Perspectives on Last Mile Logistics: A Sustainable Approach

Mauricio Dávila-Granda, Andy Pedraza-La-Barrera, Alberto Flores-Perez, Juan Quiroz-Flores,
Martin Collao-Diaz
Facultad de Ingeniería y Arquitectura, Universidad de Lima, Lima, Perú
20161933@aloe.ulima.edu.pe, 20071741@aloe.ulima.edu.pe,
alflores@ulima.edu.pe, mcollao@ulima.edu.pe, jcquiroz@ulima.edu.pe

Abstract

Gradually the urban freight transport to final consumers is gaining relevance worldwide, with a rapid adoption stimulated also by the global health crisis. This also brings to the attention of the world interest regarding its carbon footprint and sustainability; therefore, our objective is to present a review on the diverse ways in which it is proposed to lessen the impact of last mile logistics. For this, a systematic literature review was conducted, using the prism method and the VOS Viewer literature analysis tools. The analysis found a growing interest in the subject, along with proposals in every aspect of the logistics process. The main concern is the actual transportation of the items and the preferred measures to ensure sustainability were the proposals for alternative vehicles, which proved to have the greatest effectiveness in the sustainable development of logistics activities.

Keywords
Last mile logistics (LML), sustainability, delivery, urban transport, freight, and environment.

1. Introduction
Due to recent worldwide events, last mile logistics has had received a great boost due to the massive adoption of e-commerce, as Gee et al. (2021) indicates, retail is reporting increases in online sales of up to 500%, since online sales represent a safer alternative in the face of the global public health crisis. This situation has forced retailers to implement home delivery as part of their processes to remain competitive. In face of these changes, we believe that it is appropriate not only to consider the economic side on their implementation, but also their sustainability, since a good business model must consider its stability over time.

This article is a literature review on the different mechanisms, proposals, and perspectives to address sustainability in the management of last mile logistics' (LML) processes. Edwards et al. (2010), supported the idea that there is no significant difference between the methods offered by e-commerce, compared to the traditional method of purchase in a physical store, but since the delivery process is no longer in the hands of the consumer but managed by the businesses themselves, opening the door for methods standardization. M. Staniek and G. Sierpiński (2016) proposed the use of alternative means of transportation, such as electric vehicles to minimize emissions, as well as route improvements, different applications of crowdsourced logistics, as a method of improvement in LML, which would have a good impact on its sustainability.

1.1. Last Mile Logistics (LML)
According to B. Huang et al. (2021), last mile logistics is the most critical component within the growing e-commerce industry and must respond to various problems presented by its demand, such as balancing high variety of products and optimizing the movement of low volumes of products per order, where one of the most crucial elements is time. It is this set of elements that we will be engaging in our research, in short, it is mostly the B2C (business-to-consumer) environment, where a business has the responsibility of getting the product or service to the end consumer, as opposed to traditional purchasing. This process has the potential to eliminate venue costs, as the customer no longer has the need to go to a specific location to obtain their products.

1.2. Environmental Sustainability

Galati et al. (2021) define environmental sustainability as the ability of a process or activity to be conducted continuously over time without depleting the resources it consumes or destroying the environment where the activity is performed. In this case, we are not talking about sustainability of the entire chain, but only in the processes related to last mile logistics, the aim is that society can continue to enjoy this service despite the passage of time, and that this service is not to blame for the loss of other resources. These resources mostly revolve around the origins of the energy required to meet market demand.

1.3. Objectives

The objective of this study is to identify LML implementation alternatives that, in addition to maintaining the organization's competitiveness, can maintain a minimum environmental impact, making these processes sustainable over time.

Q1. What are the main obstacles to LML?
Q2. What are the main strategies to ensure sustainability in LML?
Q3. What prevents management to implement sustainable LML strategies?
Q4. What is the preferred approach to sustainable LML among the authors?
Q5. What policies promote the use of sustainable activities within LML?

