

MAKING LOGISTICS DECISIONS USING INFORMATION FROM FLP P-MEDIAN AND QGIS

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Abstract: The objective of this article was to conduct a literature review on the use of the FLP p-median technique and the QGIS software for aiding logistics decision-making. A qualitative and exploratory approach was employed through literature review. The studies revealed that the combination of the FLP p-median technique and the QGIS software provides organizations with a strategic approach to assist in decision-making regarding facility location, integration of transportation modes, reduction of operational costs, minimization of environmental impacts, and improvement of service levels.

Keywords: Facility Location Problem; P-median; QGIS; Logistics.

TOMADA DE DECISÕES LOGÍSTICA COM O USO DE INFORMAÇÕES DE FLP P-MEDIANA E QGIS

Resumo: O objetivo deste artigo foi realizar um levantamento bibliográfico sobre o uso da técnica de FLP p-mediana e do software QGIS para auxílio na tomada de decisões logísticas. Foi utilizada uma abordagem qualitativa, de caráter exploratório, por meio de revisão da literatura. Nos estudos, foi possível entender que a combinação da técnica FLP p-mediana e do software QGIS oferecem às organizações uma abordagem estratégica para auxiliar na tomada de decisão quanto à localização de instalações, integração entre os modais de transporte, redução dos custos operacionais, minimização dos impactos ambientais e aumento do nível de serviço.

Palavras-chave: Facility Location Problem; P-mediana; QGIS; Logistics.

1. INTRODUCTION

With the increasingly competitive market for goods and services, it is necessary to integrate transport modes in order to reduce costs, environmental impacts and congestion [1]. In this way, the supply chain needs to be ready to meet the growing demand that comes from the increase in commercial transactions and with the installation of a logistics hub to reduce the time taken to respond to customer orders [2].

Decision-making regarding the location of the logistics hub has often been studied in the literature [3], [6] and [5]. Thus, a hub that aims to integrate, for example,

the road and rail modes tends to increase its efficiency because of the amount of cargo that is transported at once through the rail mode [7].

One of the FLP techniques well known in several academic works is the p-median [7], [4], [1], [8] and [9]. According to the FLP technique, this study raises information about the free software QGIS (Quantum GIS) Geographic Information System (GIS) that allows the visualization, analysis and processing of geographic data [10].

Thus, this work seeks, through studies, to answer the following problem: how can the p-median FLP technique and the use of QGIS help companies in making logistical decisions? Thus, the general objective of this is to carry out a bibliographical survey on the use of the p-median FLP and QGIS technique to assist in the logistics decision making of companies.

This article presents in section 1.1 a theoretical framework with an overview of logistics, as well as the p-median FLP technique and QGIS. In section 2 the methodology used, in section 3 the results and discussions, in section 4 the final considerations and section 5 are the references used.

1.1 Logistics

Logistics can be understood as the management of material, financial, people and information flows from the point of origin to the destination point, seeking to meet customer expectations. Commonly in the literature it is treated as the process of planning, implementing and controlling the flow of storage, services and associated information from the point of origin to the destination, seeking to meet the expectations of customers at a correct cost [11].

With the consumer market increasingly demanding due to the reduction of delivery times, as well as freight costs, logistics plays a fundamental role in companies in terms of loading and unloading of materials, checking, sorting, inventory, shipping, routing, delivery and collection of cargo, all with the aim of meeting customer requirements [12].

1.1.1 FLP p-median

The Facility Location Problem (FLP) with p-median is a mathematical optimization technique that can be applied in logistical problems, especially when it comes to determining the strategic location of installations in a distribution network, because through the technique it is possible to find the location optimal use of a set of facilities, considering the minimization of distances between facilities and customers/demand points, which is essential to reduce transportation costs and respond efficiently to customers [13] and [14].

