JOURNAL OF ENVIRONMENTAL MANAGEMENT & SUSTAINABILITY

REVISTA DE GESTÃO AMBIENTAL E SUSTENTABILIDADE – GeAS

Received: 25 Feb. 2021 - **Approved:** 26 Aug. 2021
Evaluation Process: Double Blind Review
https://doi.org/10.5585/geas.v10i1.19494
e-ISSN: 2316-9834

Check for updates

Reducing the response time to the homeless with the use of Humanitarian Logistics Bases (BLHs) composed of shipping containers adapted as temporary shelters

Ana Carolina Souza Ramos[1] **Newton Narciso Pereira**[2]

[1] Master, Federal Fluminense University – UFF. Volta Redonda, RJ – Brazil. anacarolina.s.ramos@gmail.com
[2] PhD, Federal Fluminense University – UFF. Volta Redonda, RJ – Brazil. newtonpereira@id.uff.br

Cite como
American Psychological Association (APA)

Ramos, A. C. S., & Pereira, N. N. (2021). Reducing the response time to the homeless with the use of Humanitarian Logistics Bases (BLHs) composed of shipping containers adapted as temporary shelters. *Rev. Gest. Ambient. e Sust. - GeAS.*, *10*(1), 1-28, e19494. https://doi.org/10.5585/geas.v10i1.19494.

Abstract

Objective: Propose the use of adapted shipping containers as temporary shelters for prompt response to homeless victims of natural disasters in Brazil.

Methodology/Approach: In this study we call this alternative as Humanitarian Logistics Bases (BLHs). To carry out this proposition, a data collection was carried out with the public bases from 2013 to 2018 on the occurrence of natural disasters in the country. The impacts and consequences of these disasters were analyzed and quantified the total number of homeless victims in the period. To locate the BLHs, the p-Median method was applied in conjunction with Simple Multi-Attribute Rating Technique (SMART) to measure the weight of each decision criterion in the localization process. The number of BLHs was defined by the clustering method, considering the distribution of homeless people by State.

Relevance: Considering the aspects related to the end of life of containers, which has generated a new market for container houses, it was that this research identified a gap in terms of adapting these containers for temporary shelters. Thus, a study that considers the impacts of climatic events on Brazilian states is justified, as well as the ability to use alternative instruments to increase the state's prompt response to meet the needy.

Results: In the end, the results showed that the development of a methodological process for locating the BLHs, composed of shipping containers, is a possible strategy to improve the response to victims displaced by natural disasters. A greater incidence of disasters was observed in the country's coastal zone, as well as in the South, Southeast and North regions, and thus there was a need for 52 BLHs and a total of 90,775 container houses in a support network to serve the main affected regions. by natural disasters.

Contributions: This research sought to fill a gap on a procedure for locating temporary shelters of reused shipping containers for humanitarian logistics, in order to contribute so that public agencies can offer a quick combat to the homeless during the post-disaster phase.

Conclusión: The use of shipping containers is a sustainable alternative to reduce the response time to the homeless. This approach can allow entities linked to the maritime sector to enter into partnerships with the public sector in order to meet a repressed demand in the country due to the recurrence of problems of climatic events, besides contributing to reduce the problem of final destination, providing favorable conditions to container recycling. And they could also offer relief from other extraordinary events, which lacked temporary mobile structures, such as war and pandemic actions.

Keywords: Natural disasters. Humanitarian Logistics Bases. Decision making. Shipping containers. Temporary shelters.

Redução do tempo de resposta aos desabrigados com a utilização de Bases Logísticas Humanitárias (BLHs) compostas por contêineres marítimos adaptados como abrigos temporários

Resumo

Objetivo do Estudo: Propor o uso de contêineres marítimos adaptados como abrigos temporários para pronta resposta aos desabrigados vítimas de desastres naturais no Brasil.

Metodologia/Abordagem: Neste estudo nós denominamos esta alternativa como Bases Logísticas Humanitárias (BLHs). Para realizar esta proposição, foi realizada uma coleta de dados junto as bases públicas no período de 2013 a 2018 sobre a ocorrência de desastres naturais no país. Os impactos e consequências destes desastres foram analisados e quantificados o total de desabrigados vitimados no período. Para localização das BLHs foi aplicado o método das p-Medianas em conjunto com Simple Multi-Attribute Rating Technique (SMART) para mensurar o peso de cada critério de decisão no processo de localização. A quantidade de BLHs foi definida pelo método de clusterização, considerando a distribuição de desabrigados por Estado.

Originalidade/Relevância: Considerando os aspectos relativos ao fim de vida dos contêineres, que tem gerado um novo mercado de casas contêineres, foi que esta pesquisa identificou uma lacuna em termos de adaptação destes contêineres para abrigos temporários. Assim, justifica-se um estudo que considere os impactos dos eventos climáticos sobre os estados brasileiros, bem como, a capacidade de utilizar instrumentos alternativos para aumentar pronta resposta do estado para atender os necessitados.

Resultados: No final, os resultados mostraram que o desenvolvimento de um processo metodológico para localização das BLHs, compostas por contêineres marítimos, é uma estratégia possível para melhorar a resposta às vítimas desabrigadas por desastres naturais. Foi observado uma maior incidência dos desastres na zona costeira do país, bem como nas regiões Sul, Sudeste e Norte e assim verificou-se a necessidade de 52 BLHs e um total de 90.775 casas contêineres em uma rede de apoio para atender as principais regiões afetadas por desastres naturais.

Contribuições teórico-metodológicas: Esta pesquisa buscou suprir uma lacuna sobre um procedimento para a localização de abrigos temporários de contêineres marítimos reutilizados para logística humanitária, a fim de contribuir para que órgãos públicos possam oferecer um rápido combate aos desabrigados durante a fase de pós-desastre.

Conclusão: O uso de contêineres marítimos é uma alternativa sustentável para reduzir o tempo de resposta aos desabrigados. Essa abordagem pode permitir que entidades ligadas ao setor marítimo possam realizar parcerias com o setor público no intuito de atenderem uma demanda reprimida no país diante da recorrência de problemas de eventos climáticos. E também poderiam oferecer um alívio a outros eventos extraordinários, que carecessem de estruturas temporárias móveis, como por exemplo em ações de guerra e pandemia.

Palavras-chave: Desastres naturais. Base Logística Humanitária. Tomada de decisão. Contêineres marítimos. Abrigos temporários.

Reduciendo el tiempo de respuesta a las personas sin hogar con el uso de Bases Logísticas Humanitarias (BLHs) compuestas de contenedores de envío adaptados como refugios temporales

Resumen

Objetivo: Proponer el uso de contenedores de transporte adaptados como refugios temporales para una pronta respuesta a las víctimas sin hogar de los desastres naturales en Brasil.

Metodología: En este estudio llamamos a esta alternativa como Bases Logísticas Humanitarias (BLH). Para llevar a cabo esta propuesta, se realizó una recolección de datos con las bases públicas de 2013 a 2018 sobre la ocurrencia de desastres naturales en el país. Se analizaron los impactos y consecuencias de estos desastres y se cuantificó el número total de víctimas sin hogar en el período. Para ubicar los BLH, se aplicó el método p-Median junto con la Técnica de Calificación Simple de Atributos Múltiples (SMART) para medir el peso de cada criterio de decisión en el proceso de localización. El número de BLH se definió mediante el método de agrupamiento, considerando la distribución de personas sin hogar por Estado.

Relevancia: Considerando los aspectos relacionados con el fin de vida de los contenedores, que ha generado un nuevo mercado para las casas contenedor, fue que esta investigación identificó un vacío en cuanto a la adecuación de estos contenedores para refugios temporales. Así, se justifica un estudio que considere los impactos de los eventos climáticos en los estados brasileños, así como la capacidad

de utilizar instrumentos alternativos para incrementar la pronta respuesta del estado para atender a los más necesitados.
Resultados: Al final, los resultados mostraron que el desarrollo de un proceso metodológico para la localización de los BLH, compuesto por contenedores marítimos, es una posible estrategia para mejorar la respuesta a las víctimas desplazadas por desastres naturales. Se observó una mayor incidencia de desastres en la zona costera del país, así como en las regiones Sur, Sudeste y Norte, por lo que se necesitaron 52 BLH y un total de 90,775 casas contenedor en una red de apoyo para atender a los principales afectados. regiones. por desastres naturales.
Contribuciones: Esta investigación buscó llenar un vacío en un procedimiento de localización de albergues temporales de contenedores marítimos reutilizados para logística humanitaria, con el fin de contribuir a que las agencias públicas puedan ofrecer un combate rápido a las personas sin hogar durante la fase posdesastre.
Conclusón: El uso de contenedores de envío es una alternativa sostenible para reducir el tiempo de respuesta a las personas sin hogar. Este enfoque puede permitir que entidades vinculadas al sector marítimo se asocien con el sector público para atender una demanda reprimida en el país por la recurrencia de problemas de eventos climáticos, además de contribuir a reducir la problemática del destino final, brindando condiciones favorables. condiciones para el reciclaje de contenedores. Y también podrían ofrecer alivio de otros eventos extraordinarios, que carecían de estructuras móviles temporales, como acciones de guerra y pandemias.

Palabras clave: Desastres naturales. Bases Logísticas Humanitarias. Toma de decisiones. Transporte de contenedores. Refugios temporales.

