A DECISION SUPPORT SYTEM FOR LOCATION OF TEMPORARY POINTS OF DISTRIBUTION FOR HUMANITARIAN AID

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The increasing frequency of disasters highlights the critical need for efficient and adaptable humanitarian logistics systems. To enhance decision-making in these complex environments, it is essential to incorporate advanced mathematical models through the development of Decision Support Systems (DSS). This study presents the development of a DSS prototype aimed at optimizing the location of temporary Points of Distribution (PODs) following a large-scale earthquake scenario in Alto Selva Alegre, Arequipa, Peru. The system distinguishes between two types of PODs: fixed PODs, which remain operational throughout all periods and serve as stable infrastructure during both the response and recovery phases, and temporary PODs, which are activated only during the initial response to maximize proximity to the affected population. The DSS is composed of four core components—a database, an optimization model, a user interface, and a communication layer—and is structured into five interactive tabs. The Data tab presents input information; Optimization tab enables model execution and parameter adjustments based on decision-maker knowledge, resource availability, or operational priorities; Solution visualizes results by period; and Comparative allows users to analyze, and contrast saved configurations. Results show that small changes in input parameters—such as the number of modules or active PODs—can lead to significant improvements in coverage and travel distance, with only modest increases in cost. The DSS also adapts well to operational constraints, providing feasible solutions even when some sites are unavailable. By combining mathematical modelling with interactive usability, it supports quick scenario comparison and informed decision-making, offering a practical tool for humanitarian logistics planning.

Keywords: Facility Location, Temporary Facilities, Modularization, Decision Support System, Humanitarian Logistics.

1. Introduction

The increasing frequency and severity of disasters worldwide have made humanitarian logistics an emerging and important field. Among the various logistical strategies, the deployment of temporary facilities plays a vital role, enabling a rapid and cost-effective response in emergency scenarios. These facilities, typically consisting of tents or prefabricated units installed in public spaces, are essential for delivering services such as the distribution of humanitarian aid (CHEN et al., 2013). Their relatively low initial investment, compared to permanent infrastructure (LOREE; AROSVERA, 2018), and their capacity to adjust dynamically to demand help reduce transportation costs and optimize resource allocation (LIU et al., 2023).

The planning of temporary facilities is particularly complex in sudden-onset disasters such as earthquakes. Site selection must consider multiple functional requirements, notably proximity to affected populations, especially for Points of Distribution (PODs), where affected people access essential supplies (FEMA, 2010). Effective responses demand modular strategies to adjust facility capacities over time (ALIZADEH et al., 2021), supported by multi-period planning models (MANOPINIWES; IROHARA, 2020) and dynamic decisions regarding the opening and closing of facilities throughout the response phase (ALARCON et al., 2022).

Although tools for facility location and network design are well established in the commercial sector, their application in humanitarian logistics remains unexplored. The limited technical expertise of many practitioners hinders the adoption of advanced analytical models, reinforcing the need for Decision Support Systems (DSS) that combine analytical rigor with user-friendly design to ensure accessibility for non-specialists (FLOREZ, 2015).

In this context, the main objective of this article is to describe a prototype of an interactive DSS designed to optimize the location and network configuration of temporary PODs in response to a high-magnitude earthquake in Alto Selva Alegre, Arequipa, Peru. This district is particularly vulnerable to seismic hazards due to its location at the convergence of the Nazca and South American tectonic plates, as well as its proximity to active volcanoes.

The remainder of this paper is organized as follows. Section 2 presents a literature review, focusing on DSS applications in facility location and mathematical modeling for temporary facility planning in humanitarian logistics. Section 3 outlines the methodology adopted. Section 4 describes the illustrative case in which the DSS is applied. Section 5 details the DSS architecture, including its main components and interactive tabs. Section 6 provides a comparative analysis of the evaluated scenarios. Finally, Section 7 presents concluding remarks and directions for future research.

2. Literature Review

2.1. Temporary facility location problem in humanitarian logistics

Table 1 presents a summary of recent modeling approaches for temporary facility location in humanitarian logistics, with a primary focus on post-disaster response operations. All studies concentrate exclusively on the response phase (Rs), this reveals a gap in addressing the recovery phase (Rc), where logistical need to be stable (CARNERO et al., 2025a).

The models are formulated as multi-objective problems considering the challenges to balance diverse criteria such as cost, coverage, and distance (CARNERO et al., 2024). Although all studies address multiple products, humanitarian aid is often delivered in predefined kits (FEMA, 2010), simplifying operations in the last mile. In terms of temporality, most models adopt a single-period planning approach, limiting adaptability to evolving needs. Furthermore, exact solution methods dominate, due the easy use of commercial solvers.