2. Methods

According to Lee et al. (2019), to develop the systematic review methodology, we will rely on the PRISMA method (Preferred Reporting Items for Systematic reviews and Meta-Analyses) for this we will follow the following steps recommended by the Cochrane system (Figure 1):

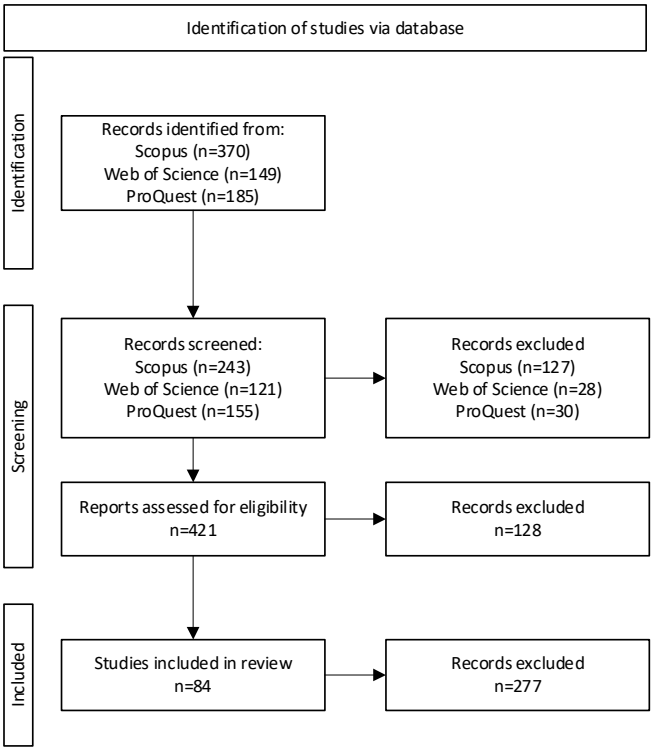

Figure 1. Articles identified by PRISMA method

2.1. Search

The identification of articles was conducted through a search in Scopus, Web of Science and Proquest repositories. In which two key terms were used, "Last Mile Logistics" and "Sustainability" along with words derived from these, in addition, this search will be restricted to only scientific articles.

Key terms were used in conjunction with the Boolean logical operators "AND" and "OR". The "AND" connector was used in the inclusion of both key terms, as in the expression "Last Mile Logistics AND Sustainability", since the items must contain both terms to be selected". It also indicates that: "The operator "OR" was used to give alternatives to each of the key terms, since we do not want to exclude an article that refers to the topic we are looking for by not using the same terminology, as the use of this connector can be observed in the following expression "Sustainability OR Sustainable". The terms were searched in all the metadata fields of the articles, this includes fields such as Title and Abstract, specified in some search managers with the term "ALL" in the search fields of the repositories (Table 1).

Table 1. Search Results by Repository

Repository	Search Syntax	Results
SCOPUS	ALL ("Last Mile Logistics") AND ALL ("Sustainability")	370
Web of Science	ALL= (Last Mile Logistics) AND ALL=(Sustainability)	149
ProQuest	("Last Mile Logistics") AND (Sustainability)	185

In this direct search, 627 articles were found in a first search, and after filtering out repeated articles, the number of articles found under this search method was 508 articles.

2.2. Evaluation

After the raw collection of articles, it is necessary to establish exclusion criteria. Articles were excluded if they did not meet any of these criteria:

- It must have been published in English or Spanish.
- It must have been peer-reviewed at least once.
- It must have been published in the last 10 years (2011-2021).

These filters were conducted through the search tools of the same repositories.

Selection of articles from the last 10 years, which are not by retailers and are in relation to the implementation of new strategies for last mile logistics. Selected articles will be reviewed based on reading their abstracts. Despite containing the keywords from our search, many of the articles do not focus on that topic, simply mentioning the words without delving into the subject matter. We are left with papers that have focus on the research topic. We also eliminated in this step all documents that are not articles published in scientific journals, i.e., we eliminated books as well as graduate or postgraduate theses, among others.

After this process, 421 articles were selected.

2.3. Inclusion

As a last step, the articles' abstracts are observed to determine their relevance to this review. According to the following criteria:

- Focused on urban areas.
- Focused on local deliveries.
- Contains proposals relevant to the research topic.

There is a possibility that despite carrying the search keywords, the articles in our repertoire do not align to the research topic, so it will be necessary to examine the abstracts to be sure.

After this process, eighty-four articles were included in this literature review.

3. Results

Diverse types of analysis were made of the articles obtained, both of their bibliographic information and of their content and proposals for improvement.

3.1. Bibliometric Analysis

For a first analysis, we used the VOS Viewer tool, where we entered both the bibliographic values and the abstracts obtained. In the first instance, a comparison was made in authorship, comparing the co-authorship of the articles (Figure 2).