The P-Median technique seeks, through a mathematical model, to find a set of points, known as medians, that minimize the sum of the weighted distances between

them and the demand points. The choice of mathematical model depends on the specificity and size of the problem, data availability, specific restrictions, optimization objectives (minimize costs, distances or maximize profit and number of deliveries, for example) and computational resolution capacity [15]. P-median, after the studies of [16] became a popular method in the literature for location problems, an example of a mathematical model of p-median is:

$$y_i = \begin{cases} 1, & \text{whether the facility is open on site } i \\ 0, & \text{opposite case} \end{cases}$$

There is the optimization model:

Table 1: P-median optimization model

Objective function	$\sum_{i \in I} \sum_{j \in J} c_{ij} x_{ij}$ (1)
Restrictions	$\sum_{i \in I} x_{ij} = 1, \forall j \in J$ (2)
Restrictions	$x_{ij} \leq y_i, \forall i \in I, \forall j \in J$ (3)
Restrictions	$\sum_{i \in I} y_i = p$ (4)
Restrictions	$x \in B^{ I \cdot J }, y \in B^{ I }$ (5)

Source: Authors (2023)

The objective function (1) minimizes the total cost of the operation. Constraints (2) ensure that each customer j is served by a single facility, while constraints (3) ensure that each customer j can only be assigned to an open facility at location i . Constraint (4) indicates that exactly p facilities are open, and constraint (5) represents the type of variables.

This article is not based on the application of p-median mathematical formulas, but on the collection of academic information on the importance of its use. In this sense, a company applying the technique will be able, according to [17], to make strategic decisions about opening or closing facilities, reallocating resources, planning the distribution network to better meet its demands, consolidating cargo flows and the implementation of multimodal strategies, such as the integration between road, rail and water transport.

1.1.1.1 QGIS

QGIS (Quantum Geographic Information System) is a free and open source Geographic Information System (GIS) software that allows the visualization, analysis and processing of geographic data [10]. QGIS is a tool widely used in territorial planning studies, as it enables the integration and analysis of geographic data with various other information, allowing the creation of thematic maps, the generation of spatial models and the analysis of spatial patterns.

Thus, one of the main advantages of QGIS for logistical decision-making is its ability to integrate and analyze spatial data, in addition to the results derived from

the application of the p-median FLP technique, information on transport routes, location of facilities, distribution zones, geographic characteristics of each region (states, cities and neighborhoods) [18].

With this data, logistics managers can identify the best routes, optimize distribution network planning, consider geographic factors and make strategic decisions to achieve competitive advantage.

2. METHODOLOGY

The approach of this research is quantitative, because from the use of the following descriptors: “facility AND location AND problem”; “p-median AND logistic AND hub OR facility AND location” and “logistical AND decisions AND QGIS”. From the elaboration of the descriptors, the Scopus scientific search platform was used, thus identifying the works related to the object of study through filters such as keywords, area of knowledge, with a time interval between 2017 and 2022 and the most cited, according to table 2 below:

Table 02: Main works found with the descriptors on the Scopus platform

Document title	Authors	Citations
A genetic algorithm approach for location-inventory-routing problem with perishable products	Hiassat, A., Diabat, A., Rahwan, I.	216
Application of hierarchical facility location problem for optimization of a drone delivery system: a case study of Amazon prime air in the city of San Francisco	Shavarani, S.M., Nejad, M.G., Rismanchian, F., Izbirak, G.	123
Hybrid manufacturing – integrating traditional manufacturers with additive manufacturing (AM) supply chain	Strong, D., Kay, M., Conner, B., Wakefield, T., Manogharan, G.	86
Location selection of intra-city distribution hubs in the metro-integrated logistics system	Zhao, L., Li, H., Li, M., ...Li, J., Xue, J.	64
Analyzing the location of city logistics centers in Istanbul by integrating Geographic Information Systems with Binary Particle Swarm Optimization algorithm	Çakmak, E., Önden, İ., Acar, A.Z., Eldemir, F.	16

Source: Authors (2023)

Regarding the nature, this research has a theoretical character to generate discussions and the deepening of the theme. Other authors and works were used from searches on the Google Scholar platform, using the theme of FLP with p-median, in order to compose the framework of studies in the composition of this article.