Table 1 – Articles on temporary facility location problem in humanitarian logistics

Article	Case	Phase	Obj	Prod	Per	Sol	LocD	ModD
Jami et al. (2024)	General	Rs	M	M	M	E	O,C	R
Mazloum et al. (2024)	Earthquake, Iran	Rs	M	M	S	E	O	Rd
Mousavi et al. (2024)	Earthquake, Iran	Rs	M	M	S	E	O	-
Qing et al. (2025)	Earthquake, Iran	Rs	S	M	M	NE	O,C	R
Zhang et al. (2025)	Earthquake, Türkiye	Rs	M	M	S	E	O	-
This research	Earthquake, Perú	Rs, Rc	M	S	M	E	O,C	C,R, Ex,Rd

Note: Phase: Response (Rs), Recovery (Rc). Objective (Obj): Single (S), Multiple (M). Product (Prod): Single (S), Multiple (M). Period (Per): Single (S), Multiple (M). Solution Approach (Sol): Exact (E), Nonexact (NE). Location Decisions (LocD): Open (O), Close (C). Modular Decisions (ModD): Configuration (C), Relocation (R), Expanding (Ex), Reducing (Re).
Source: Own Elaboration

Regarding facility location decisions, most models focus on opening facilities, whereas closing, which is an important feature given their temporary nature, is often neglected. Modular approaches, that consider configuration, relocation, expansion, or reduction of modules (ALARCON et al., 2022), remain largely underexplored.

2.2. Decision support systems in facility location problems

DSSs are interactive computer-based tools designed to assist decision-makers. They are composed of four components: the user interface, database, analytical models, and communication modules (POWER, 2002). According to KEEN (1980), an effective DSS should also encourage users to explore new alternatives and innovative approaches.

The integration of optimization methods is central to enhancing facility location decisions through DSSs. For instance, Hajiali et al. (2022) developed a ambulance relocation DSS based on integer linear programming. Moreover, user-friendliness is a key design priority for DSSs in facility location, promoting accessibility through intuitive interfaces and familiar platforms, as exemplified by Erdoğan, Stylianou, and Vasilakis (2019), who developed a DSS integrating Excel and GIS for easy data entry and interpretation. Interactivity also plays a crucial role, enabling users to adjust parameters based on their expertise and to explore alternative scenarios in real time, thereby improving engagement and fostering trust in the system (SANTOS, 2021). Finally, a DSS must integrate decision-making elements specific to the problem context, such as managing road closures during disasters (FIKAR, GRONALT, AND HIRSCH, 2016) or anticipating infrastructure failures to optimize humanitarian supply allocation (FLOREZ ET AL., 2015).

To address the gaps identified in this section, this research proposes a DSS-integrated approach that incorporates multi-objective optimization across response and recovery phases, modular planning in a multi-period framework, and the strategic opening and closing of PODs to enhance adaptability and operational continuity.

3. Methodology

The development of the Decision Support System (DSS) followed a two-phase methodology.

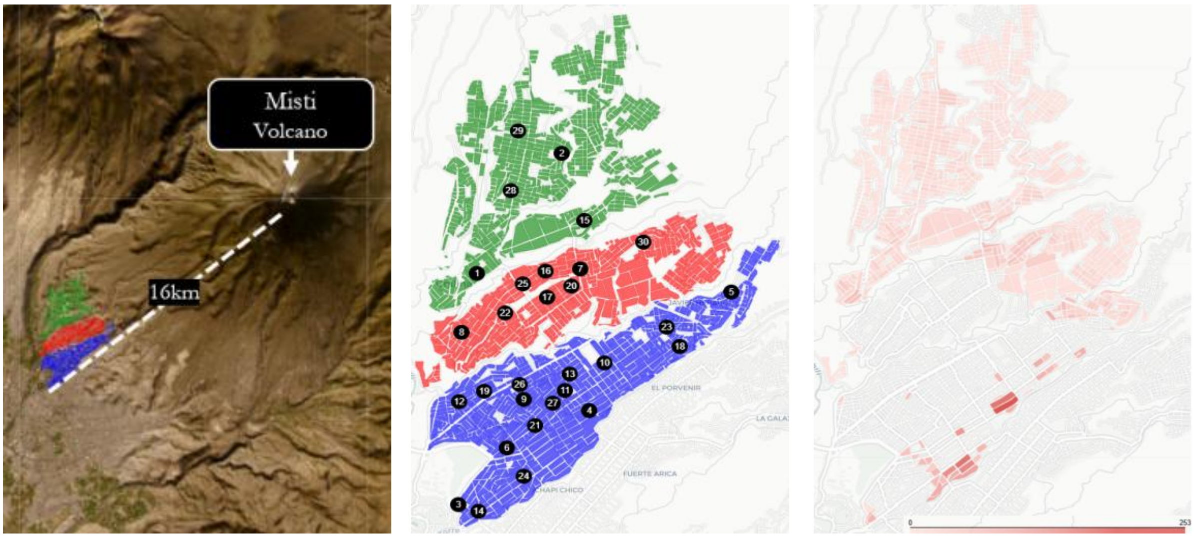
The first phase focused on understanding the illustrative case of earthquake response in Alto Selva Alegre, Arequipa, Peru. Data was collected and validated through direct collaboration with key decision makers, including the Disaster Risk Management Submanager and a staff member from ASA Municipality, as well as a specialist from INDECI's Decentralized Directorate in Arequipa, during four dedicated meetings. The process involved four main meetings: initial consultations to understand operational protocols, a session to review available datasets (block-level information on population, economic strata, and seismic risk), and follow-up meetings to identify candidate PODs. Finally, distances between blocks and PODs were computed using the OpenStreetMap API.

