities.

Within the Montañas region, the COVID 19 pandemic has caused 3,402 suspected cases, 24,690 confirmed cases, and 2,734 deaths to date on March 9th, 2021 [29].

3.2 Problem statement

Because of the presence of the Covid-19 in the region, the program delivery was modified to supply additional areas. It creates a new delivery program with which new delivery routes are generated.

The initial delivery program Warehouse's product supply contemplates making deliveries six days a week every day with approximately 26 points through 5 vehicle units (5 different routes). However, due to the SARS-CoV-2 virus in the region, 11 new delivery points are added, thus giving an aggregate delivery schedule that adds the scheduled and added stores. Which generates an increase in distances travelled, logistics costs, and quantity of products to supply.

Table 2 shows the initial delivery program; in the first column, the day of delivery is reflected, and in the second, the destinations to be supplied on that day. While in Table 3, the areas added to the program are shown, having in the initial program a total of 3,220.80 km travelled, which, added with the new supply points, generate a total of 3,732.80 km.

Table 2. Schedule of initial daily deliveries of the warehouse

No. day	Locations to supply
1	Xopilapa–Acatitla–Apipitzactitla–Tehuipango-Tzompoalecca Dos–Acuayucan-Tepecuitlapa–Tlalchichilco–Axoxohuilco–Tepeica–Tepepa-Teapa Ocomtempa–Tepetlampa-Tzompoalecca 1–Tlacojtepec-Loma Bonita-Barrio Cuarto-Buena Vista–Mixtlantlakpak–Huapango–Opotzinga–Cuauyolotitla-Ojo de Agua–Zacatlaixco–Xonacayolca
2	Choapa–Totolacatla–Tezizapa-San Sebastián–Poxcautla–Independencia-Exohda Tlazololapan–Tlecuaxco–Coxitlitla–Tlanecpaquila–Xochitla-Palenque Cotlaixco–Coeztapotitla-El Campanario–Cotlaixco-Real del Monte-Emiliano Zapata–Teotzacualco- Ayojapa Dos–Xalxocotla–Ocotzocotla-San Francisco Atitla–Ocotepec–Cortezca-La Pila-Nexca Naranjal
3	Mixtla de Altamirano–Ayahululco-Coapa Pinopa–Xochtiitla-Barrio Segundo–Xochitla–Acontla–Tepetitlanapa–Apoxteca–Texhuacán–Acahualco–Tlalca-San Isidro (Apanga)–Cuautlajapa-Tonalixco Grande–Xala–Tecolotla–Atzingo-Tlaxcantla (Ocom)-Tlacuitlapa Chico–Palulca–Ahuacatla-Barrio Tercero-Ocotempa (B 1ª)–Coximalco -Zacatilica
4	Tlacuilolteca-Cortínez-Zomajapa-Xochiaca-Loma de Dolores-Amatepec-Nacaxtla-Comalapa-Linda Estrella-La Palma-Cuahixtlahuac- Palama Sola-Acuapa-Colonia Modelo-Macuilca-El Porvenir-Comalapa II-Tlacuiloltecac Grande-Zacatal Chico-Piedras Blancas-Cerro Chico-La Palma-Citlalapa-Huixtla-Azcuahutlamanca-Quetzaltototl
5	Los Reyes-Atlanca-Atlahuilco-Barrio San Pedro-Ahuatepec-Totolinga-Oxitotitla-Zihuateo-Llano Grande-Tlaquetzaltitla-Pitzcautla-Zincalco-Atlajco Cruz-Mitepecte-Tequila-Tequila Green–Tenexcalco–Ocotempa-Eyitepec-Cuacaballo-Abaloma Cautla–Cubanicuilco-Zacatlamanca
6	Tepepa I-Nepopualco-Moxala-Palapa-Xochiotepec–Ixpaluca-Huaxtcatl Uno-Xonamanca-Zacatal Grande-Atexoxocuapa-Ejuitepec-Loma Grande-Ixmaloyuca-Tlaixco-Tonacalco-Puente Porras-Laguna Chica-Chininiapan-Tecoxco-La Quinta-Laguna-Ixpaluca-Atempa-Ixcohuapa
	Total kilometres: 3,977.50

Table 3. Zones added from the SARS-CoV2 virus

Localities added
El Porvenir-Totolacatla-Los Reyes-Xochiojca-Tepetlampa-Tehuipango-Mixtla de Altamirano-Ejuitepec-Moxala-Tonalixco Grande-Ixpaluca

4 Methodology

Figure 4 presents the methodology used for the investigation, which begins with the compilation of the necessary information to feed the programmed system from the logistic model, followed by the feeding of said system, to later interpret the results.