Furthermore, the character of this research regarding its objective and knowledge of the problem is exploratory, as it involved a bibliographical survey, quantitatively measuring the scientific production regarding the theme [19] and [20].

3. RESULTS AND DISCUSSION

In order to answer the central problem of this research (how can the p-median FLP technique and the use of QGIS help companies in logistical decision-making?) p-median and QGIS to help companies make logistical decisions) used a bibliographical survey, with studies related to the importance of its use.

Thus, table 3 below shows the main authors used, as well as the methodology and the relationship with the importance of the p-median technique and QGIS.

Table 3: Main authors used and related themes

Authors	Methodology	Importance of technique	Methods used	Synthesis
Hiassat, A., Diabat, A., Rahwan, I. [13]	Development and application of a model	Supply chain decisions	Combination of algorithms	The model determines the number and location of warehouses needed, the stock level at each retailer, and the routes taken by each vehicle.
Shavarani, S.M., Nejad, M.G., Rismanchian, F., Izbirak, G. [14]	Development and application of a model	Sustainable network, supply chain and decisions	Combination of algorithms	Heuristic algorithms are proposed as a solution method
Strong, D., Kay, M., Conner, B., Wakefield, T., Manogharan, G. [3]	Development and application of a model	Supply chain decisions	Combination of algorithms	An uncapacitated facility location model is used to determine the optimal locations for AM hub
Zhao, L., Li, H., Li, M., ...Li, J., Xue, J. [1]	Case study, development and application of a model	Supply chain decisions	Combination of algorithms	A mathematical model was formulated to locate metropolitan distribution centers from the candidate distribution centers
Çakmak, E., Önden, İ., Acar, A.Z., Eldemir, F. [2]	Case study, spatial analysis, development and application of a model	Supply chain decisions	Combination of algorithms	The optimal clustering of logistics mobility in a metropolitan area was carried out with GIS and a meta-heuristic approach
Franco, D.G.D.B., Steiner, M.T.A., Assef, F.M. [5]	Case study, spatial analysis, development and application of a model	Waste management and logistical decisions	Combination of algorithms	propose a model of territorial partitioning that does not depend on extra restrictions to maintain contiguous clusters.

Source: Authors (2023)

After the bibliographic survey, it was possible to perceive that it is necessary for companies that wish to make the right decision to use techniques that promote assertiveness. Thus, the example of technique used in this work (FLP with p-median), provides organizations with information regarding the decision on the location of factories, distribution center, how to trace an optimal route, possibility of integration between modes of transport and proximity to consumption points. However, the

objective of this work was not the application of the technique, but the bibliographic survey from the point of view of its importance for companies that wish to decide for a better positioning of their production plants and places for the disposal of materials.

4. CONCLUSION

The present paper studied from the literature survey, how the p-median FLP technique and the use of QGIS software can assist companies in making logistics decisions regarding the location of factories and logistics hubs, integration between modes of transportation (to reduce costs, environmental impacts, and congestion), increased level of service, especially with the growing demand driven by commercial transactions.

It is worth pointing out that this research has limitations in terms of the number of descriptors and search platforms used (only two), which may limit the breadth of available sources; furthermore, it was based mainly on theoretical/academic sources and case studies of the researched works.

Thus, it is recommended that future research consider the inclusion of interviews with professionals in the area to enrich the analysis of the characteristics of the p-median FLP technique with the use of QGIS; approach of other techniques/tools to increase efficiency in the decision making process of companies; the use of computer simulation applied to logistics problems; study software that can be used to help in the logistic decision making process regarding the installation of hubs, calculation of alternative routes, indication of multimodal integration, among others.

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