Introduction

Global estimates, carried out by CRED and UNISDR (2020), indicated that in the period 2000 to 2019, there were 7,348 significant disasters recorded, causing the loss of 1.23 million lives, affecting 4.2 billion people, resulting in approximately $2.97 trillion in global economic losses. About 22 million people worldwide lost their homes in natural disasters in 2019, and the urban population is expected to reach 70% of the world's population by 2050 (UN, 2019). Meanwhile, UN-Habitat (2020) reported that, in developing countries, a third of the urban population lives in slums that are highly vulnerable in terms of housing and that currently, nearly 1 billion people worldwide reside in precarious settlements.

Most natural disasters cause problems directly connected to housing collapses, and therefore, temporary shelter needs to be provided to victims (Hong, 2017). Consequently, the choice of materials in the construction process plays a fundamental role, as it is at this point that decisions are made that impact positively or not throughout the entire life cycle of the shelter. The more durable, the better (Hong, 2017). The types of temporary shelter most used in cases of natural disasters are stays in family homes; social rents, usually subsidized by the government; stay in public offices, self-construction of shelters with materials from the disaster itself, tents, prefabricated housing units, and brick houses (Lizarralde; Johnson; Davidson, 2010). The topic addressed in this study, temporary shelters in case of disasters, has been discussed by public and private entities in order to seek an alternative to mitigate post-disaster housing impacts (Perrucci et al. 2016).

For example, in Brazil, the Ministry of Regional Development (2019), in partnership with the United Nations Development Program (UNDP), issued a notice for the selection of projects to carry out studies aimed at temporary housing for the population displaced by disasters in Brazil, with the aim of strengthening risk management in the country.

Considering the many possible and viable alternatives for use as a shelter in disaster response, it is also possible to evaluate the use of shipping containers. In the last decade, the reuse of shipping containers has proven to be a new construction method that seeks to minimize the costs, time, and environmental impact generated by conventional constructions and also ensures material recirculation (Islam et al. 2016; Ramos & Pereira, 2018). For its construction, it must meet the criteria established by the International Convention for Safe Containers (CSC) (Tang & Ling, 2018). Sea containers have a standard height x width = 2.438 m × 2,438 m, and two typical lengths of 6.96 m (referred to as "20 ft container") and 12,192 m (referred to as "40 ft container"). Some 40 ft specialty containers can be 2,743 m (9 ft) high, which is called a High Cube container. Due to its standardization in terms of dimensions, it can be used to build houses with stacks, which can be connected to each other and can be used in large quantities, occupying little space (Tang & Ling, 2018). On the other hand, container houses have lower costs in relation to masonry houses under similar conditions and may reach a difference ranging between 20% (Wong et al. 2018) and 41% (Ramos & Pereira, 2018). In addition to causing a positive impact on the maritime transport sector, which can profit from the sale of containers at the end of their useful life to meet other demands of society, such as housing and temporary shelters.

There are different works in the literature outside Brazil on natural disasters using adapted shipping containers as alternatives for temporary shelters (Zabinski et al. 2010; Aleksic et al. 2014; Zhang & Setunge, 2014; Tang & Ling, 2018; Cascone et al.2019; Perrucci & Baroud, 2020). However, most of this research presented case studies of weather events with a predominance of hurricanes, earthquakes, and tsunamis.

Although there are several studies on the location of temporary shelters in the context of natural disasters (Chang & Liao, 2014; Bayram & Yaman, 2017; Nappi & Souza, 2019), most are related to evacuation in the face of a disaster. Another noteworthy point is that these studies used different localization methods than those addressed in this research, as shown by Perrucci and Baroud (2020).

Additionally, it is noteworthy that in the context of this research, queries on the terminology" container shelter, "that is, container shelter has more excellent coverage in other countries than in Brazil, according to the search carried out on Google Trends, 2020 in May 2020 (Figure 1). It is precisely these countries that have also presented the most significant number of publications on the subject. When the term in Portuguese is consulted, no return is presented by the search engine, which shows little interest in this issue in Brazil.

Figure 1

Consultation of the terminology "container shelter"

Source: Google Trends, 2020.

An important issue, considering the size of the country 8,516,000 km^2 and 27 federative units, was to identify where the locations of BLHs will be proposed regarding the number of homeless people per affected region to avoid waste and costs of public bodies, reuse containers accumulated in ports, and, above all, reduce the response time to homeless victims. As such, container shelters can be used to provide help in a given disaster and then reused by another family in a new catastrophe and at another location. As it is an alternative to a temporary shelter with high mobility and flexibility, it is possible, before defining the installation of container shelters, to revalidate it, in collaboration with the population, so that the most suitable places can be chosen according to location criteria, availability, infrastructure and security (Da Costa, Fontainha & Leiras, 2017).

More specifically, within Brazil, the Integrated Disaster Information System (S2iD) explained that in 2019 alone, more than 300,000 people were left homeless (definitely homeless) or displaced (temporarily homeless) in the event of natural disasters. The survey found that 59.4% of the country's municipalities do not have any planning and risk management instrument capable of supporting and debating the prevention, reduction, and management of risks and disasters (IBGE, 2017).

The research considered as a basis for the development of the proposal the collection of data in Brazilian public databases, the natural disasters that occurred between (2013-2018) and the BHL proposal was discussed according to a disaster pattern different from what is discussed in the scientific literature and considering the large territorial dimensions of the country.

As a result, it was possible to identify the regions of the country with the highest rates of victims by natural disasters that may need temporary shelter, as well as the amount of 52

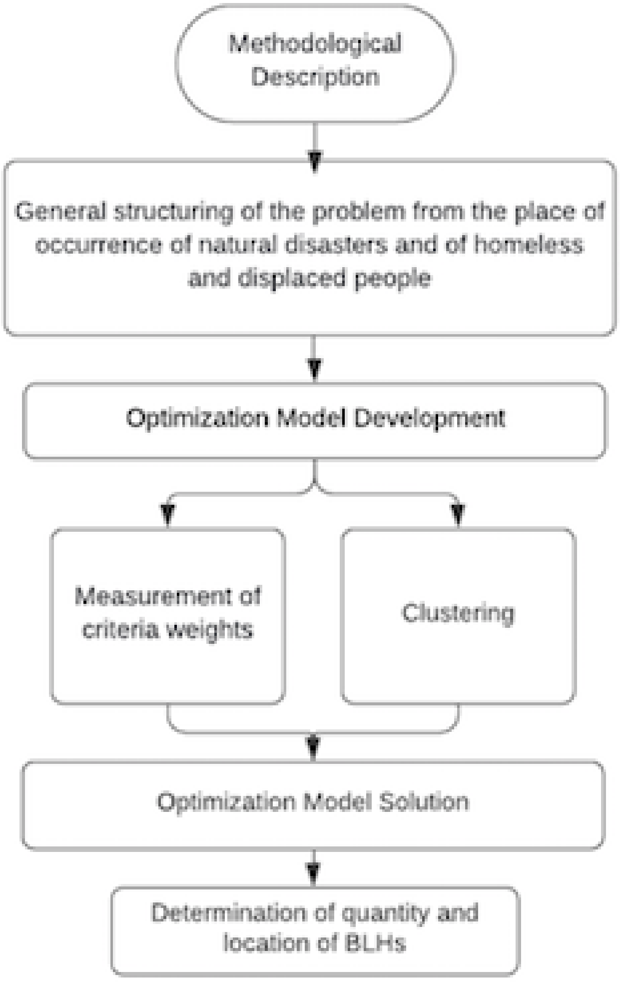
HMBs totaling 90,775 adapted recycled shipping containers required to meet the demand for homeless people. From a national point of view, it was possible to visualize an integrated national distribution and support network between the BLHs. Finally, we proposed a flowchart for decision-making to use the HMB, which can be used as a reference for decision-makers. The main contribution of this article is to present a proposal for an integrated support network for natural disasters composed of adapted shipping container shelters.

Methodology

This article sought to assess the characteristics of natural disasters that occurred in the Brazilian territory between 2013 – 2018, considering their impacts and the quantification of homeless and homeless people at the national level. Figure 2 demonstrates the synthesis of the methodological procedure adopted in this research.

Figure 2

Synthesis of the methodological research procedure



Source: Own elaboration, 2020.

Having obtained, research data surveys were carried out in the public databases of various government agencies responsible for natural disasters in Brazil. The tool with the most significant coverage and the most recent information was the Integrated Disaster Information System (S2iD), a consultation base for citizens, organized in a "Geo" tool that allows public managers and researchers to develop knowledge in managing risks and disasters (Ministry of Regional Development, 2019). The main variables analyzed were types of natural disasters, State, Municipality and the numbers of homeless and displaced people, as the target audience of the study are people whose homes were destroyed or damaged by disasters or are located in areas with imminent risk of destruction, and who need temporary shelters to be accommodated (Defesa Civil Paraná, 2012).

In the research, the existence of a high standard deviation of the samples (number of homeless and displaced) was verified in the analyzed states, justifying the randomness of the events. Thus, a redesignation of the sample size was carried out according to the places of most remarkable occurrence, selecting priorities through the Pareto technique, which according to Vergueiro (2002), is used to identify the place where there is the most significant number of occurrences of problematic situations and prioritize your actions. The selected municipalities were those that obtained an accumulated percentage of up to 80% of homeless people in the period from 2013 to 2018. This reduction was adopted as a premise so that there would be no idleness of adapted containers due to the low number of homeless people in several Brazilian municipalities.