The second phase involved the development of a DSS to optimize the location of temporary PODs for the illustrative case. The User Interface was developed using HTML, CSS, and JavaScript; the optimization model was implemented in Python 3.12.4 and solved with the Gurobi 11.0.2 solver. The Database Component manages input and output data through CSV and Excel files. The Communication Component, built with JavaScript and Python, ensures seamless interaction between system modules. By integrating these components, the DSS provides a comprehensive and adaptable tool to support strategic, data-driven decisions in POD network design.

4. Illustrative case

Peru is highly prone to seismic activity due to the convergence of the Nazca and South American tectonic plates. One of its cities, Arequipa, is particularly vulnerable because of its proximity to the Misti, Chachani, and Pichu Pichu volcanoes (IGP, 2001). Specifically, Alto Selva Alegre district in Arequipa lies less than 16 km from Misti. Also, the district is traversed by several ravines, the two largest, "Huarangal" and "El Pato," divide the district into three sectors interconnected by bridges. However, these areas may become inaccessible following an earthquake (MUNICIPALIDAD DE ALTO SELVA ALEGRE, 2019). The three sectors are depicted in blue, red, and green in Figure 1a.

Figure 1 – Characteristics of Alto Selva Alegre: (a) Location (b) Candidate PODs (c) Demand



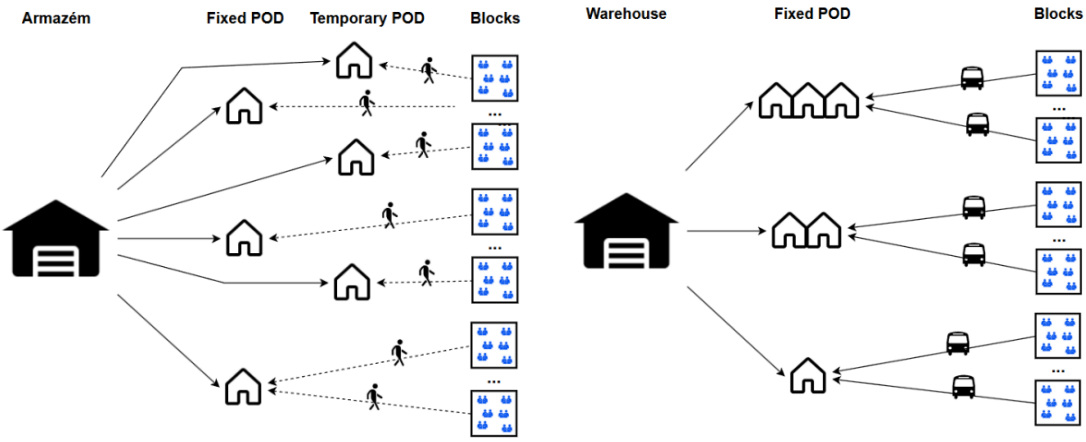
(a) (b) (c)

Source: Own Elaboration

Based on available parks and municipal land, 30 candidate PODs were identified with the assistance of decision-makers, aiming to ensure operational feasibility during disaster response. These candidate locations are illustrated as black dots in Figure 1b. In parallel, and according to decision-makers, demand is estimated as the number of residents with low or lower-middle income levels, as well as by those living in blocks classified as high-risk or prone to collapse due to seismic events. The spatial distribution of this demand is presented in Figure 1c.

Considering the geographical challenges and the insights from the literature review, a logistics network was designed to adapt to the different stages of the disaster response process. In the first stage (Figure 2a), corresponding to the response phase, affected individuals must reach the PODs on foot to receive essential supplies. Consequently, a larger number of PODs is required to ensure proximity to the population. In the second stage (Figure 2b), during the recovery phase, once the road network is restored, individuals will be able to access PODs using public transportation, enabling a reduction in the number of operational PODs.

Figure 2 – Logistic network configuration: (a) Response phase network (b) Recovery phase network



(a) (b)

Source: Own Elaboration

In this context, adopting a modular approach becomes essential, as it enables adjustments in POD configurations and the relocation of modules between PODs to expand or reduce capacity according to evolving needs (ALARCON et al., 2022). Based on this principle, the logistics network was structured around two types of PODs: fixed and temporary. Fixed PODs remain operational throughout the entire planning horizon and are the only facilities active during the recovery phase. Temporary PODs, in contrast, are activated exclusively during the response phase and may operate for some periods, with the primary objective of ensuring proximity to the affected population.