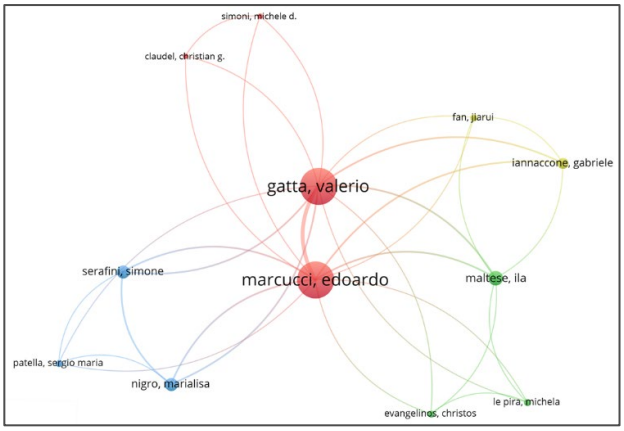

Figure 2. Graph of co-authorship relationships between authors

From this graph the major contributors are Marcucci (6 entries), and Valerio (6 entries), and most of the other authors have collaborated with them. Continuing with the analysis, we proceeded to count the use of terms in the articles, limiting ourselves to words or phrases that were used in the articles, VOS Viewer generated the network and the map shown in figure 3 and figure 4.

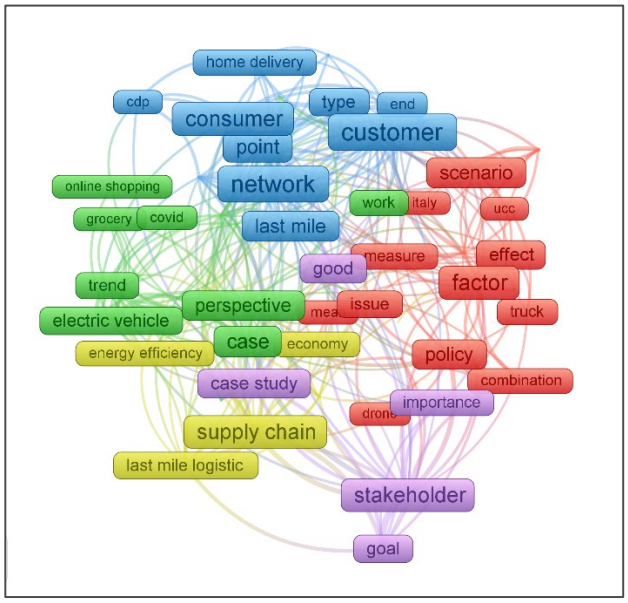

Figure 3. Keyword network graph of the articles

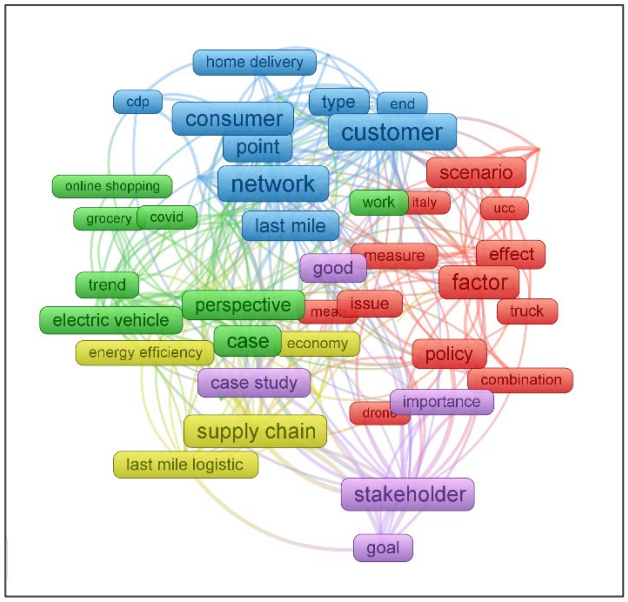

Figure 4. Graph of keyword density of the articles

In this case, we can observe that both key search terms and their derivatives are interrelated with the rest of the relevant terms of the articles included in the study, showing their relevance in this document (Figure 5).