From the definition of the numbers of homeless people in each Brazilian State, the p-Medians problem was used as a method of locating facilities. p-Median is a category of location-allocation model whose objective is to identify the ideal locations for a p number of facilities that need to supply N customers in order to minimize the sum of distances between each customer (or user) and the nearest facility (Revelle & Swain, 1970). A weight is assigned to each demand vertex, Baray and Cliquet (2013) comment that demand restriction, in the case of health services, for example, consists of offering accessibility to the most significant number of users, which means that an installation should cover most of the demand in its reach region.

Hakimi (1965) made it simple to determine a median. Considering a graph G, where V is the set of vertices and E is the location of edges. In many applications, it happens that the vertices are associated with values that represent the importance of each one. That is, the vertices are weighted by a demand. In order for the formulation for application in several problems to be more generic, consider weights such as. From this information, a matrix, called distance-weight, is constructed, where the inputs are the minimum distance between the vertex and the vertex multiplied by the vertex weight, that is. For each vertex, considering the distance from the vertex to the vertex represented by, the transmission number is defined by Equation, objective function (2.1).

$$Min\ \sigma(x_i) = \sum_{x_j \in V} v_j d(x_i, x_j) \quad (2.1)$$

S.a.

$$\sum_{j \in V} x_{ij} = 1; i \in \quad (2.2)$$

$$\sum_{j \in V} x_{ij} = \mathrm{p} \quad (2.3)$$

$$x_{ij} \leq x_{jj}; i, j \in V \quad (2.4)$$

$$x_{ij} \in \{0, 1\}; i, j \in V \quad (2.5)$$

The objective function (2.1) determines the minimization of the weighted distances. Constraints (2.2) ensure that each customer is allocated to only one facility. Restrictions (2.3) ensure that only p medians offer services to (homeless) customers and also define the number of medians that will be installed. Conditions (2.4) certify that a customer is only served in a location where there is a median offering such services. Constraints (2.5) state that the variable is binary, zero, or one (Pizzolato & Almamora, 2012).

Thus, the ideal location for the installation of an BLH in each Brazilian State is an essential strategy for reducing the response time for people who need temporary shelter. For the construction of this algorithm, it was necessary to determine some variables, such as the number of p installations required in each State. In this sense, clustering was used, which consists of finding clusters in the data, considering that cluster analysis allows identifying which variables belong to the same group. For cluster analysis, Origin software was used. With the formation of groups, the number of clusters found was used as the number of BLHs, located in the p-Median method in each Brazilian State.

In the application of the p-Medians method, it was also necessary to include the matrix of distances between cities for each State. For this, we used geographic points to determine the calculations through the Google Maps tool, choosing the shortest route between cities.

The SMART method was used to measure the weight of each criterion, as it has greater freedom of choice (Barron & Barret, 1996; Lopes & Almeida, 2008). The criterion "Number of Homeless" was proposed as the most important, as homeless people, as referred to by the Civil Defense (DC) definition, are those who have permanently lost their homes and need housing assistance from the government. The criterion "Number of Displaced Persons" was identified as the least important because people do not necessarily lack shelter provided by the State. The criteria weights were also normalized to maintain the same scale of such weights, following the SMART method considerations. The least important criterion assumed the weight of 10 points, and the most important one assumed the weight of 15 points, preserving the relationship of how many times the most important criterion is more desirable than the antecedent one. Then, the normalization and weighting of the criteria were performed, and thus, the final weights, vj, of each city were defined by multiplying the values of the normalized criteria by their respective normalized weights, obtaining the final matrix of weights for each State.

After the identification of the matrices and the objective function, Equation 2.1, the p-Medians method was used in the optimization software, free version, CPLEX Optimization (IBM), to identify the best location of the BLHs.

In the end, it was necessary to estimate the number of containers for each BLH. Based on the number of homeless individuals in the States, a division was made by the number of members of a Brazilian family, which, according to data from the last IBGE Demographic Census (2010), the average number of residents per household in Brazil is 3.3 people. With this, a new variable was estimated, the number of homeless families, also determining the average demand per container for each BLH. And so, a cost projection for each BLH was determined, taking into account the price of a simple 40-foot container house (Ramos & Pereira, 2018). Although (Zabinski et al. 2010) have estimated the cost of a container house at $17,489 and €11,364 per (Aleksic et al. 2014), in this research, the cost of (Ramos & Pereira, 2018) was considered for estimation. The fact that the amount of R$ 25,350.88 (±$6.670 in the period) was estimated considering a survey carried out with Brazilian suppliers. The costs of transportation, storage, installation, and other possibly necessary adaptations were not considered in this cost projection, being a limitation of this research. Furthermore, it was thought that each adapted 40-foot container would already have its housing items such as kitchen, bedroom, and bathroom inside the unit itself. Additionally, a functional flowchart of BLH operation was proposed, considering the process of activating the shelters available to be used in combating victims of natural disasters.

Results

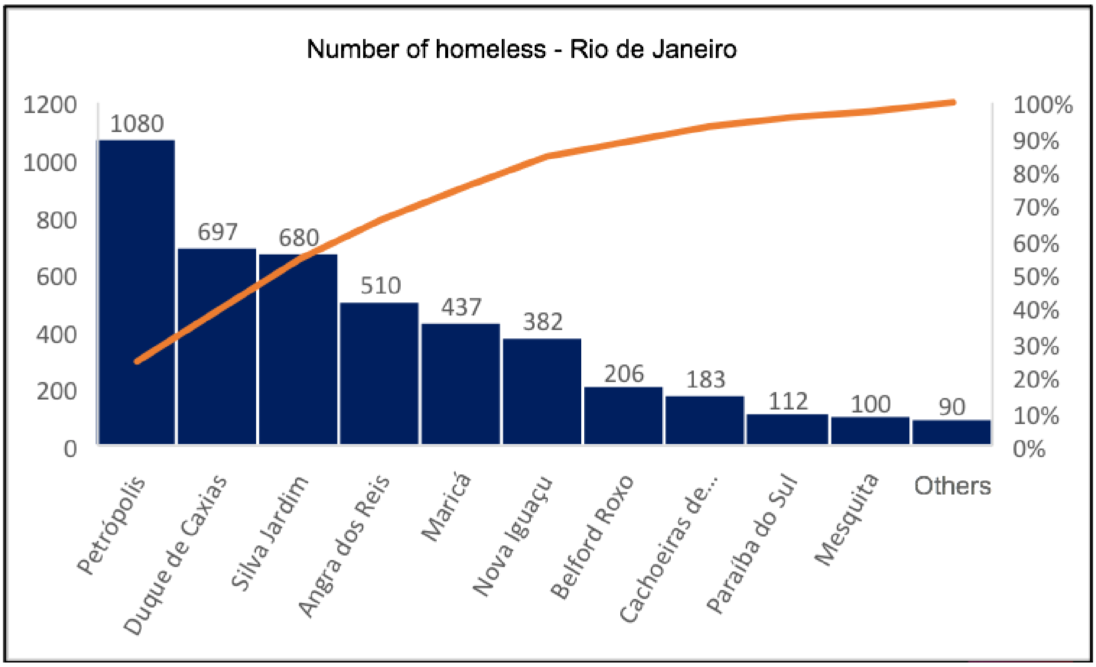
The survey results found the analysis of the characteristics of natural disasters during the period (2013-2018) for all and Brazilian states. To exemplify the procedure used, I exposed the results of the State of Rio de Janeiro in this section.

The main types of natural disasters that most displaced the population of the State of Rio de Janeiro were floods with 44%, followed by landslides (36%) and runoff (17%). In addition, natural disasters caused the loss of human lives and many homeless people

(Barcellos et al. 2016; Costa, 2016). Figure 3 showed the municipalities with the highest numbers of homeless individuals, with the cities of Petrópolis (1,074), Duque de Caxias, and Silva Jardim being the most relevant in this regard. In these cities, events linked to flooding (Barcellos et al. 2017) were the most pertinent.

Figure 3

Number of homeless people in the municipalities of the State of Rio de Janeiro (2013-2018)



Source: Own elaboration, 2020.

Table 1 presented the numbers of homeless and displaced persons related to natural disasters in the country. For example, viewers found that the floods, heavy rains, and floods caused many people to homeless.