5. Decision Support System

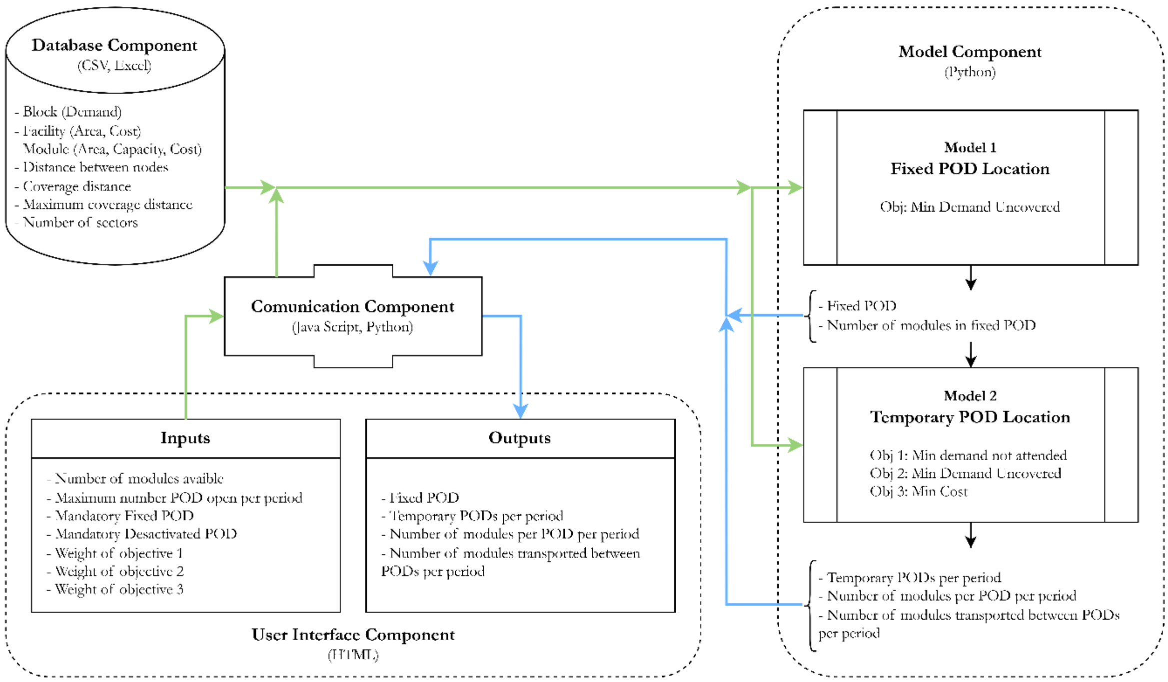
5.1. Decision Support System Components

Figure 3 illustrates the DSS components of the system developed for the illustrative case, that considers: User Interface, Database, Model, and Communication.

The database component stores essential logistical data including block-level demand, facility information, and distances. It manages input and output data efficiently, using CSV and Excel files to store and retrieve the information required by the model.

The Model Component was developed in Python and employs Gurobi as the optimization solver. Initially, a single integrated model was constructed to represent the entire problem. However, this approach proved computationally infeasible due to the large-scale complexity of the realistic scenario. To address this limitation, the problem was strategically decomposed into two sequential models, both solved using a commercial solver. Despite this improvement, solution times for the evaluated scenarios ranged from 46 to 568 seconds, highlighting the potential need for heuristic approaches to enhance scalability and responsiveness. The complete mathematical formulation is detailed in Carnero (2025).

Figure 3 - DSS Components



Source: Own Elaboration

The first model identifies the optimal locations for fixed PODs and the allocation of modules to each, aiming to minimize unmet demand while considering resource constraints, such as module availability, the maximum number of PODs that can be opened per period, and the list of PODs to be considered. Some candidate PODs may be excluded due to disaster-related damage or safety concerns, while others are designated as mandatory based on their strategic accessibility and operational advantages.

The second model adopts a multi-period approach to determine the optimal placement of temporary PODs and the period-specific allocation of modules across all PODs. It allows for the relocation of modules between PODs during the operation, aiming to simultaneously minimize unmet demand, uncovered demand, and operational costs. A key constraint is that the final period must replicate the fixed POD configuration obtained from the first model, ensuring a smooth transition from a dynamic setup during the response phase to a stable configuration in the recovery phase. An additional advantage of this approach is that it preserves the fixed POD setup established in the first model, maintaining operational continuity throughout the recovery phase.