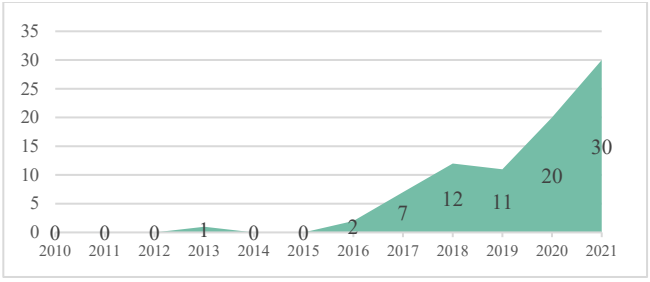

Figure 5. Graph of number of publications per year

It is inevitable to note the increased interest in the subject in recent years, which gives us an optimistic outlook for the future of this area, as interest is clearly on the rise (Figure 6).

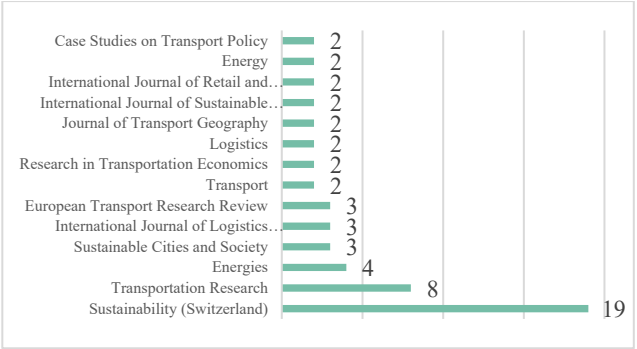

Figure 6. Graph of number of publications per journal

Clearly, we can see that the journal with the largest contributions on the subject was "Sustainability (Switzerland)", from which we have identified 19 relevant articles on the subject over the last 10 years. To diversify our observations, the IBM SPSS Statistics software was used to, after setting up variables, analyse the relevance of these within the selected articles. To begin the process, the articles were ordered in ascending order according to the year of publication, and a numbering was assigned to the observation variables. Once the score of each article was obtained according to each question, a descriptive graph was made through frequency tables showing the result of how many articles talk about that answer according to each objectives' questions, each graph is in each section of the article according to its relevance in the observations made.

3.2. LML obstacles

In this case, transportation was the most frequent obstacle considered (25% corresponding to 21 items) (Figure 7).

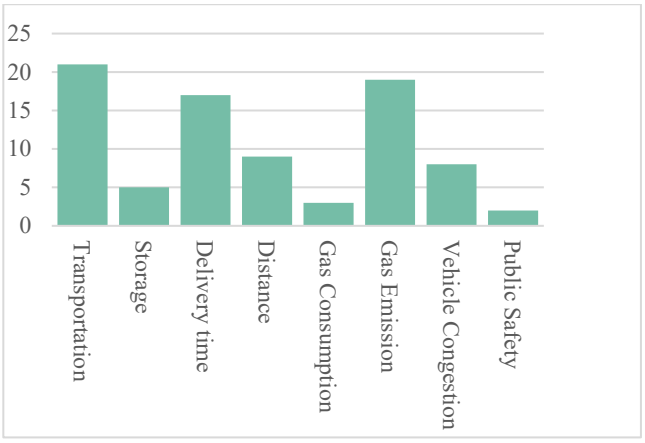

Figure 7. Bar Chart of LML Obstacles

Table 2. Frequency Chart of LML obstacles

Obstacles	Frequency	Percentage
Transportation	21	25.0
Storage	5	6.0
Delivery time	17	20.2
Distance	9	10.7
Gas Consumption	3	3.6
Gas Emission	19	22.6
Vehicle Congestion	8	9.5
Public Safety	2	2.4
TOTAL	84	100

The second most representative obstacle within the articles are the problems related to gas emissions, which represent 22.6% of the mentions in the articles. We can appreciate that gas consumption (3.6%) and public safety (2.4%) are the least concerning topics on the matter (Table 2).

3.3. Improvement proposals for LML

It is clearly observed that the use of alternative digital technologies (e.g. e-commerce, logistics analysis software) was one of the most frequent proposals (32.1% corresponding to 27 items), followed by the use of alternative transportation (31% corresponding to 26 items) (Figure 8, table 3).