Table 1

List of numbers of homeless and displaced persons with the types of natural disasters

States	No. of homeless	No. of displaced	Types of natural disasters
AC	11168	25779	84% - Floods
AL	7055	14141	96% - Heavy Rain
AP	315	525	58% - Fires
AM	108650	108353	65% - Floods
BA	15554	34951	36% - Floods 25% - Enxurradas
CE	330	478	72% - Coastal Erosion
ES	5205	35992	37% - Floods 35% - Enxurradas
GO/DF	1351	1640	73% - Flooding
MA	1672	2290	28% - Floods 28% - Flooding
MT	1273	2187	41% - Floods 29% - Heavy Rain
MS	1285	3659	46% - Floods 36% - Flooding
MG	8336	23066	36% - Heavy Rain 13% - Floods 11% - Drought
PA	21184	26711	67% - Floods
PB	23535	20562	43% - Heavy Rain 34% - Slips
PR	7616	58236	64% - Heavy Rain
PE	11373	58797	71% - Enxurradas
PI	4255	2905	78% - Fires
RJ	4387	29783	44% - Floods 36% - Slips
RN	105	965	95% - Enxurradas

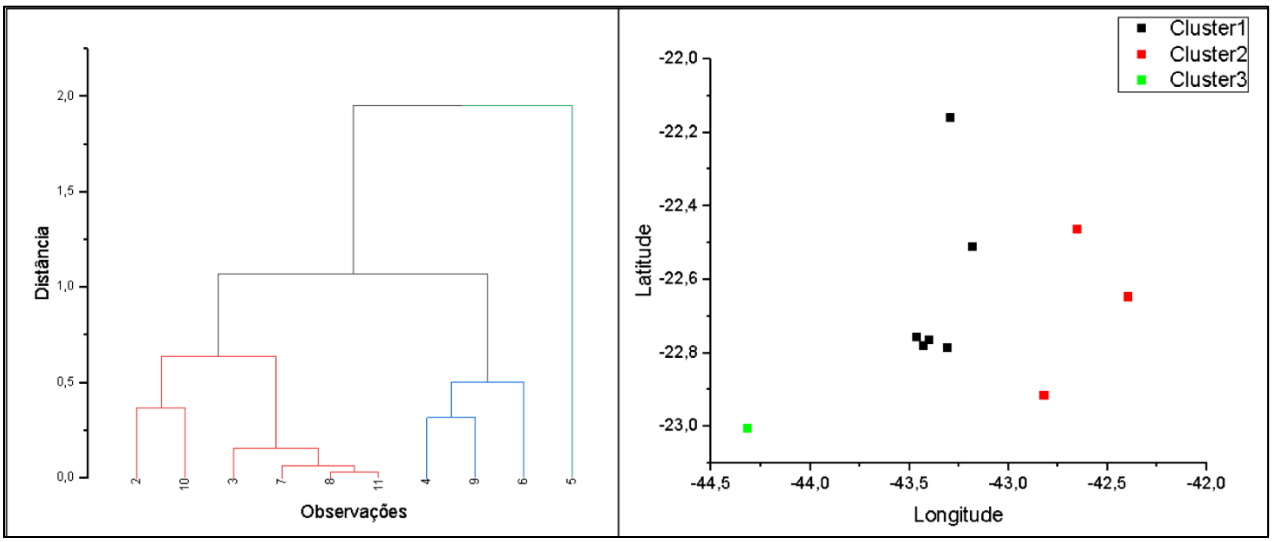
States	No. of homeless	No. of displaced	Types of natural disasters
RS	34348	213870	51% - Floods 20% - Hail
RO	3449	19174	97% - Floods
RR	355	945	65% - Gale
SC	20693	125989	33% - Floods 31% - Heavy Rain
SP	3982	19906	46% - Flooding 17% - Floods
SE	162	76	92% - Heavy Rain
TO	1920	0	100% - Heavy Rain

Source: Own elaboration, 2020.

Figure 4 presented a dendrogram identified by the Origin software from the longitude and latitude of the municipalities of the State of Rio de Janeiro, showing the presence of three clusters (clusters) identified by the colors red, blue, and green. You can then observe the non-homogeneous geographic distribution in the State. Thus, three HLBs for the State of Rio de Janeiro, so three medians were located in the p- Median method.

Figure 4

Dendrogram and cluster graph - Rio de Janeiro



Source: *Software Origin, 2020.*

From the determination of the number of BLHs, applied the p-Median method using the CPLEX solver. Thus, identified the locations of the HLBs, taking into account the demand and distance between cities to serve several regions. To exemplify the procedure applied to all areas of the country, I processed the data from the State of Rio de Janeiro using an algorithm in the CPLEX software (IBM), which generated the 10x10 solution matrix as a result (Figure 5). The lines identify the cities allocated to the BLHs, and the columns, the “candidate” cities to receive the premises of the BLHs. In the columns (cities) Duque de Caxias, Silva Jardim, and Angra dos Reis, respectively, the value one was assigned, which means that these cities were verified as the ideal place to house the HLBs using the p-Median method. It's also observed the distribution of which cities the BLH will serve from the interaction = 1. When the city's interaction with the city is equal to 1, BLH will attend the same.

Having applied the p-Medians method, a matrix of distances includes the between the cities for each State. For this, the geographic points were pointed out to determine the calculations through the Google Maps tool, choosing the shortest route among the cities. Table 2 shows the distance matrix in kilometers between towns in the State of Rio de Janeiro.

Tabela 2

Distance (Km) between cities in Rio de Janeiro

Rio de Janeiro State										
	Petrópolis	Duque de Caxias	Silva Jardim	Angra dos Reis	Maricá	Nova Iguaçu	Belford Roxo	Cachoeiras de Macacu	Paraíb a do Sul	Mesquita
Petrópolis	0	46	127	182	115	70	64	86	79	67
Duque de Caxias	49	0	122	144	72	27	20	90	122	24
Silva Jardim	147	123	0	253	83	137	130	93	220	134
Angra dos Reis	184	147	253	0	203	130	137	225	197	136
Maricá	114	73	81	204	0	88	81	69	187	85
Nova Iguaçu	70	25	137	133	86	0	8	111	143	5
Belford Roxo	65	20	133	138	82	8	0	105	138	6
Cachoeiras de Macacu	106	87	93	223	70	111	104	0	179	108
Paraíba do Sul	77	117	220	199	186	142	135	179	0	139
Mesquita	68	23	136	139	85	6	7	109	141	0

Source: Own elaboration, 2020.

After carrying out the normalization and weighting of the criteria, the final weights of each city were defined by multiplying the values of the normalized criteria by their respective normalized weights, thus obtaining the final matrix of weights for each State. As an example, Table 3 shows the thin weights of cities in the State of Rio de Janeiro.

Tabela 3

Final Weights of the cities of Rio de Janeiro

Counties	Final Weights
Petrópolis	0,17041
Duque de Caxias	0,13025
Silva Jardim	0,16573
Angra dos Reis	0,18555
Maricá	0,09334
Nova Iguaçu	0,07203
Belford Roxo	0,05504
Cachoeiras de Macacu	0,06630
Paraíba do Sul	0,02673
Mesquita	0,03463

Source: Own elaboration, 2020.

The final weights obtained in Table 3 are applied to the objective function of Equation 2.1, matrix, being essential for the implementation of the p-Median problem algorithm. Figure 5 represents the solution matrix in which the cities of Duque de Caxias, Silva Jardim, and Angra dos Reis were found as "optimal solutions" for locating BLHs to serve the homeless in the State of Rio de Janeiro.

Figure *5*

Solution for determining the HLB – Rio de Janeiro

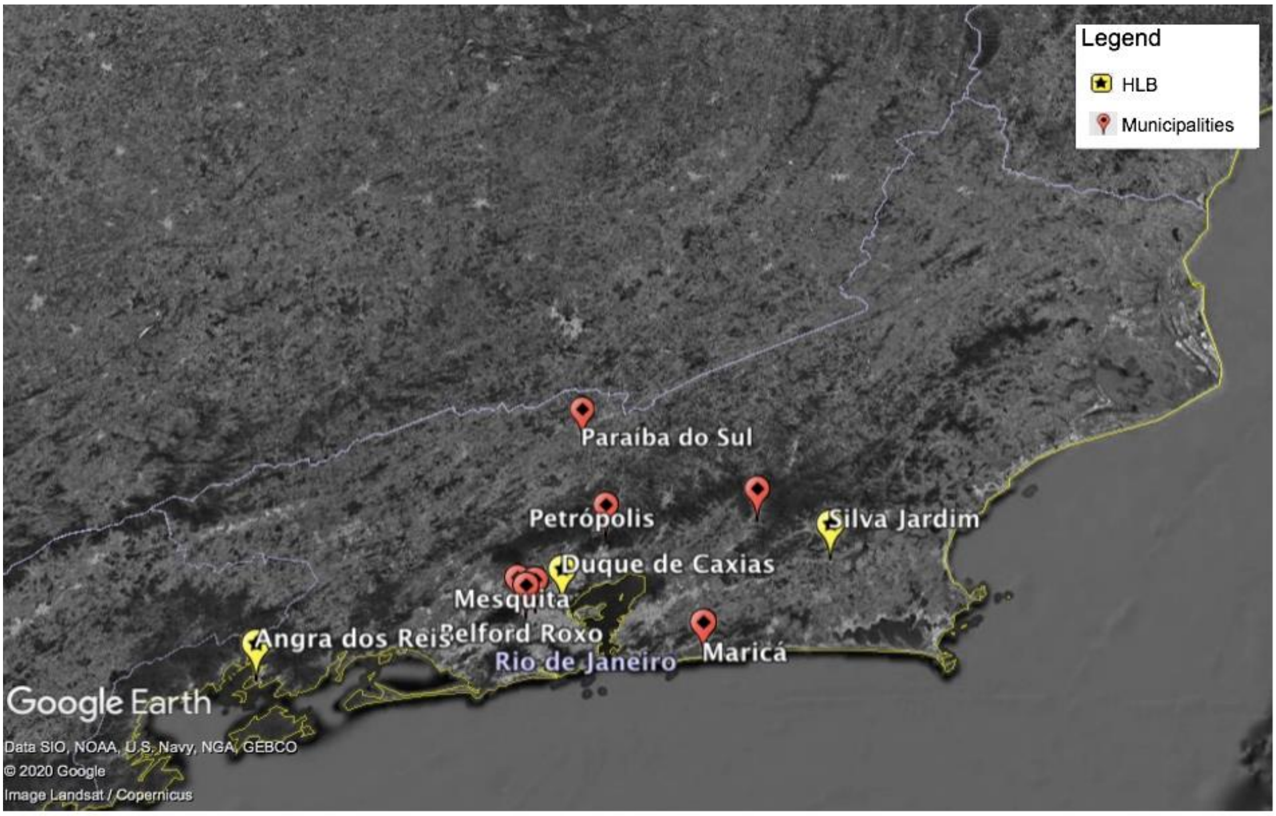
```
Problemas   Log de Script   Soluções ☒   Conflitos   Livres   Log do mecanismo
// solution (optimal) with objective 27.246655493
// Quality Incumbent solution:
// MILP objective                              2,7246655493e+01
// MILP solution norm |x| (Total, Max)         1,00000e+01  1,00000e+00
// MILP solution error (Ax=b) (Total, Max)     0,00000e+00  0,00000e+00
// MILP x bound error (Total, Max)             0,00000e+00  0,00000e+00
// MILP x integrality error (Total, Max)       0,00000e+00  0,00000e+00
// MILP slack bound error (Total, Max)         0,00000e+00  0,00000e+00
//

x = [[0
             1 0 0 0 0 0 0 0 0]
             [0 1 0 0 0 0 0 0 0 0]
             [0 0 1 0 0 0 0 0 0 0]
             [0 0 0 1 0 0 0 0 0 0]
             [0 1 0 0 0 0 0 0 0 0]
             [0 1 0 0 0 0 0 0 0 0]
             [0 1 0 0 0 0 0 0 0 0]
             [0 1 0 0 0 0 0 0 0 0]
             [0 1 0 0 0 0 0 0 0 0]
             [0 1 0 0 0 0 0 0 0 0]];
```