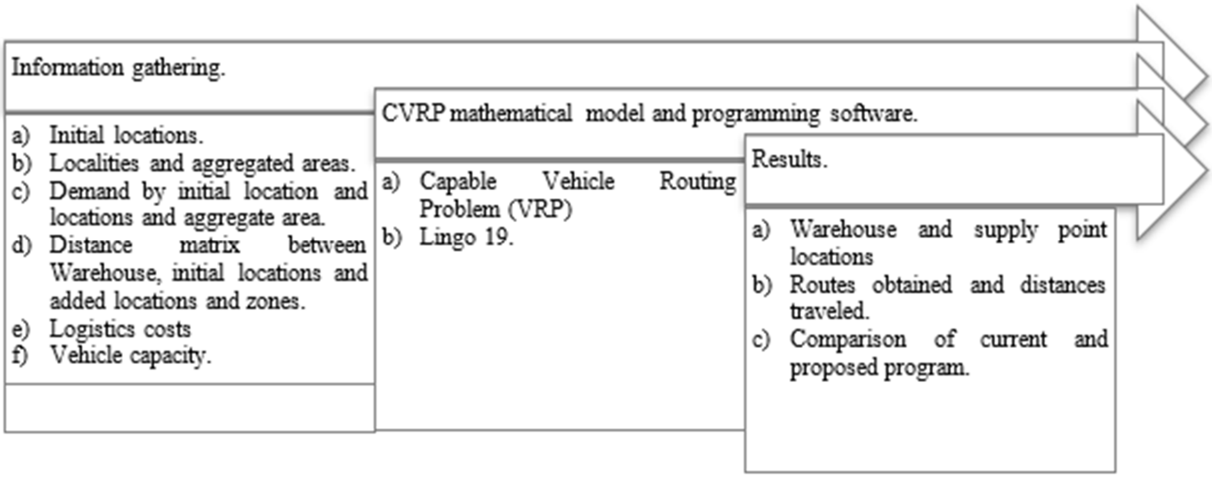


Figure 4 Research methodology

4.1 Information gathering

The database is created that feeds the system from government pages, with information on:

- *Initial locations supplied within the initial Warehouse delivery program*, the number of headquarters locations for a store provided by the warehouse within its initial program add up to 151 sites.
- *Localities and areas in need of supply from the appearance of the SARS-CoV2 coronavirus*, from the presence in the region of the High Mountains of the disease called COVID-19, new 11 supply areas have added a total of 162 new towns and areas to be supplied.
- *Demands*, from the delivery histories of the community stores of the warehouse, the demands are obtained in weekly kilos for each community. Distance matrix between localities and areas to be supplied, a matrix of distances of the localities of initial stores and aggregates is created with the support of the Google Maps® software.
- *Matrix of distances between warehouse*, initial locations, and added locations and areas, a matrix of distances is created between warehouse and locations and areas to be supplied, which will feed the system to obtain delivery routes.
- *Vehicle capacity*, a fixed capacity of approximately 12000 kg, is maintained based on the model and characteristics.

4.2 Mathematical model of Vehicle Routing with Capacity and programming software

A mathematical model for a CVRP aims to design the lowest cost distribution route for a fleet of vehicles located in a distribution center that has to visit a set of customers (nodes). The vehicles belong to a fleet and are located in the distribution center and have a capacity. Each client is located in a geographic region (node) and has a demand. Two components generate distribution costs: a fixed cost associated with each truck required for the planning horizon and a variable cost per unit of distance travelled. Each route starts from the warehouse and ends there, and the vehicle's capacity should not be overloaded [37-41].