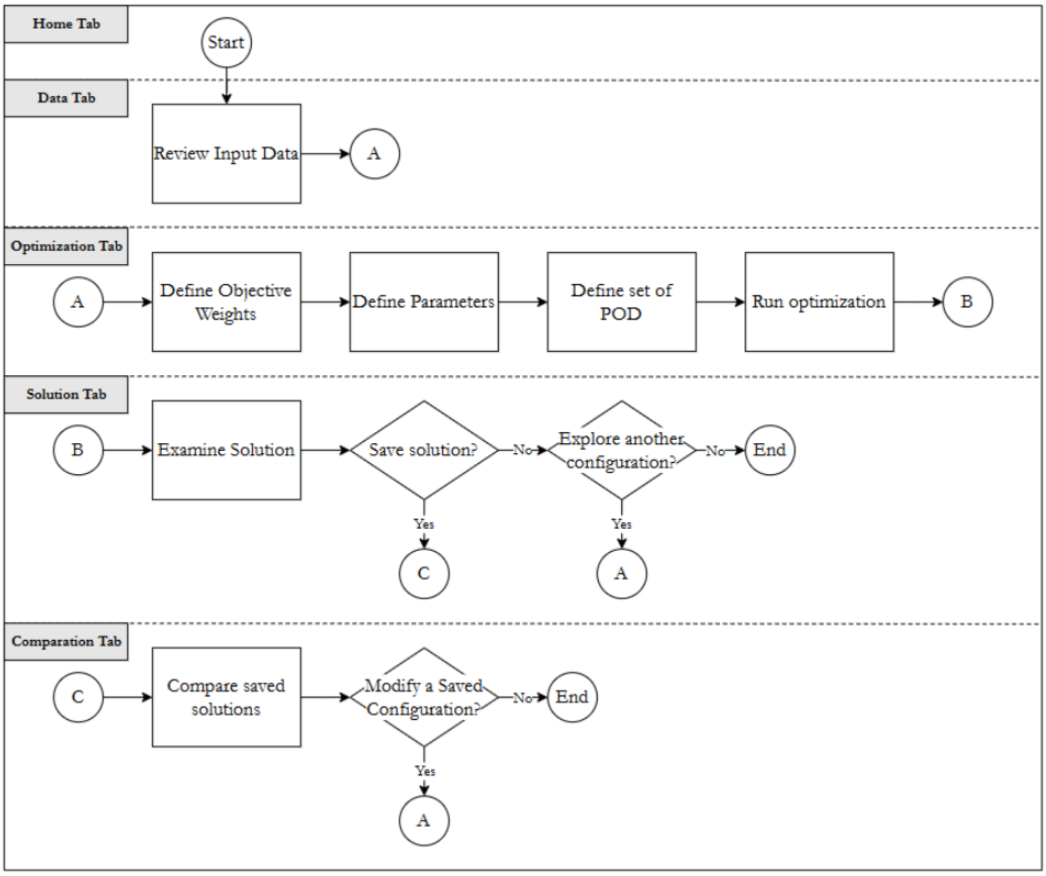
The User Interface component is developed using HTML, CSS, and JavaScript to ensure an interactive and user-friendly experience. Initially, it enables users to define exogenous input parameters, including the number of available modules, the maximum number of PODs that can be opened per period, mandatory fixed and inactive PODs, and the weight of objectives. This information relies on damage assessment conducted during the initial immediate response. Subsequently, the interface allows users to visualize the mathematical modeling results, which can be saved and compared across different configurations, facilitating analysis of feasible POD network designs.

The Communication Component serves as the intermediary between the different system modules, ensuring seamless data exchange. Implemented using JavaScript and Python, it facilitates interaction between the User Interface, Database, and Model, ensuring that user inputs are correctly transmitted to the model and that the computed solutions are accurately displayed in the interface.

5.2. Decision Support System Tabs

To ensure a user-friendly experience, the site was designed with five main tabs: Home, Data, Optimization, Solution, and Comparative. Figure 4 presents the structured workflow followed by the user when interacting with the DSS.

Figure 4 – Data Tab



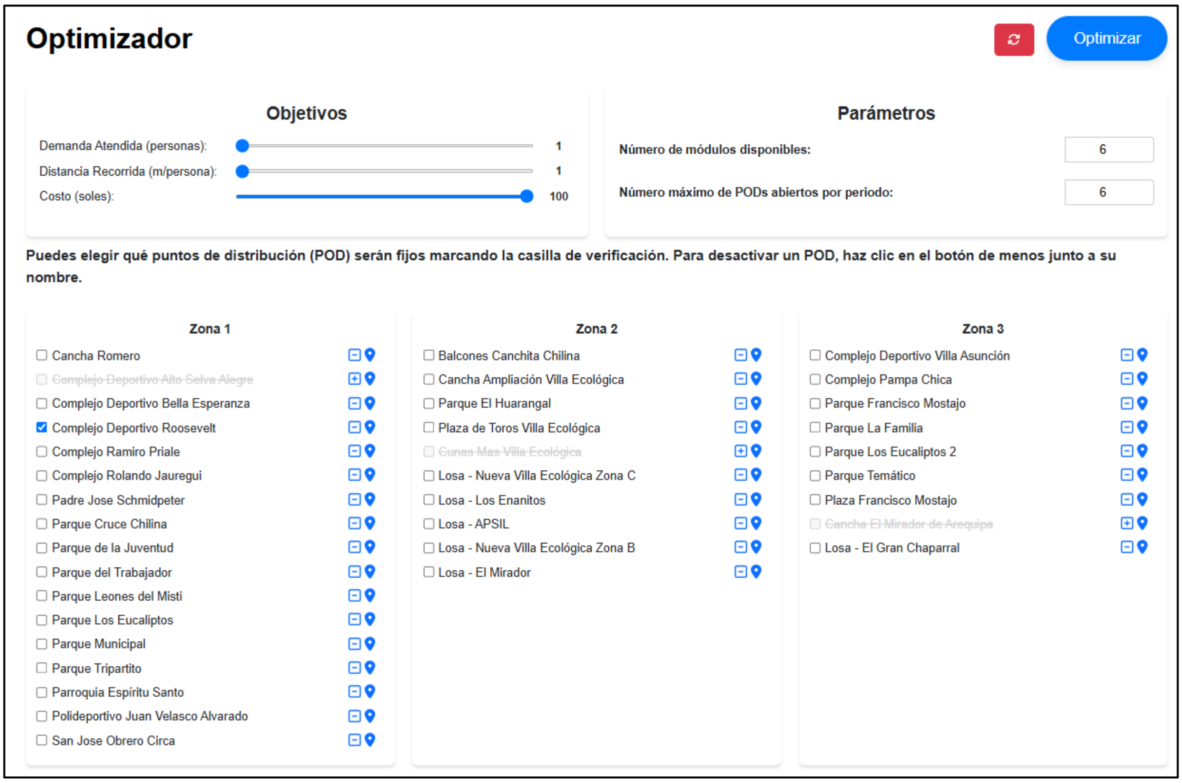
Source: Own Elaboration

The home tab features a navigation bar at the top of the screen, which includes the site name and a menu that allows users to switch between different tabs. The data tab of the DSS. This tab displays information about geographical data, demand per block and location of candidate PODs.