Source: *Software* IBM ILOG CPLEX, 2020.

Figure 6 presents a political map of the State of Rio de Janeiro with many homeless people in the analyzed period, highlighted in red and the BLHs in yellow. Also, there is a municipalities concentration in the southern coastal region of the State, observing the presence of BLHs in this region, demonstrating a non-coverage throughout the State's territory. These regions are those having the greatest problems concerning natural disasters reported in recent years (Ardaya & Ribbe, 2017; Barcellos et al. 2016; Barcellos et al. 2017; Mendonca and Gullo, 2020; Mendonca & Da Silva, 2020), showing that the solution identified considered the most relevant points for the State.

Figure 6

Location of HLBs in the State of Rio de Janeiro



Source: Google Earth Pro, 2020.

The results of the location of the BLHs in the other Brazilian states are presented in Table 3. In the third column of Table 3 are the municipalities that were identified, the optimal solution of the algorithm, as the best location for the installation of the BLHs in each State, being also presented their respective geographic coordinates. The number of BLH's for each State (fourth column), in addition to the number of containers needed and the overall cost (fifth column).

The Brazilian states had different amounts of BLHs among themselves due to the variability of the numbers of homeless and displaced people, depending on the history of natural disasters that occurred between (2013-2018).

After identifying the location where the BLHs were to be installed, a conversion of the numbers of homeless people into homeless families was carried out, thus obtaining the number of container houses that each BLH would need to assist victims of natural disasters.

Based on the numbers of homeless people in each State (Table 3), a division was made by the average number of people per household in Brazil, with about 3.3 people IBGE (2010). Therefore, the number of containers for each BLH was defined (Table 3).

Table 3 shows that the South and Southeast regions had more than one BLH in all their states. This fact is explained by the high number of municipalities in these territories that have been devastated by natural disasters over the past few years, with 62,657 homeless in the South region and 21,910 in the Southeast region, which can also be observed by the Atlas of Natural Disasters, as well as, by the flood and landslide vulnerability index presented (Debortoli et al. 2017). The North region also stood out for the number of homeless (147,041); specific municipalities such as Careiro, Manaus, and Manaquiri in the Amazon region presented numbers of approximately 15,000 homeless in the analyzed period. This is explained by being a region that suffers every year from the floods of the Amazon rivers that surround the identified municipalities. These impacts in terms of housing losses due to rainfall in this region, as they are in a region of high exposure to natural disasters related to flooding identified by the Index-Disaster Risk Indicators in Brazil DRIB (de Almeida et al. 2017).

Table 3

Results of the HLBs allocation procedure in Brazil

States	Municipalities (HLBs)	LONG	LAT	No. of HLBs	No. of containers	Investment by HLB ($)
AC	Rio Branco	-67,80756	-9,97388	2	3384	$15.887.689,55
	Cruzeiro do Sul	-72,67433	-7,63025			
AL	Marechal Deodoro	-35,84087	-9,77	2	2138	$10.036.501,59
	Pilar	-35,95215	-9,59044			
AP	Vitória do Jari	-52,4054	-0,92045	1	95	$448.121,62
AM	Manaus	-60,0518	-3,10915	3	32924	$154.566.392,37
	Tefé	-64,71713	-3,35475			
	Itamar	-68,24726	-6,43375			
BA	Xique-Xique	-42,72482	-10,823313	3	4713	$22.127.249,58
	Itabuna	-39,27719	-14,78895			
	Riachão do Jacuípe	-39,38642	-11,80701			
CE	Trairi	-39,26798	-3,2761	1	100	$469.460,74
ES	Santa Maria de Jetibá	-40,74228	-20,02727	2	1577	$7.404.676,23
	Barra de São Francisco	-40,89295	-18,75237			

States	Municipalities (HLBs)	LONG	LAT	No. of HLBs	No. of containers	Investment by HLB ($)
GO/DF	Planaltina	-47,5663	-15,43054	1	409	$1.921.943,82
MA	Trizidela do Vale	-44,62628	-4,5549	1	507	$2.378.601,09
MT	Campo Novo do Parecis	-57,89293	-13,65997	1	386	$1.810.980,37
MS	Porto Murtinho	-57,88613	-21,69622	2	389	$1.828.051,67
	Aquidauana	-55,7867	-20,47551			
MG	Francisco de Sá	-43,48642	-16,47396	4	2526	$11.858.862,83
	Resplendor	-41,25113	-19,32437			
	Belo Horizonte	-43,93833	-19,91952			
	Novo Oriente de Minas	-41,21611	-17,41512			
PA	Marabá	-49,12513	-5,37091	2	6419	$30.136.534,34
	Terra Santa	-56,48864	-2,10966			
PB	João Pessoa	-34,86108	-7,11526	1	7132	$33.481.086,46
PR	Rio Negro	-49,79881	-26,10382	4	2308	$10.834.584,85
	União da Vitória	-51,08665	-26,2306			
	Irati	-50,65111	-25,46774			
	Nova Prata do Iguaçu	-53,34449	-25,63592			
PE	Bodocó	-39,93261	-7,77936	3	3446	$16.179.324,26
	Calendar	-35,71347	-8,6741			
	Rio Formoso	-35,15342	-8,66269			
PI	Luzilândia	-42,36859	-3,46499	1	1289	$6.053.198,34
RJ	Duque de Caxias	-43,30513	-22,786412	3	1329	$6.240.982,64
	Silva Jardim	-42,39551	-22,647636			
	Angra dos Reis	-44,31551	-23,005735			
RN	Tours	-35,4605	-5,19887	1	32	$149.373,87
RS	Nonoai	-52,77486	-27,36694	3	10408	$48.863.750,07
	Itaqui	-56,5566	-29,12144			
	Esteio	-51,17082	-29,84776			

States	Municipalities (HLBs)	LONG	LAT	No. of HLBs	No. of containers	Investment by HLB ($)
RO	Porto Velho	-63,90199	-8,76167	2	1045	$4.906.576,04
	Cacoal	-61,44862	-11,43117			
RR	Caracaraí	-61,12766	1,82513	1	108	$505.025,95
SC	Barra Velha	-48,41728	-26,37593	4	6271	$29.438.033,66
	Três Barras	-50,18434	-26,72691			
	Rio do Sul	-49,38359	-27,125819			
	Dionísio Cerqueira	-53,38106	-26,155392			
SP	Cajamar	-46,87803	-23,355618	2	1207	$5.664.826,27
	Dracena	-51,5382	-21,490791			
SE	Aracaju	-37,07446	-10,90921	1	49	$230.462,55
TO	Lagoa da Confusão	-49,62148	-10,79036	1	582	$2.731.407,95
Total				**52**	**90.775**	**$426.153.698,72**

Source: Own elaboration, 2020.

In terms of investments to acquire the number of containers for the adoption of this type of temporary shelter alternative, an estimate was made for each State (sixth column of Table 3), considering the value of an adapted container house. The cost of a simple 30 m 2 house with sustainable pet wool coatings and vinyl flooring is approximately R$25,350.88 (Ramos & Pereira, 2018).

