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Original Research

Humanitarian logistics: A multicriteria decision approach for venezuelan refugee resettlement process

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Abstract: The number of people seeking shelter in other countries is increasing due to the escalating humanitarian and political crisis. In South America, the case of Venezuelan refugees is known worldwide as the cause of local political crisis. Due to its geographic proximity to Brazil, Venezuelans tend to migrate in their primary movement to Brazilian cities that are close to the border between the two countries. Afterwards, their secondary movement is characterized by their spread throughout the Brazilian territory, also known as resettlement. In this sense, this paper aims to propose a multicriteria decision making approach for choosing the best cities as resettlement locations for the Venezuelan refugees in Brazil. The study was conducted considering fifteen cities in the state of Amazonas. The multicriteria decision making methods Best-Worst Method (BWM) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) were applied. The BWM method focused on determining the weights of the decision criteria, while the TOPSIS method was instantiated to rank the decision alternatives. The decision criteria that are associated with employment and basic sanitation were given the highest weights, as they represent the most important needs of the refugees. The analysis of the decision alternatives showed that the city of Manaus, Humaitá and Iranduba were the top three in the alternatives ranking. Although these alternatives have different characteristics reflected in their performance regarding the decision criteria, they are recommended as resettlement locations because they can satisfy the most important needs of the refugees.

Keywords: Humanitarian logistics, Refugee, Multicriteria decision making, BWM, TOPSIS

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Introduction

Refugees can be conceptualized from different perspectives such as the one from the United Nations High Commissioner for Refugees (UNHCR), the one from the legal status, and the one from business and management [1, 2]. The UNHCR describes refugees as people who are outside their homeland and are unable or unwilling to return, because they fear persecution due to their race, religion, nationality, membership of a particular social group or political opinion, which make them cannot or do not want to return to their country because of this "well-founded fear of persecution". The legal status approach defines a refugee as a person who, due to their legal conditions, is able to fulfill the mandatory national immigration regulations to be granted protection [2]. The business and management approach considers a refugee as an individual who left their homeland towards another country to find protection and safety, being unable to return due to their homeland circumstances and regardless of their legal status [3]. In our study, we adopt the last refugee conceptualization, the business and management approach, as it corresponds to our intention to systematize refugee logistics in the south side of Brazil.

In the effective action of becoming a refugee, an individual needs to make a primary and then a secondary movement. The primary movement refers to the physical move that refugees make from their homeland to a foreign location and is influenced by a decision making involving the selection of a possible destination [4]. Subsequently, the secondary movement is characterized by refugees relocating within the destination of their primary movement or physically moving to a secondary foreign location [5].

In recent years, multiple refugee movements have been observed worldwide. Since 2011, more than 5.6 million Syrians have been displaced to neighboring countries such as Lebanon, Turkey and Jordan [6]. Due to the war in Ukraine, more than 3 million Ukrainians fled to Poland from February 2022 to April 2022. With a daily arrival rate of more than 100,000 people in the first few weeks, Polish local services were quickly overwhelmed [7]. In the case of South America, Venezuela has seen the largest mass exodus, with nearly 7.77 million citizens making their primary movement to foreign locations [8]. Although Peru, Ecuador, Chile and Trinidad & Tobago have made entry increasingly difficult, most Venezuelan refugees have been accommodated in neighboring countries such as Colombia and Brazil [9, 10].

Particularly in Brazil, there is a large influx of refugee into the state of Roraima, which is overburdening local public services, especially in the cities of Pacaraima and Boa Vista. From 2019 to 2023, a total of 347,832 requests for recognition of refugee status were analyzed by the Brazilian National Committee for Refugees (CONARE) [11-15]. Of these, 219,116 are Venezuelan citizens, representing 62.99% of total requests. In the state, 71,198 requests were analyzed for the year 2023 only. This is the largest number of requests in the northern region of Brazil [15]. In 2022, the in-state population was 636,707 in Census [16]. Therefore, considering that the requests for recognition of refugee status are placed in their primary movement location, these requests represent an increase of 11.18% in the population of the Roraima state, caused only by the refugees entering, which justifies the overload of the public system.

To provide humanitarian aid and emergency assistance to these Venezuelan refugees arriving in Brazil, an operation called "Acolhida" was launched in 2018. It is a joint action by the Brazilian army, navy, aviation, the federal government, United Nations agencies and local civilian organizations. The goal of this operation is to ensure border ordering, refugees reception and refugees internalization. Border ordering consists of the documentation, vaccination and control phase by the Brazilian army. The refugee's reception involves offering shelter, food and health care to immigrants. The refugee's internalization is concerned with the voluntary relocation of Venezuelans from the state of Roraima to other cities in Brazil with the aim of socio-economic integration [17].

As one of the "Acolhida" operation goals, the refugee's internalization can be understood as a resettlement process. This process is defined as an organized selection, transfer and arrival of individuals to another country [3]. In the context of this study, it represents the secondary movement of refugees within the Brazilian territory. It is observed that many incoming Venezuelans face difficulties in socio-economic integration, as they are struggling to find a job, housing, and dealing with the language [8]. Therefore, these are potential misleading criteria when choosing the second location for the refugee's resettlement.