According to Kir et al. [41], the general model for a CVRP is:

$$Min\ Z = \sum_{i=1}^{N} \sum_{j=1, j\neq i}^{N} c_{ij}x_{ij} \quad (1)$$

Subject to:

$$\sum_{l=2, k\neq 1}^{N} x_{lk} + x_{1k} = 1 \quad \forall k \quad (2)$$

$$\sum_{l=2, k\neq 1}^{N} x_{kl} + x_{k1} = 1 \quad \forall k \quad (3)$$

$$\sum_{k=2}^{N} x_{1k} \leq V \quad (4)$$

$$\sum_{j=1, j\neq i}^{N} x_{ij} = \sum_{j=1, j\neq i}^{N} x_{ji} \quad \forall k \quad (5)$$

$$x_{kk} = 0 \quad \forall k \quad (6)$$

$$x_{lk} + x_{kl} = 1 \quad \forall k, l_{k\neq 1} \quad (7)$$

$$\sum_{j=1, j\neq i}^{N} F_{ij} = \sum_{j=1, j\neq i}^{N} F_{ji} + d_i \quad \forall k \quad (8)$$

$$d_i x_{ij} \leq + f_{ij} \quad \forall i, j_{i\neq j} \quad (9)$$

$$F_{ij} \leq (A - d_j)x_{ij} \quad \forall i, j_{i\neq j} \quad (10)$$

Where
A: Capacity of each vehicle.
V: Maximum number of vehicles.
F_{ij}: Product flow from node a.
Z: Total cost of transportation.
d_i: Demand at the node.
c_{ij}: Cost of travelling the distance from the node to node.
N: Number of nodes.

Equation (1) represents the objective function, which minimizes the total costs of all arcs route obtained solution. *Equations (2)* and *(3)* indicate precisely one output node i. *Equation (4)* provides not exceed the total number of vehicles. *Equation (5)* provides a balance between incoming and outgoing arcs at a given node. *Equation (6)* eliminates the flow of node i to node i. *Equation (7)* is a trivial restriction removal sub-tour. *Equations (8), (9),* and *(10)* provide a balance between the total input and output flow in the node.

Programming software.
The LINGO 19.0 software was used to carry out the CVRP programming, allowing building and solving models easily, quickly, and efficiently [42].

5 Result and discussion

With 22 routes obtained distributed over five days a week, a 26% decrease in the routes was achieved. Tables 4 and 5 show five delivery routes, the kilometres travelled, and the kilos of products supplied by said routes.

Table 4 Route 1 and Route 2

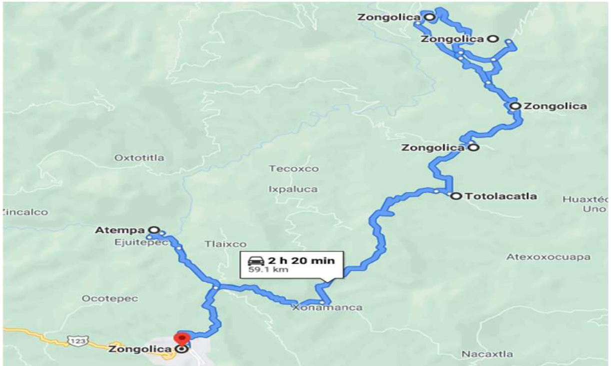
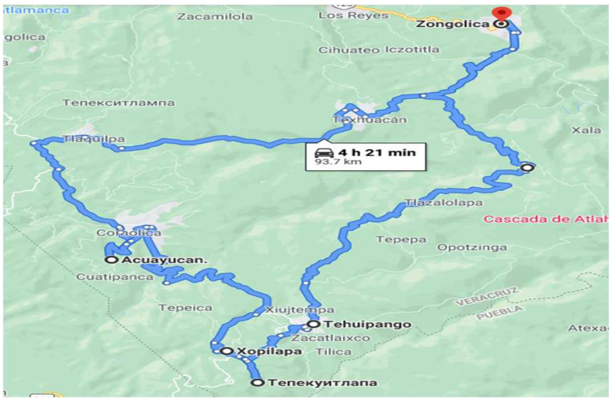
<table>
<tr><td rowspan="3">Route 1</td><td colspan="4">Destination</td><td>Km</td><td>Kg.</td></tr>
<tr><td>Totolacatla</td><td>Totolacatla</td><td>San Sebastian</td><td>Tlanecpaquila</td><td rowspan="2">59.1</td><td rowspan="2">10,700</td></tr>
<tr><td colspan="2">Coeztapotitla</td><td>Cotlaixco</td><td>Atempa</td></tr>
<tr><td></td><td colspan="6">
</td></tr>
<tr><td rowspan="3">Route 2</td><td colspan="4">Destination</td><td>Km</td><td>Kg.</td></tr>
<tr><td>Acuayucan</td><td>Xopilapa</td><td>Tepecuitlapa</td><td>Tzompoalecca 1</td><td rowspan="2">93.7</td><td rowspan="2">11,300</td></tr>
<tr><td>Tlacojtepec</td><td>Coximalco</td><td>Axoxohuilco</td><td>Mixtla Altamirano</td></tr>
<tr><td></td><td colspan="6">
</td></tr>
</table>