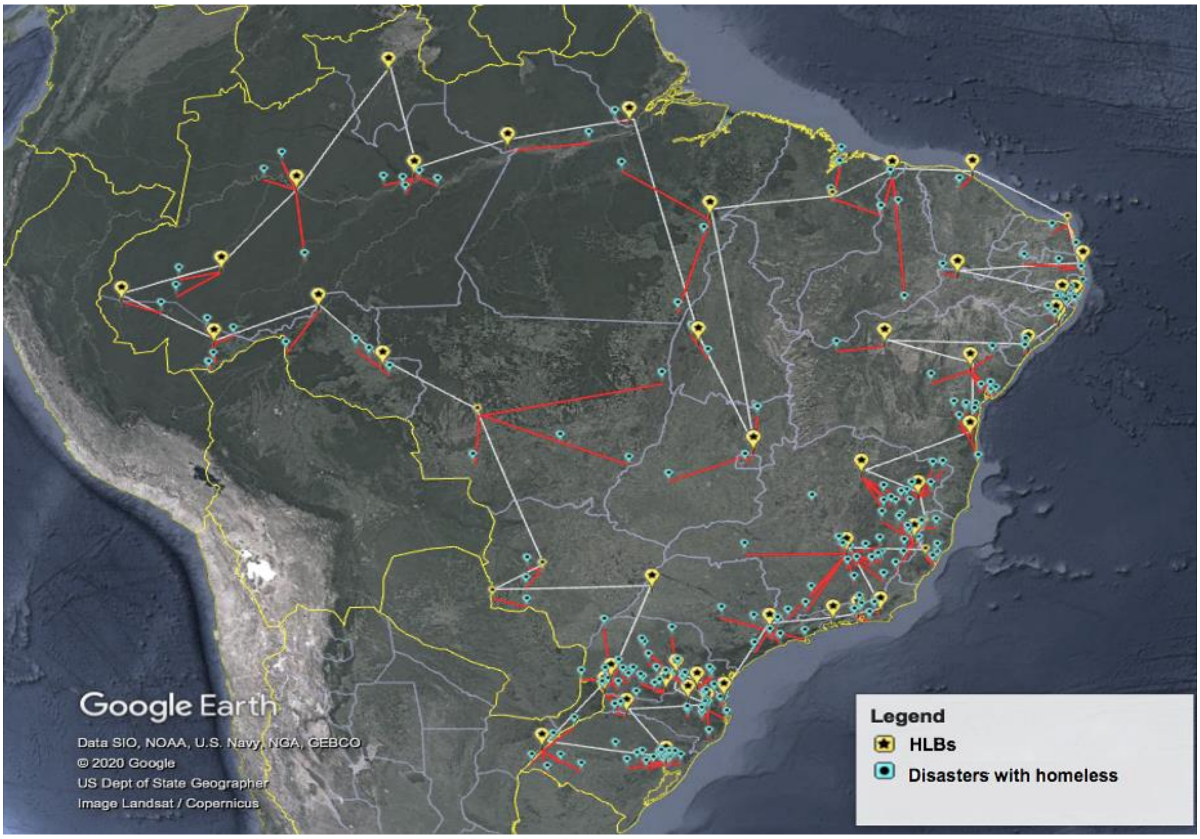
It is noted that, according to the results in Table 3, 52 BLHs would be needed, distributed throughout the country, with a quantity of 89,471 containers adapted to meet the average number of homeless people in the period analyzed in each Brazilian State. The investment required would be of the order of R$ 2.3 billion (± $605 million dollars) considering the value of R$ 3.80 for conversion (Ramos & Pereira, 2018), considering only the investments necessary for the acquisition of the shelters, not storage, logistics, installation and maintenance costs being evaluated. In this regard, an estimate made for the installation of 205 container shelters to be used as temporary shelters for war refugees and victims of natural disasters in Serbia was estimated at €1,379,263.70 (Aleksic et al. 2014). On a smaller scale for the construction of a temporary shelter for adapted containers considering an infrastructure with collaborative kitchen, shared bathrooms, and housing in 20-foot containers, for 64 units it was budgeted at $1,587,657 to be used in natural disasters in the United States (Zabinski et al. al, 2010).

From the results, it can be observed that the State of Amazonas demanded the greatest quantity of container shelters, and consequently, the greatest investment from BLH. This fact may possibly be related to the fact that the State is located in a region with a high rate of natural disasters due to flooding, as well as the conditions of housing and social vulnerability (Dolman et al. 2018; Menezes et al. 2018; Guimarães et al. 2019).

From Figure 7, it is possible to obtain a spatial view of the distribution network that the 52 BLHs would reach in the country. Note that coastal regions have a higher concentration of BLHs compared to the central region of the country (Midwest). The locations of the BLHs in some states, such as Santa Catarina, Paraná, Rio de Janeiro, and Pernambuco, were very close to each other, which can maximize the support network in these regions in case of natural disasters of greater magnitude and with a high number of homeless. This is also related to the distribution and areas of greatest environmental vulnerability that can be observed (Debortoli et al. 2017).

Figure *7*

Georeferencing the map of Brazil



Source: Google Earth Pro, 2020.

The proposition of this procedure vis or propose a conceptual model of functioning that can guide public power in operationalizing the BLHs in the Brazilian territory. Therefore, the principle of reusing adapted containers would be guaranteed when the homeless will serve by the government or have their original conditions restored. Thus, the proposal ensures a permanent stock of containers adapted to attend the events that occur year after year in the Brazilian territory. Furthermore, this proposed model has an innovative character in Brazil and can serve as a reference for other countries.

Discussion

Due to violence and agility, characteristics of natural phenomena, there are high rates of homeless, displaced people, and even deaths from natural disasters. According to the Brazilian Atlas of Natural Disasters, the southeast region of Brazil had a high number of deaths (1991-2020), with a total of 2,294 deaths (Debortoli et al. 2017).

When analyzing the natural disasters that affected Brazil in the period studied (2013-2018), it is noted that climate events do not happen in precisely the same places every year, as they are unpredictable events. However, the type of natural disaster, such as floods and floods, occurs more frequently in all Brazilian states, leaving numerous families homeless/homeless (Soler et al. 2013; Dolman et al. 2018; Guimarães et al. 2019).

Floods are events related to increased rainfall concentrated in a short period of time, and floods, unlike floods, are directly related to long periods of continuous rain (CEPED, 2012). The highest rainfall indices occur in summer, between the months of October and March (de Albuquerque & Mendiondo, 2014). Therefore, it is noted that the events that act, mainly in the rainy season and in the summer, have a greater probability of causing damage and homeless victims.

There are several works in the literature outside Brazil on natural disasters using adapted shipping containers as alternatives for temporary shelters (Zabinski et al. 2010; Aleksic et al. 2014; Zhang & Setunge, 2014; Wong et al. 2018; Tang & Ling, 2018). However, most of these researches presented case studies of climatic events different from those that occur more frequently in the Brazilian territory (floods and landslides), with a greater predominance of hurricanes, earthquakes, and tsunamis.

Although there are several studies on the location of temporary shelters in the context of natural disasters (Bayram & Yaman, 2017; Chang & Liao, 2014; Nappi & Souza, 2019), most are related to evacuation in the face of disaster. In addition, they use different location methods from the one discussed in this research. It was also observed that researches that employ the p-Medians method in the location of temporary shelters with containers is a subject little or hardly debated in the Brazilian scenario.

Having the method analyzed, the researchers used the p-Medians. It is possible to see that there were limitations in its application. In view of the results, it was noted that in some states such as Paraná, Santa Catarina, Rio de Janeiro, and Pernambuco, it generated greater proximity between the HMBs in the State itself. Such proximity reflects the concentration of cities affected by natural disasters in a given region. Thus, in these same states, coverage by HMBs was not verified throughout the state territory. This limitation is due to the fact that the method analyzes demand as a function of the distance between cities. Thus, for states that witnessed an agglomeration of municipalities, the method responds according to the relation of demand and distance (Xi et al. 2013).

When checking the georeferencing of the map of Brazil, it appears that most BLHs were distributed throughout the country's coastal region, mainly in the South and Southeast regions. This result reflects the demographic density of the country, the focus of occurrences of these disasters, often caused by irregular occupations along rivers and places of high environmental vulnerability. The Southeast and South regions have the highest Brazilian densities, which means that the majority of Brazil's population resides in these territories (IBGE Demographic Census, 2013), which are also subject to natural disasters.

The Midwest region had the lowest number of homeless and BLHs allocated across the country. Most states in this region required one BLH in each, but there was no concentration of municipalities in these states. Thus, the BLHs were located in the central region of each State in this region, allowing for better service throughout the territory. Despite the low number of HMBs in the Midwest region, there is a need for these HMBs, as there was a concentration of bases in the coastal zone of the country, this region would be helpless if it were served by bases from other Brazilian regions, due to the form of occupation of the territory.

The states of Rio Grande do Norte (Northeast) and Roraima (North) had only one municipality with numbers of people displaced by natural disasters in the analyzed period. Therefore, the HMB was located in these municipalities. These states have borders and proximity to other states and regions that have had a greater number of cities with homeless people. Therefore, an alternative would be the sharing of BLHs, in order to avoid idleness in places that have lower demands. It should be noted that the lack of information on records and data in relation to natural disasters, as well as the number of homeless people, can interfere with these numbers and analyses.