In this sense, this research aimed to develop a decision-making model that supports a resettlement rationale capable of addressing the issues in the selection of secondary movement on the Brazilian-Venezuelan border. By understanding the main needs of these refugees and supported by multicriteria decision making methods, the goal of the model was to systematize the selection of the best cities for receiving Venezuelan refugees in the Brazilian state of Amazonas. This goal is an important aspect for the integration of Venezuelan refugees into the Brazilian socio-economic system, as well as a strategy to overcome the overburdening of the local public system. To achieve this, firstly, we investigated the basic needs of a group of Venezuelan refugees who arrived in Brazil and focused on defining their evaluation criteria for the location selection process. Then we structured the multicriteria analysis model considering the selected criteria based on the Best-Worst Method (BWM) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) methods.

Multicriteria decision-making models have already been used for studying refugee logistics. Intelligent multi-agent system approaches the Fuzzy Analytic Hierarchy Process and Axiomatic Design to rank refugee settlement locations [18]. The dynamic multi-objective location-routing model integrates strategic, tactical and operational decisions for relief logistics planning [19]. The multi-objective optimization model relocates relief supplies during disaster recovery operations, considering both current disruptions and future incidents [20]. These studies collectively highlight the importance of multicriteria decision methods in addressing the complex and dynamic nature of refugee logistics. We considered this multicriteria decision making approach to reduce the bias of decision makers, but at the same time, consider what is important for them in terms of selection criteria.

The TOPSIS method was adopted due to its simplicity and foundational concept that the best solution in a decision is associated with its closeness to the positive ideal solution and its distance from the negative ideal in a system [21]. The method can help decision makers to understand the decision problem and find the best alternative based on their goals rather than providing an "optimal" solution [22]. In addition, its simplicity, rationality and computational efficiency make it possible to be applied to both crisp and interval data [23, 24].

The BWM was utilized to obtain the weights of the criteria. It is a powerful tool for multi-criteria decision making that has gained popularity due to its efficiency in determining the criteria weights, especially because of its structured pairwise comparisons that can overcome judgement. Additionally, it can be combined with other methods such as TOPSIS to improve decision making [25-28].

Materials and methods

To conduct this study, the methodology was divided into three stages. In the first stage, the decision-making hierarchy focused on identifying the refugees' decision-making criteria, as well as identifying the decision alternatives represented by the resettlement location. In the second stage, data collection aimed at gathering alternatives performance data associated with each of the identified criteria. In the third stage, MCDM implementation worked towards applying the selected multicriteria decision-making methods to process the data collected in stage two and to analyze the results obtained. Figure 1 schematizes the research method rationale that supported the implementation of this study.