The optimization tab (Figure 5) enables users to input parameters for the optimization process. At the top of the interface, the title is displayed alongside a reset button, which restores the initial configuration, and an optimize button, which runs the model using the provided data. In this tab, users can adjust the objective weights via a slider on the left and specify the number of available modules and the maximum number of PODs per period on the right. Additionally, a list of candidate PODs by zone allows users to mandate a POD by selecting a checkbox or to deactivate it by clicking a minus button. This functionality is critical as it provides decision-makers with the flexibility to incorporate operational constraints, external priorities, or context-specific considerations directly into the optimization framework, thereby enhancing the model's practical applicability.

When optimization is triggered, the system first normalizes the objective weights while preserving their relative importance. The number of periods for the optimization is then dynamically determined based on module availability to ensure feasibility in Model 1. Afterward, the system sequentially executes Model 1 and Model 2, consolidates the results, and automatically redirects the user to the Solution tab, where the outputs are displayed.

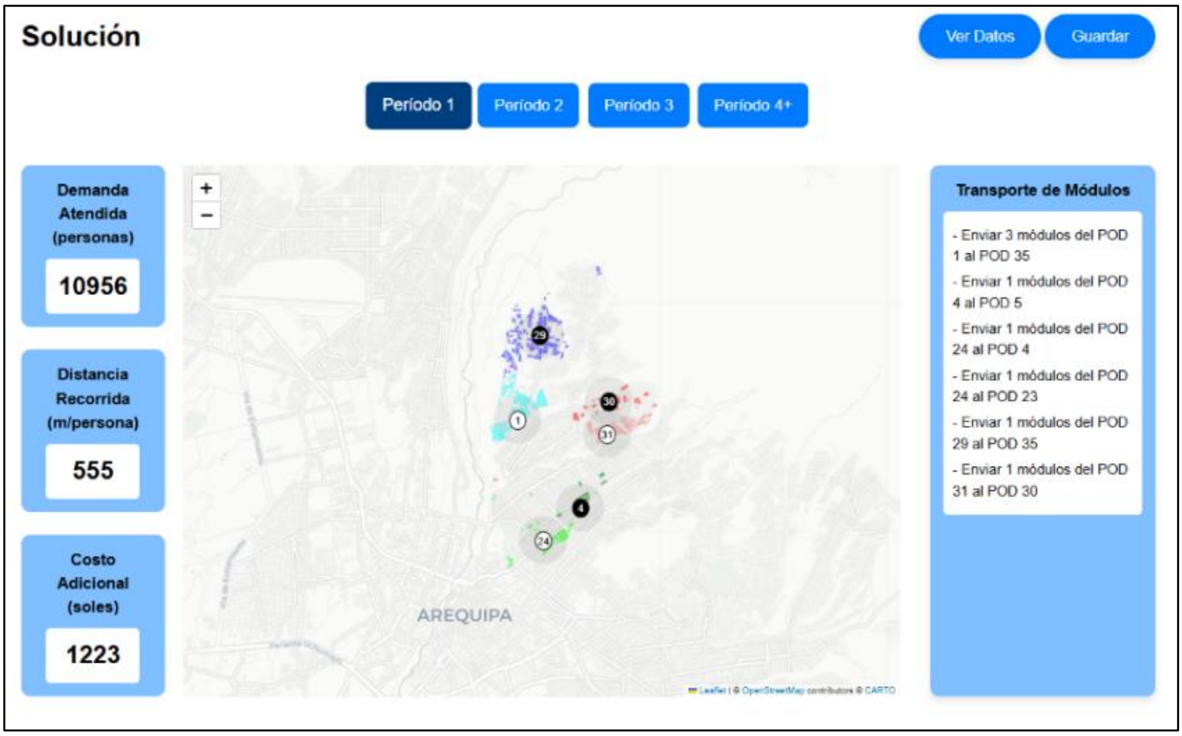
Figure 5 – Optimization Tab



Source: Own Elaboration

The Solution tab (Figure 6) offers an interactive interface that allows users to explore model outputs for each period. This tab has two action buttons: one to access detailed data and another to store the selected solution. A navigation bar enables users to switch between periods, while key performance indicators such as demand attended, distance travel, and additional cost are displayed. Also, an interactive map presents the optimized POD network, where clicking on individual PODs reveals assigned modules and allocated demand. Finally, a sidebar lists the transportation actions required at the end of each period.

Figura 6 – Solution Tab



Source: Own Elaboration

Finally, the comparative tab allows users to review and analyze previously saved solutions to support decision-making. This tab includes a table that organizes saved configurations, displaying objective weights, module counts, PODs opened per period, and indexes of deactivated and fixed PODs. General performance indicators, such as number of periods, average demand attended, distance traveled, and additional cost, enable comparison across solutions. Also, a button reloads the selected solution into the Optimization tab for further adjustments if needed.