Determining the ideal location for the installation of BLHs in Brazilian states is a strategy to reduce the response time for people in need of temporary shelter. The importance of a correct location also interferes with the transport costs of the container shelter, as they can be reduced if the help centers are more decentralized, thus creating alternative routes that are shorter and, consequently, less costly. As seen in the distribution of the HMBs, although some are more centralized among themselves, there is a support network formed by the connection of the HMBs that covers the entire national territory, offering a contribution in relation to prompt assistance to homeless victims. Thus, the location of a temporary shelter should focus on efficiency and effectiveness in the emergency management process (Coutinho-Rodrigues et al. 2012; Xi et al. 2013), considering the evacuation process and the location of the shelter (Alçada - Almeida et al. 2009).

Unlike conventional temporary shelters used in Brazil, such as collective shelters in public offices, tents, or masonry houses, container shelters can be used to provide help in a given disaster and then reused by another family in a new disaster in another location. This is an alternative that aims to avoid waste and costs of public agencies, reuse containers accumulated in ports, and, above all, reduce the response time to homeless victims. Examples of studies involving containers for shelters were presented in the United States by (Zabinski et al. 2010); in Serbia (Aleksic et al. 2014); in Japan (Abulnour, 2014); in Malaysia (Tan and Ling, 2018); and in Brazil (Ramos & Pereira, 2018), considering post-disaster shelters. Therefore, this research shows potential for innovation in the management of homeless victims of natural disasters in Brazil since this type of shelter alternative is not used in the country.

BLHs could also assist in expediting other extraordinary events that required temporary physical structures. Due to the emergence of the Covid-19 pandemic in 2020 and the questioning of how to expand healthcare facilities in a short period of time, CURA (Connected Units for Respiratory Ailments) emerged, intensive healthcare units built with containers, developed and tested in Turin, Italy (World Economic Forum, 2020). Container constructions contribute to these emergency situations; as they are quick to assemble and disassemble structures, they can be moved from epicenter to epicenter by road, train and ship, within cities, states, countries, and even around the world (Abulnour, 2014). Problems faced in Amapá on the border of Pacaraima with Venezuelan refugees could also be mitigated with the use of this type of shelter since it was necessary to build 13 shelters in different places provided, which met a demand of 7,000 Venezuelan immigrants (Mendes, 2019).

In this context, this research initiative can help public managers to base analysis and direct political decisions and risk management techniques appropriate to their local reality, in addition to providing a detailed methodological process for locating and operating BLHs that can be used as a reference for building emergency plans in case of disasters in different time intervals and regions.

Conclusion

Planning early response measures for natural disaster situations is a recognized challenge in reducing the impact of such events around the world (Kunz et al. 2014). Therefore, this article presented procedures for locating temporary shelters for adapted shipping containers for victims of natural disasters. From the combination of p-Median methods for locating facilities, clustering, and SMART, it was possible to identify the locations of 52 HMBs across the Brazilian territory, considering the 26 states and municipalities that had the greatest natural disasters between 2013 and 2018. The location of BLHs concentrated in the coastal regions of the country due to the records of the highest rate of occurrence of natural disasters in the period analyzed. Therefore, the 52 HMBs total 90,775 40-foot container homes in a support network to serve the main regions affected by natural disasters across the country.

The damage caused by natural disasters in Brazil and in underdeveloped countries is not only connected with the magnitude of the event but also linked to human actions that lead to risky situations. A large part of the population lives in precarious conditions, where there is no basic infrastructure and unsuitable land is used for housing construction. This precariousness of cities generates vulnerability to the population, increasing risk situations in the occurrence of natural phenomena, mainly concentrated in the northern region of Brazil.

The use of adapted shipping containers is a sustainable alternative to reduce the response time of public agencies and reduce the period in which families stay in temporary shelters or without adequate shelters. This approach can allow entities linked to the maritime sector to establish partnerships with the public sector in order to meet a repressed demand in the country due to the recurrence of weather events, in addition to helping to reduce the problem of final destination, providing favorable conditions for recycling of containers. Additionally, BLHs could also offer relief from other extraordinary events that lack temporary mobile structures, such as war and pandemic actions.

References

Abulnour, A. H. (2014). The post-disaster temporary dwelling: Fundamentals of provision, design and construction. Hbrc Journal, 10(1), 10-24. https://doi.org/10.1016/j.hbrcj.2013.06.001

Alçada-Almeida, L., Tralhao, L., Santos, L., & Coutinho-Rodrigues, J. (2009). A multiobjective approach tolocate emergency shelters and identify evacuation routes in urban areas. Geographical analysis, 41(1), 9-29. https://doi.org/10.1111/j.1538-4632.2009.00745.x

Aleksic, J., Mihajlovic, V., & Jovanovic, T. (2014). Cost-benefit analysis of shipping container emergency shelters: the case study of the Republic of Serbia. Aktual'ni Problemy Ekonomiky= Actual Problems in Economics, (158), 56. https://www.researchgate.net/publication/292623055_Cost-benefit_analysis_of_shipping_container_emergency_shelters_The_case_study_of_the_republic_of_Serbia

Barcellos, P. D. C. L., Da Costa, M. S., Cataldi, M., & Soares, C. A. P. (2017). Management of non-structural measures in the prevention of flash floods: a case study in the city of Duque de Caxias, state of Rio de Janeiro, Brazil. Natural Hazards, 89(1), 313-330. https://doi.org/10.1007/s11069-017-2966-4

Barcellos, P. D. C. L., Silva, F. P. D., Vissirini, F. S. B., Magalhães, C. D. A., Terra, J. M., Dutra, M. R. F., & Amaral, I. C. F. D. (2016). Diagnóstico meteorológico dos desastres naturais ocorridos nos últimos 20 anos na cidade de Duque de Caxias. Revista Brasileira de Meteorologia, 31(3), 319-329. http://dx.doi.org/10.1590/0102-778631320150146

Barreto, S., Ferreira, C., Paixão, J., & Santos, B. S. (2007). Using clustering analysis in a capacitated location-routing problem. European Journal of Operational Research, 179(3), 968–977. https://doi.org/10.1016/j.ejor.2005.06.074

Baray, J., Cliquet, G. (2013). Optimizing locations through a maximum covering/p-median hierarchical model: Maternity hospitals in France. Journal of Business Research, 66(1), 127-132. https://doi.org/10.1016/j.jbusres.2012.09.003

Bayram, V., Yaman, H. A stochastic programming approach for Shelter location and evacuation planning. RAIRO-Oper. Res. 52 (3) 779-805, 2018. https://doi.org/10.1051/ro/2017046

Celik, E. (2017). A cause-and-effect relationship model for location of temporary shelters in disaster operations management. International journal of disaster risk reduction, 22, 257-268. https://doi.org/10.1016/j.ijdrr.2017.02.020

CEPED (Centro Universitário de Estudos e Pesquisas sobre Desastres). Relatório de danos materiais e prejuízos decorrentes de desastres naturais no Brasil: 1995 – 2014. Florianópolis: Universidade Federal de Santa Catarina, 230 p, 2016. Disponível em: http://www.ceped.ufsc.br/wp-content/uploads/2017/01/111703-WP-CEPEDRelatoriosdeDanoslayout-PUBLIC-PORTUGUESE-ABSTRACT-SENT.pdf

Costa, G. G. (2016). Identificação de Municípios Homogêneos Quanto A Ameaças Ambientais No Estado do Rio de Janeiro por Two Step Cluster. Revista Brasileira de Gestão Ambiental, 10(1), 62-71. https://www.gvaa.com.br/revista/index.php/RBGA/article/view/4207

Coutinho-Rodrigues, J., Tralhão, L., & Alçada-Almeida, L. (2012). Solving a location-routing problem with a multiobjective approach: the design of urban evacuation plans. Journal of Transport Geography, 22, 206-218. https://doi.org/10.1016/j.jtrangeo.2012.01.006

Guimarães, D. F. S, dos Santos Belmiro, C., Alves de Vasconcelos, M., & dos Santos Pereira, H. (2019). Fluvial environmental disasters: risk perception and evaluation of government responses by riverine populations in Cacau Pirêra, Iranduba/AM. Sustainability in Debate/Sustentabilidade em Debate, 10(3). https://doi.org/10.18472/SustDeb.v10n3.2019.23711

Dalal, J., Mohapatra, P. K. J., & Mitra, G. C. (2007). Locating cyclone shelters: A case. Disaster Prevention and Management: An International Journal, 16(2), 235–244. https://doi.org/10.1108/09653560710739559

de Almeida, L. Q., Welle, T., & Birkmann, J. (2016). Disaster risk indicators in Brazil: a proposal based on he world risk index. International journal of disaster risk reduction, 17, 251-272. https://doi.org/10.1016/j.ijdrr.2016.04.007

de Mendonca, M. B., & da Silva, D. R. (2020). Integration of census data based vulnerability in landslide risk mapping-The case of Angra dos Reis, Rio de Janeiro, Brazil.

International Journal of Disaster Risk Reduction, 50, 101884. https://doi.org/10.1016/j.ijdrr.2020.101884

de Mendonca, M. B., & Gullo, F. T. (2020). Landslide risk perception survey in Angra dos Reis (Rio de Janeiro, southeastern Brazil): A contribution to support planning of non structural measures. Land Use Policy, 91, 104415. https://doi.org/10.1016/j.landusepol.2019.104415

Debortoli, N.S., Camarinha, P.I.M., Marengo, J.A. et al. An index of Brazil's vulnerability to expected increases in natural flash flooding and landslide disasters in the context of climate change. Nat Hazards 86, 557–582 (2017). https://doi.org/10.1007/s11069-016-2705-2

DEFESA CIVIL. Glossário de defesa civil estudos de riscos e medicina de desastres. Disponível em: < http://www.defesacivil.mg.gov.br/images/documentos/Defesa%20Civil/manuais/GLOSSARIO-Dicionario-Defesa-Civil.pdf>. Acesso em: 03/04/2019.