Table 5 Route 3, Route 4, and Route 5

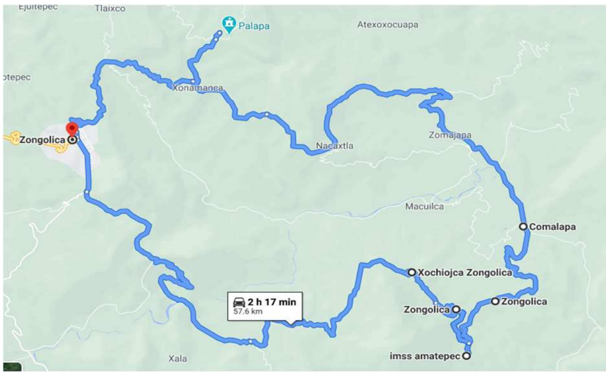
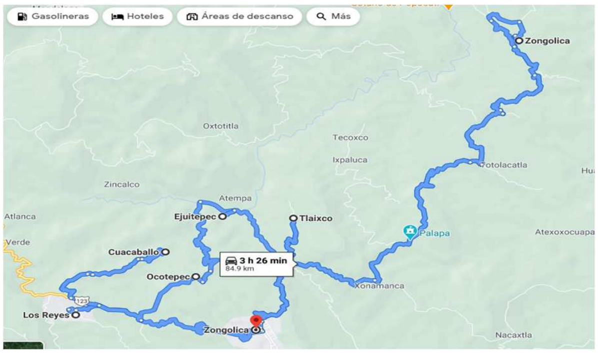
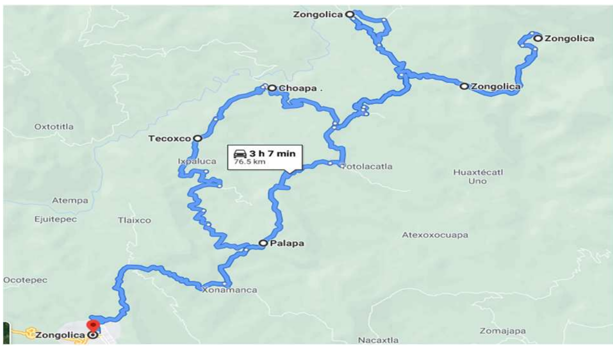
<table>
<tr><td rowspan="3">Route 3</td><td colspan="4">Destinations</td><td>Km</td><td>Kg.</td></tr>
<tr><td>Xochiojca</td><td>Amatepec</td><td>La Palma</td><td>El porvenir</td><td rowspan="2">57.6</td><td rowspan="2">10,300</td></tr>
<tr><td colspan="2">El Porvenir</td><td>Comalapa</td><td>Zongolica</td></tr>
<tr><td colspan="7">
</td></tr>
<tr><td rowspan="2">Route 4</td><td>Los Reyes</td><td>Los Reyes</td><td>Cuacaballo</td><td>Ocotepec</td><td rowspan="2">84.9</td><td rowspan="2">12,000</td></tr>
<tr><td>Ejuitepec</td><td>Ejuitepec</td><td>Emiliano Zapata</td><td>Tlaixco</td></tr>
<tr><td colspan="7">
</td></tr>
<tr><td rowspan="2">Route 5</td><td>Palapa</td><td>Zacatal Grande</td><td>Tecoxco</td><td>Choapa</td><td>76.5</td><td>9,500</td></tr>
<tr><td>Independencia</td><td colspan="2">La pila</td><td>Real del Monte</td><td></td><td></td></tr>
<tr><td colspan="7">
</td></tr>
</table>