6. Comparative Analysis

Table 2 shows ten selected solutions generated by the DSS to illustrate trade-offs between key operational objectives, assuming equal weight for all criteria. It corresponds to the table shown in the Comparative tab and allows assessment of how changes in module availability, POD activation limits, and constraints affect overall outcomes.

One relevant observation concerns the relatively low additional costs incurred across the solutions. Even the most expensive configurations (Solutions 6 and 10) remain under 4000 soles (approximately 1000 USD), which can be considered low when compared to the operational benefits they provide, such as higher demand coverage or significantly reduced travel distances. This indicates that, in realistic disaster response scenarios, it is feasible to prioritize broader service accessibility through temporary facilities without imposing a substantial financial burden. Moreover, the DSS empowers decision-makers to justify minor cost increases in exchange for more balanced, efficient, and context-appropriate solutions.

Table 2 – Comparative Analysis of Selected Optimization Solutions

Solution	**Avaible Modules**	**Max. PODs per period**	**Desac. POD**	**Fixed POD**	**Number of periods**	**Dem/Per (people)**	**Dist (m/pers)**	**Cost (soles)**
1	11	6			3	6907	610	3601
2	11	3		3,28,29	3	6907	1378	0
3	11	4		3,28,29	3	6907	879	1264
4	11	5		3,28,29	3	6907	727	2489
5	11	6	3,28,29	5	3	6907	715	2819
6	10	3	3,28,29	5	4	5526	733	3949
7	10	4	3,28,29	5	4	5526	1440	0
8	10	5	3,28,29	5	4	5526	1529	0
9	6	6	3,28,29	6	6	3947	1529	0
10	6	6	3,28,29	6	6	3947	766	3595

Source: Own Elaboration

In terms of demand coverage, Solutions 1 to 5 achieve the highest average (6907 people per period) by allowing broader POD access and using more modules. This level of coverage tends to be maintained as long as the number of open PODs remains constant, since the system adjusts the number of planning periods to ensure the full demand is attended. In contrast, Solutions 6 to 10 operate under stricter logistical constraints, such as fewer modules.

Also, travel distance per person highlights the humanitarian impact of restricted access to temporary distribution points. This metric is strongly influenced by the number of PODs opened per period: solutions that activate more PODs simultaneously tend to significantly reduce travel distances, reaching as low as 610 m/person, thereby enhancing accessibility, particularly for vulnerable populations. In contrast, cost-minimizing configurations that limit the number of active PODs often result in average distances exceeding 1300 m/person, which may delay relief delivery and reduce the system's overall responsiveness in emergency contexts.

The best solution identifies PODs 3, 28, and 29 as the most suitable fixed locations. However, when certain PODs must be deactivated due to legal or logistical constraints—such as limited site availability or restrictions on park use—the system loses flexibility. This often leads to less efficient configurations, resulting in increased travel distances. Nevertheless, this is an important consideration because such constraints reflect real-world limitations that must be incorporated into the planning process to ensure feasible and implementable humanitarian response strategies.

The DSS proves to be a valuable tool for comparing alternative solutions, making trade-offs between cost, coverage and service explicit. It enables decision-makers to identify balanced and context-appropriate strategies, even under resource constraints.

7. Conclusion

This article describes a DSS for the multi-period planning of temporary distribution facilities in humanitarian logistics, detailing both its technical development and its practical application for supporting decision-making in disaster response scenarios. Grounded in an earthquake scenario in Alto Selva Alegre, Arequipa, Peru; the DSS integrates optimization techniques with an interactive interface to support critical decisions in the allocation and configuration of temporary and fixed PODs.

The comparative analysis of selected solutions demonstrated the system's capacity to make trade-offs explicit, showing how minor increases in cost can lead to significant gains in demand coverage and accessibility. The results confirmed that activating a higher number of PODs per period can substantially reduce travel distances, which is crucial in emergency contexts where access to aid must be both rapid and equitable. Moreover, the system adapts to real-world constraints, such as the deactivation of PODs due to legal or logistical limitations and still offers feasible configurations that preserve humanitarian effectiveness.

Despite its strengths, the DSS has some limitations. Its reliance on a commercial solver may restrict accessibility in operational environments where licensing is not feasible. Future improvements could include the development of heuristics capable of solving the initial integrated model. Moreover, the current prototype assumes that decision-makers operate in a centralized planning context; further research is needed to explore how the DSS could be integrated into decentralized or collaborative decision-making environments. Enhancements in interface interactivity, data visualization, and integration with real-time geospatial data platforms could also strengthen its usability at real-time.

Overall, the DSS proved to be a valuable tool for strategy comparison of logistical POD networks, enabling decision-makers to explore context-sensitive solutions under multiple constraints.

REFERÊNCIAS

ALARCON, E.; BUSCHER, U. **Modular and mobile facility location problems: a systematic review**. Computers & Industrial Engineering, v. 173, p. 108734, 2022.

ALIZADEH, R; NISHI, T.; BAGHERINEJAD, J., & BASHIRI, M. **Multi-period maximal covering location problem with capacitated facilities and modules for natural disaster relief services**. Applied Sciences (Switzerland), v. 11, p. 1–22, 2021.