Degrossi, L. C., de Albuquerque, J. P., Fava, M. C., Mendiondo, E. M. (2014, July). Flood Citizen Observatory: a crowdsourcing-based approach for flood risk management in Brazil. In SEKE (pp. 570-575). https://www.researchgate.net/publication/262939561_Flood_Citizen_Observatory_a_crowdsourcing-based_approach_for_flood_risk_management_in_Brazil

Dolman, D. I., Brown, I. F., Anderson, L. O., Warner, J. F., Marchezini, V., & Santos, G. L. P. (2018). Re-thinking socio-economic impact assessments of disasters: The 2015 flood in Rio Branco, Brazilian Amazon. International journal of disaster risk reduction, 31, 212-219. https://doi.org/10.1016/j.ijdrr.2018.04.024

Hakimi, S. L. (1965). Optimum distribution of switching centers in a communication network and some related graph theoretic problems. Operations research, 13(3), 462-475. https://doi.org/10.1287/opre.13.3.462

Hong, Yan. A study on the condition of temporary housing following disasters: Focus on container housing, Frontiers of Architectural Research, 2017. https://doi.org/10.1016/j.foar.2017.04.005

IBGE. Pesquisa de Informações Básicas Municipais. Perfil dos Municípios Brasileiros, 2013. Disponível em: <http://www.ibge.gov.br>. Acesso em: 20/02/2018.

Islam, H., Zhang, G., Setunge, S., & Bhuiyan, M. A. (2016). Life cycle assessment of shipping container home: A sustainable construction. Energy and Buildings, 128, 673–685. https://doi.org/10.1016/j.enbuild.2016.07.002

Johnson, C., Lizarralde, G., Davidson, C. H. (2006). A system view of temporary housing projects in postdisaster reconstruction. Construction Management and Economics, n. 24, p. 367–378. doi:10.1080/01446190600567977. https://doi.org/10.1080/01446190600567977

Kunz, N., Reiner, G., & Gold, S. (2014). Investing in disaster management capabilities versus pre-positioning inventory: A new approach to disaster preparedness. International Journal of Production Economics, 157, 261-272. https://doi.org/10.1016/j.ijpe.2013.11.002

Lall, S. V., Deichmann, U. Density and Disasters Economics of Urban Hazard Risk. The World Bank Research Observer, 2009. https://dx.doi.org/10.2307/23262822

Liao, K., Guo, D. (2008). A Clustering-based approach to the capacitated facility location problem. Transactions in GIS, 12(3), 323–339. https://doi.org/10.1111/j.1467-9671.2008.01105.x

Ling, P. C. H., Tan, C. S., Saggaff, A. (2019, September). Feasibility of ISO shipping container as transitional shelter-a review. In IOP Conference Series: Materials Science and Engineering (Vol. 620, No. 1, p. 012056) IOP Publishing. https://iopscience.iop.org/article/10.1088/1757-899X/620/1/012056

Marcelino, E. V. Desastres Naturais e Geotecnologias: Conceitos Básicos. Caderno Didático nº 1. INPE/CRS, Santa Maria, 2008.38p, 2008. http://mtc-m16c.sid.inpe.br/col/sid.inpe.br/mtc-m18@80/2008/07.02.16.22/doc/publicacao.pdf

Mendes, R. L. D. C. (2019). Logística de ajuda humanitária na operação acolhida: a mobilização em apoio à população Venezuelana. http://bdex.eb.mil.br/jspui/handle/123456789/5069

Menezes, J. A., Confalonieri, U., Madureira, A. P., Duval, I. D. B., Santos, R. B. D., & Margonari, C. (2018). Mapping human vulnerability to climate change in the Brazilian Amazon: the construction of a municipal vulnerability index. PloS one, 13(2), e0190808 https://doi.org/10.1371/journal.pone.0190808

Nappi, M. M. L., Souza, J. C. Conceitos e ferramentas na engenharia de transportes. Desastres naturais: seleção e localização espacial de abrigos para flagelados, Kanashiro. – Ponta Grossa, PR: Atena Editora, 2019.

Nappi, M. M. L., Souza, J. C. Disaster Management: Hierarchical Structuring Criteria for Selection and Location of Temporary Shelters. Natural Hazards, v. 75, n. 3, p. 2421-2436, 2014. Disponível em: https://doi.org/10.1007/s11069-014-1437-4

Noji, E. K. (1991). Natural disasters. Critical care clinics, 7(2), 271-292. https://doi.org/10.1016/j.ccc.2019.05.001

Peña, J. A., Schuzer K. Design of Reusable Emergency Relief Housing Units Using General-Purpose (GP) Shipping Containers. Int. J. Eng. Res. Innov., vol. 4, no. 2, pp. 55–64, 2012.

Perrucci, D.V.; Vazquez, B.A.; Aktas, C.B. Sustainable Temporary Housing: Global Trends and Outlook. Procedia Eng. 2016, 145, 327–332. https://doi.org/10.1016/j.proeng.2016.04.082

Perrucci, Daniel; Baroud, Hiba. A Review of Temporary Housing Management Modeling: Trends in Design Strategies, Optimization Models, and Decision-Making Methods. Sustainability, v. 12, n. 24, p. 10388, 2020. https://doi.org/10.3390/su122410388

Pizzolato, N. D., Raupp, F. M. P., Alzamora, G. S. Revisão de métodos aplicados em localização com base em modelos da p-mediana e suas variantes. Revista Eletrônica Pesquisa Operacional para o Desenvolvimento, 4, p, 13 42, 2012. https://www.researchgate.net/publication/351130546_Aplicacao_do_metodo_das_p-medianas_para_otimizacao_da_localizacao_dos_hospitais_de_campanha_na_cidade_do_Rio_de_Janeiro_em_uma_possivel_segunda_onda_de_contagio_do_Covid-19

Ramos, A.C; Pereira, N.N. Contêineres marítimos como alternativa para mitigar impactos de desastres naturais. In: 27º CONGRESSO INTERNACIONAL DE TRANSPORTE AQUAVIáRIO, CONSTRUçãO NAVAL E OFFSHORE, 2018, Rio de Janeiro. Anais eletrônicos... Campinas, Galoá, 2020. Disponível em: https://proceedings.science/sobena-2018/papers/reutilizacao-de-conteineres-maritimos--uma-solucao-sustentavel?lang=pt-br. Acesso em: 18 jan. 2020.

Ramos, A.C; Pereira, N.N. Reutilização de contêineres marítimos: uma solução sustentável. In: 27º CONGRESSO INTERNACIONAL DE TRANSPORTE AQUAVIáRIO, CONSTRUçãO NAVAL E OFFSHORE, 2018, Rio de Janeiro. Anais eletrônicos... Campinas, Galoá, 2020. Disponível em: https://proceedings.science/sobena-2018/papers/reutilizacao-de-conteineres-maritimos--uma-solucao-sustentavel?lang=pt-br. Acesso em: 18 jan. 2020.

Revelle, C., Swain, R. Central facilities location. Geographical Analysis, 2, 30–40, 1970. https://doi.org/10.1111/j.1538-4632.1970.tb00142.x

Soler, L. S., Gregorio, L. T., Leal, P., Gonçalves, D., Londe, L., Soriano, É., & Saito, S. (2013, October). Challenges and perspectives of innovative digital ecosystems designed to monitor and warn natural disasters in Brazil. In Proceedings of the Fifth International Conference on Management of Emergent Digital EcoSystems (pp. 254-261). https://doi.org/10.1145/2536146.2536191

Tang, C. S., & Ling, P. C. (2018). Shipping Container as shelter provision solution for post-disaster reconstruction. In E3S web of conferences (Vol. 65, p. 08007). EDP Sciences. https://doi.org/10.1051/e3sconf/20186508007

Tzeng, G. H., Cheng, H. J., Huang, T. D. Multi-objective optimal planning for designing relief delivery systems. Transportation Research Part E, v. 43, p. 673–686, 2007. https://doi.org/10.1016/j.tre.2006.10.012

UNHCR (United Nations High Commissioner for Refugees). Handbook for emergencies, 2nd Ed., Geneva, 2000. https://www.refworld.org/pdfid/46a9e29a2.pdf

Vergueiro, Waldomiro. Qualidade em serviços de informação. São Paulo: Editora, Arte & Ciência, 2002.

Valencio, N. F. L. S. Desastres, ordem social e planejamento em Defesa Civil: o contexto brasileiro. Saúde e Sociedade, v. 19, n. 4, p. 748-762, 2010. doi: http://dx.doi.org/10.1590/S0104-12902010000400003

Zabinski, K. B., brodaski, M. A., Campanelli, R. L. Shipping Container Emergency Shelters, 2010. Disponível em: https://digitalcommons.wpi.edu/mqp-all/639

Zhang, S., setunge, G., Van elmpt, S. Using Shipping Containers to Provide Temporary Housing in Post-disaster Recovery: Social Case Studies. Procedia Econ. Financ., vol. 18, no. September, pp. 618–625, 2014. https://doi.org/10.1016/S2212-5671(14)00983-6