Table 6 compares the results obtained between the initial delivery program and the aggregate delivery program. It should be remembered that, within the first, there are a total of 151 supply points, distributed in 5 different routes each day during six days of the week, while the second has a total of 162 delivery points spread over a range of 4 and 5 different routes every day for five days of the week.

More specifically, column one presents the day of the week on which the products are delivered to the points already set by the Warehouse; Columns two, three, and four refer to how the deliveries were carried out before running the model, that is, the initial program, while columns five, six and seven present the routes proposed through the application. CVRP and the increase in routes due to the pandemic, that is, the added program. These columns are described in detail below: (a) Column 2 and 5: show the number of routes to which the supply points for that day correspond; (b) Column 3 and 6: refer to the distance travelled to supply the points contained in the routes, and (c) Column 4 and 7: show the number of kilograms of product to be delivered, it should be mentioned that the capacity of delivery is measured in kilos. The last row or row of totals shows the sums of the columns of "total distance" and "total demand" to make a comparison and obtain a percentage of improvement. There is a decrease of 23.61% in the distance travelled, even with an 8% increase in the number of recipients and just over 19.84% in demand. Therefore, an improvement in the aggregate delivery program is established through a decrease in distance and a decrease in the company's logistics costs, and greater customer satisfaction.

Table 6 Comparison of distance and delivered demand

Comparison		Initial program		Aggregate program		
Day	Routes	Total distance (km)	Total demand (kg)	Routes to travel	Total distance (km)	Total demand (kg)
1	1,2,3,4,5	647.40	36,300	1, 2,3,4,5	433.15	57.800
2	6,7,8,9,10	713.50	41,200	6,7,8,9,10	534.55	59,750
3	11,12,13,14,15	539.40	43,400	11,12,13, 14	472.20	59,800
4	16,17,18,19,20	387.00	44,200	15,16,17,18	493.60	60,300
5	21,22,23,24,25	553.10	42,350	19,20,21,22	526.90	57,900
6	25,27, 28,29,30	380.40	39,100			
Totals		3,220.80	246,550		2,460.40	295,550

6 Conclusions

The decrease in logistics costs is one of the challenges currently facing organizations, even more so, if they are providers of areas with a certain degree of marginalization, that is why the purpose of the research presented is to decrease the distances travelled by a Warehouse located in the central area of the State of Veracruz, Mexico. The initial delivery program supplies 151 destinations, but due to the virus in the region, 11 goals were increased; with the delivery schedule and the five vehicles that the company has, the supply was complicated.

The importance of this case study lies in the fact that, although the social activity is carried out all over the world, and there are many case studies carried out in private companies, in the social sphere, it is lacking. Hence, being of vital importance a reduction of costs, independently in the area of the organization in which it is present, which will allow more significant support to people who for any reason need it.

Based on the application of the CVRP, a redesign of delivery routes is carried out weekly. Proposing a new weekly delivery schedule added with 11 destinations and 22 routes spread throughout the week, which resulted in a decrease in the distance travelled, of 23.61% even with an 8% increase in the number of recipients and a little more than 19.84% in demand, thus establishing an improvement in the aggregate program, through a decrease in distance and therefore a reduction in the company's logistics costs and greater customer satisfaction.

As can be seen, the percentage of decrease in distance traveled is essential; this is because the distribution strategy is not carried out empirically. The CVRP programming facilitates the grouping of nearby points to supply products without leaving aside from the homogeneous vehicle capacity.

The future works are the application of a vehicular routing with time windows that ensure the vehicles accomplish during a mixed working day and with a heterogeneous fleet of vehicles due to the characteristics of the geographical area in which the products are delivered. On the other hand, establish inventory levels for each product according to their demand.

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