CARNERO QUISPE, M. F.; CHAMBILLA MAMANI, L. D.; YOSHIZAKI, H. T. Y.; BRITO JUNIOR, I. D. **Temporary facility location problem in humanitarian logistics: a systematic literature review**. Logistics, v. 9, n. 1, p. 42, 2025.

CARNERO QUISE, M. F. **Location of temporary points of distribution for humanitarian aid**. São Paulo, 2025. 91 p. Dissertação (Mestrado em Engenharia de Produção) – Programa de Pós-Graduação em Engenharia de Produção, Escola Politécnica, Universidade de São Paulo, 2025.

CARNEIRO QUISPE, M. F.; COUTO, A. S.; BRITO JUNIOR, I.; CUNHA, L. R. A.; SIQUEIRA, R. M.; YOSHIZAKI, H. T. Y. **Humanitarian logistics prioritization models: a systematic literature review**. Logistics, v. 8, n. 2, p. 60, 2024.

CHEN, A. Y.; YU, T. Y. **Network based temporary facility location for the emergency medical services considering the disaster induced demand and the transportation infrastructure in disaster response**. Transportation Research Part B: Methodological, v. 91, p. 408–423, 2016.

CHEN, Z.: CHEN, X., LI, Q.; CHEN, J. **The temporal hierarchy of shelters: a hierarchical location model for earthquake-shelter planning**. International Journal of Geographical Information Science, v. 27, p. 1612–1630, 2013.

ERDOĞAN, Güneş; STYLIANOU, Neophytos; VASILAKIS, Christos. **An open source decision support system for facility location analysis**. Decision Support Systems, v. 125, p. 113116, 2019.

FEMA. **IS-26: Guide to Points of Distribution**. 2010. Available at: https://training.fema.gov/is/courseoverview.aspx?code=IS-26&lang=en. Accessed on: 28 Apr. 2025.

FIKAR, Christian; GRONALT, Manfred; HIRSCH, Patrick. **A decision support system for coordinated disaster relief distribution**. Expert Systems with Applications, v. 57, p. 104–116, 2016.

FLOREZ, J. V. et al. **A decision support system for robust humanitarian facility location**. Engineering Applications of Artificial Intelligence, v. 46, p. 326–335, 2015.

HAJIALI, Mahdi; TEIMOURY, Ehsan; RABIEE, Mohammad; DELEN, Dursun. **An interactive decision support system for real-time ambulance relocation with priority guidelines**. Decision Support Systems, v. 155, p. 113712, 2022.

IGP. **El terremoto de la región del sur del Perú del 23 de junio de 2001**. 2001. Available at: https://repositorio.igp.gob.pe/handle/20.500.12816/695. Accessed on: 28 Apr. 2025.

JAMI, M.; IZADBAKHSH, H.; KHAMSEH, A. A. **Developing an integrated blood supply chain network in disaster conditions considering multi-purpose capabilities**. Journal of Modelling in Management, 2024.

KEEN, P. G. W. **Decision support systems: a research perspective**. Cambridge: Center for Information Systems Research, Sloan School of Management, Massachusetts Institute of Technology, 1980.

LIU, K. et al. **Multi-period stochastic programming for relief delivery considering evolving transportation network and temporary facility relocation/closure**. Transportation Research Part E: Logistics and Transportation Review, v. 180, 2023.

LOREE, N.; AROS-VERA, F. **Points of distribution location and inventory management model for post-disaster humanitarian logistics**. Transportation Research Part E: Logistics and Transportation Review, v. 116, p. 1–24, 2018.

MANOPINIWES, W.; IROHARA, T. **Optimization model for temporary depot problem in flood disaster response**. Natural Hazards, v. 105, p. 1743–1763, 2021.

MAZLOUM, M. et al. **An integrated relief pre-positioning, procurement planning, and casualty type's allocation in a humanitarian supply chain**. International Journal of Systems Science: Operations and Logistics, v. 11, 2024.

MUNICIPALIDAD DE ALTO SELVA ALEGRE. **Plan de Prevención y Reducción del Riesgo de Desastres del distrito de Alto Selva Alegre**. 2019. Available at: https://sigrid.cenepred.gob.pe/sigridv3/documento/9836. Accessed on: 28 Apr. 2025.

MOUSAVI, S. et al. **Hybrid mathematical and simulation model for designing a hierarchical network of temporary medical centers in a disaster**. Journal of Simulation, v. 18, p. 119–135, 2024.

POWER, D. J. **Decision support systems: concepts and resources for managers**. Westport: Quorum Books, 2002.

QING, L. et al. **A two-stage adaptive robust model for designing a reliable blood supply chain network with disruption considerations in disaster situations**. Naval Research Logistics (NRL), v. 72, n. 1, p. 45–71, 2025.

SANTOS, Filipe Aécio Alves de Andrade. **Otimização visual interativa com múltiplos critérios: sistema de apoio à decisão para treinamento em logística humanitária**. 2021. Dissertação (Mestrado em Engenharia de Sistemas Logísticos) - Escola Politécnica, Universidade de São Paulo, São Paulo, 2021.

ZHANG, W. et al. **Robust location-allocation decision considering casualty prioritization in multi-echelon humanitarian logistics network**. Information Sciences, v. 695, p. 121731, 2025.