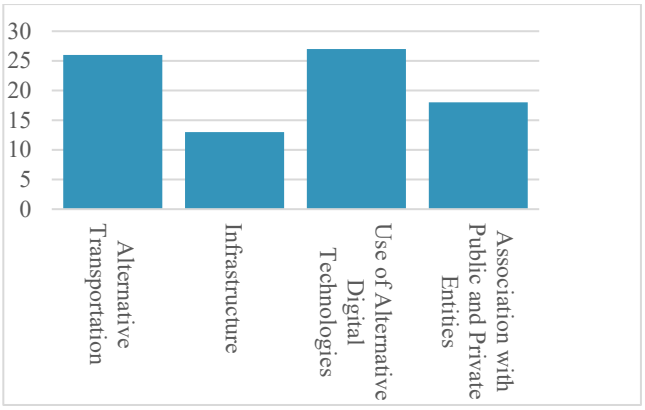

Figure 8. Bar chart of LML Proposals

Table 3. Frequency of Proposals for LML

Proposals	Frequency	Percentage
Alternative Transportation	26	31.0
Infrastructure	13	15.5
Use of Alternative Digital Technologies	27	32.1
Association of Public and Private Entities	18	21.4
TOTAL	84	100

3.4. Sustainable proposals for LML

It is clearly seen that the use of small and environmentally friendly vehicles was the most frequent implementation strategy (40.5 % corresponding to 34 items) (Figure 9, table 4).

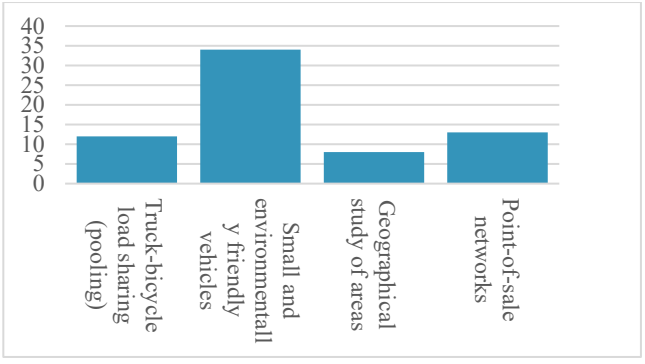

Figure 9. Sustainable Proposals bar chart

Table 4. Frequencies of sustainable proposals

Proposals	Frequency	Percentage
Truck-bicycle load sharing (pooling)	12	14.3
Small and environmentally friendly vehicles	34	40.5
Geographical study of areas	8	9.5
Point-of-sale networks	13	15.5
Analytical computer systems for optimization	17	20.2
TOTAL	84	100

1) ***Electric vehicles.*** This multitude of articles gives us different a wide variety of proposals to ensure sustainability, one of the main methods proposed are those of alternative transportation, from the use of bicycles to

the use of drones. With respect to the use of cargo bikes with electric motors, a study (Mühlbauer & Fontaine, 2021) presents a case study in Munich, where they see a decrease of up to 36% in CO2 emissions, and up to 10% in operating costs compared to traditional cargo vans. There is also a proposal in Seoul, according to Lee et al. (2019) to replace trucks with electric-powered bicycles, also mentioning the ability to reach areas that are difficult to access for large vehicles. In their experimentation, they achieved a 14% reduction in costs on average. In both cases, the replacement by bicycles is not done in the entire delivery system, but coexists with the traditional system, focusing on deliveries closer to the distribution centre. G. Aiello et al. (2021) finds a design proposal, a customized vehicle for urban transport of goods, and, as well as the earlier ones, this vehicle is effective, and decreases costs in short range deliveries.

2) ***Drones.*** In recent years, to the list of technological innovations for urban delivery, the concept of aerial deliveries through drones has been added, that could decrease the environmental impact in cities and in high density areas, so they are in finding models that can optimize battery savings and number of deliveries (Resat, 2020; Serrano-Hernandez et al., 2021; Troudi et al., 2018).

3) ***Lockers.*** Moving on from transportation infrastructure, there are also proposals for the final way the final product is delivered. M. Schnieder et al. (2021) evaluates the proposal of delivery lockers, which proposes a middle point between the logistics service and the end consumer, avoiding excess transit for multiple destinations, but, the use of vehicles by end customers in order to pick up their packages, can make this method counterproductive, so it could only be applied in specific and controlled situations.

4) ***Data mining.*** In addition to technological solutions, delivery planning methods are explored in the articles that can reduce reverse logistics, thus saving on costs and eliminating reprocesses that can multiply the environmental impact. For example, Pan et al. (2017) propose the use of consumer data mining, such as, for example, electricity consumption history, to predict the most proper delivery schedule, thus avoiding unfinished deliveries due to customer absence.

5) ***Crowdsourcing.*** According to Gatta et al. (2018) and Qi et al. (2018) there are other methods that greatly reduce environmental impact, which is cooperative transport, applicable especially in smaller scale delivery. By merging orders from multiple suppliers, it is easy to cut on redundant trips, decreasing the carbon footprint of the logistics process, and there are those who propose to include the ordinary citizen.

3.5. Impediments to sustainable improvement

It is clearly seen that operative costs for the implementation of alternative transportation were the most frequent impediments (33.3% corresponding to 28 items), followed by lack of infrastructure (28.6% corresponding to 24 items) (Figure 10, table 5).

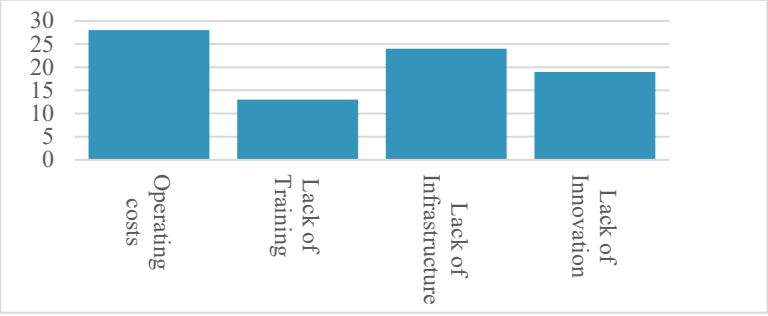

Figure 10. Bar Chart of Impediments to Sustainable Improvement

Table 5. Frequencies of Impediments to improvement

Impediments	Frequency	Percentage
Operative costs	28	33.3
Lack of Training	13	15.5
Lack of Infrastructure	24	28.6
Lack of Innovation	19	22.6

TOTAL	84	100

4. Discussion

The authors do not prove a single way in which sustainability can be incorporated into last mile logistics, as there are multiple methods as there are different cities, different contexts, and different capabilities. This is one of the main obstacles to the implementation of sustainable practices, homogeneity makes it easier to launch large-scale projects, heterogeneity hinders their adoption. For example, according to Serrano et al. (2021) The bike solution is a suitable alternative in cases of low accessibility, and short distances, the same with the rest of the strategies that rely on alternative vehicles. Resat (2020) wrote that lower impact fuels grant less travel to vehicles, so it would force the dispersion of distribution centres to reach destinations. According to Villa and Monzón (2021), resource collaboration is one of the most adopted methods in recent years since it has already yielded positive results in its implementation. If each company were exclusively in charge of its products and/or services, there would be a redundancy of trips, so many have opted (for economic reasons) for the consolidation of orders, so that it is one who oversees the distribution of many.

It is also observable, as, in many of the improvement cases, methods are used that were designed primarily to decrease operating costs, which shows us that sustainability can be a side effect of the search for financial reasons and is also the best way to encourage companies to adopt sustainable practices.

It is seen in the case studies that the countries where sustainable methods are implemented and experimented with are mostly developed countries Bi et al. (2020), which shows a correlation between the economic situation of a country and the interest in sustainable proposals (Galati et al., 2020).

5. Conclusions

It is concluded that the main obstacles in last mile logistics are found in transportation (25%), followed by gas emissions (22.6%) and waiting times (20.2%). Therefore, any proposal must be prepared to address these obstacles. Regarding the main strategies that seek to ensure the sustainability of last mile logistics is, first, the integration of digital technologies in the use of e-commerce, saw in the score of 32.1% among the items seen. Since, both in data mining, as in the different planning methods, the use of digital means eases the optimization of available resources, not only affecting the final logistics costs, but also in reducing the carbon footprint. The second proposal is about alternative transportation (31%), whose attractiveness lies in the use of renewable energies and taking pollution out of urban areas. Regarding the impediments to the implementation of new methods capable of ensuring sustainability, one of the main obstacles is operational costs, mentioned in 33.3% of the cases. Implementation stands for a first cost overrun, which for small businesses is not easy to overcome. This reason goes hand in hand with the lack of infrastructure (22.6%), which is difficult to overcome if the current business does not have sufficient income margins. It is also worth mentioning that another major factor is the lack of innovation, which can exist due to a lack of resources as well as disinterest on the part of the company. The preferred proposal among the authors includes alternative vehicles, both drones and electric vehicles, depending on the density and urban distribution of each delivery area. Where despite requiring multiple trips, it is still more sustainable compared to traditional transport. Finally, as a conclusion we can mention that the review articles have transportation as the main obstacle of last mile logistics, and the implementation of small and environmentally friendly vehicles are the most practical solution. However, operating costs and lack of infrastructure are an obstacle, but that can be solved with the use of environmentally friendly alternative transport (bicycles) associated with new digital technologies for logistics optimization.

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Biographies

Mauricio Dávila-Granda holds a bachelor's degree in Industrial Engineering from Universidad de Lima. He is interested on logistics and processes management. Performed his internship at Banco de Comercio in the administrative area of process management and has been volunteer on the administration of Albergue Infantil el Amparo.

Andy Pedraza-La-Barrera holds a bachelor's degree in Industrial Engineering from Universidad de Lima . Performed his internship at "La Torre Ingenieros & Magisters SAC" carrying out logistics traceability projects to supply 51 CRFA (Alternative Rural Training Center - in Spanish) managing the supply chain, route planning, logistics monitoring, reverse logistics as well as in the "Corporación Hermanos Mantilla SAC" in the logistics and supply area, generating inventory rotation, supply planning, logistics traceability, quotes and price comparison, supplier classification.

Alberto Flores-Pérez holds a doctorate degree in Education from Universidad de San Martin de Porres. Master's degree in Supply Chain Management from Universidad ESAN. Engineer in Food Industries from Universidad Nacional Agraria La Molina. Currently working as an undergraduate professor at Universidad de Lima and

postgraduate professor at Universidad Nacional Agraria. Professional, consultant, businessman and professor with more than 27 years of experience in project implementation, quality management and safety and agro-industrial plants' management. Expert in Supply Chain (supplier management, storage systems, transport modeling and distribution systems), Supply Chain and Operations. Specialization in integrated management system audit and Shortsea Logistics at the Escola Europea Short Sea Shipping. Leader of transformational projects, productivity, and change generator. Specialist in the implementation of Continuing Improvement Projects, PDCA, HACCP, BPM in the agro-industrial sector, trainer of national government institutions and the United Nations (UNDP). Development of high-performance team. Member of IEEE, SCEA Ohio, IOEM and CIP (College of Engineers of Peru).

Juan Carlos Quiroz-Flores is an MBA from Universidad ESAN. Industrial Engineer from Universidad de Lima. PhD in Management and Business Administration at Universidad Nacional Mayor de San Marcos, Black Belt in Lean Six Sigma. Current is Undergraduate teaching at Universidad de Lima. Expert in Lean Supply Chain and Operations with over 20 years of professional experience in the direction and management of operations, process improvement and productivity; specialist in the implementation of Continuing Improvement Projects, PDCA, TOC and Lean Six Sigma. Leader of transformational projects, productivity and change generator. Capable of forming high-performance teams, aligned to company strategies and programs for "Continuous Improvement". He has published journal and conference papers and his research interests include supply chain management and logistics, lean manufacturing, lean six sigma, business process management, agribusiness, design work, facility layout design, systematic layout planning, quality management and Lean TPM. He is member of IEOM, IISE, ASQ, IEEE and CIP (College of Engineers of Peru).

Martín Collao-Diaz at ESAN University and Industrial Engineer from the University of Lima specialized in supply chain management and operations. Leader with more of 25 years in local and international experience in national and multinational companies at industrial, hydrocarbon and mass consumption sectors. Broad experience in supply chain management (purchasing, inventory, suppliers and supply sources management, logistics: transport, distribution and warehouse management), operations (planning and control of production and maintenance) and integrated system management (ISO 9001, ISO 14001 and OHSAS 18001). Business alignment based on sales and operations planning (S&OP). Besides, continuous search for improvements in profitability based on process optimization and saving projects using tools such as Six Sigma methodology among others, focused to be a High-performance Organization (HPO). Development of high-performance team. Member of IEEE and CIP (College of Engineers of Peru).