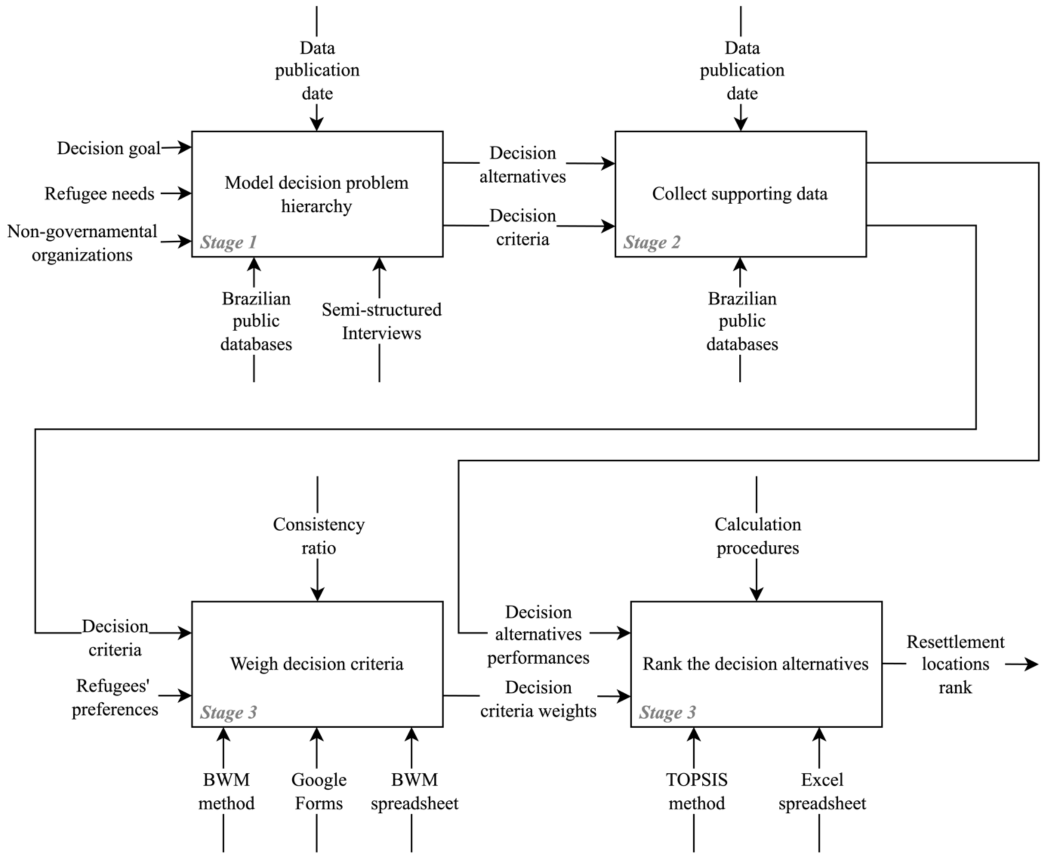

Figure 1. Research method scheme

The following subsections provide a more detailed description of each of these stages.

Decision-making hierarchy for the selection of refugees' resettlement

The decision-making hierarchy stage focused on structuring the decision problem hierarchy. Building this structure is important to support the correct implementation of the multicriteria decision-making methods used in this study.

First, it was necessary to understand what criteria need to be considered in the refugees' resettlement decision-making. To this end, we interviewed some non-governmental organizations located in the states of Roraima and Amazonas by telephone. These organizations are involved in supporting refugees in the internalization (resettlement) process conducted by operation "Acolhida" in collaboration with the UNHCR. The interview was semi-structured with questions aimed at inquiring about the main needs of refugees upon their arrival in Brazil. These semi-structured questions were not read out word by word to the interviewees, but were used to keep track of and focus on the natural flow of the conversation [29], as shown in Table 1.

Table 1. Semi-structured interview questions

Order	Question
1	Do the assisted families have school-age children?
2	Where do the families usually live?
3	When they arrive in Brazil, do these refugees promptly consider moving to another city far from the border?
4	What are the main needs reported by the refugees?
5	What are the main reasons that lead refugees to leave the shelters at the borders and move to other cities in Brazil?
6	What are the main difficulties they face in finding a job?
7	What are the main work positions they fill in Brazil?

The telephone interviews were audio-recorded to ensure that all data was properly collected. After each interview was completed, the recording was transcribed so that it could be analyzed in detail. The main objective of this analysis was to capture the real needs of the refugees.

Then, we accessed the databases of the Brazilian Unified Health System (SUS), the Brazilian Institute of Geography and Statistics (IBGE), the Ministry of Health, the National Electric Energy Agency (ANEEL) and the National Institute of Educational Studies and Research Anísio Teixeira (INEP) to identify potential performance indicators for the decision alternatives that could be aligned with the identified needs. To be considered, a performance indicator must have had available data published from 2020 to 2023.

The hierarchy of decision-making problem consists of three structural elements: the decision problem, the decision criteria and the decision alternatives. In this study, the decision problem is characterized by the selection of a resettlement location for the refugees. The alternatives to this decision problem are represented by all potential cities that met the requisites to be considered as a feasible location for resettlement. Last, the decision criteria for this problem are represented by the performance indicators by which all alternatives are evaluated. By compiling these structural elements, it was possible to build the hierarchy that is adherent to the decision problem we focus on.

The next stage, described in detail in the next section, is about collecting all the necessary data to perform the multicriteria decision-making methods used in this study.

Data collection for selection criteria of refugees's resettlement

The first step was to filter the cities in the state of Amazonas that could be feasible alternatives for the resettlement of Venezuelan refugees. The Human Development Index (HDI) data was collected for each of the cities listed. Although this data was published in 2010, it was the only HDI data available in the IBGE database and was used solely for the list filtering process. The threshold for selecting the cities as alternatives considering their HDI was the range specified in the Human Development Report published by the United Nations Development Programme for 2023/2024.

The second step was to obtain performance data for each selected decision alternative associated with each of the decision criteria considered. These data were collected from the Unified Health System (SUS), the Brazilian Institute of Geography and Statistics (IBGE), the Ministry of Health, the National Electric Energy Agency (ANEEL) and the National Institute of Educational Studies and Research Anísio Teixeira (INEP). The data used was published from 2020 to 2023.

In order to develop a formal process to address migration difficulties in this Brazilian region, the purposive sampling method was used, which characterizes the sample studied as non-probabilistic [29, 30]. In total, 23 refugees from Venezuela, 15 of whom were Venezuelans and 8 were Haitians, were interviewed and answered the questionnaires of this study. Although this sample is small and cannot provide a robust basis for generalization, it was important to shed light on what kind of criteria should be adopted to make the decision for the resettlement location.

MCDM implementation for the best selection of refugees's resettlement

This stage focused on the application of MCDM methods to select the best location for refugee resettlement. This was a hybrid approach by dividing the stage into two parts. The first part looked towards determining the weights of decision-making criteria by the instantiation of the BWM method. The second part was driven by the selection of best decision-making alternative, which was performed by applying the TOPSIS method.

The BWM method was applied with the goal of determining the weight of each decision criteria. Initially, two online forms consisting of multiple-choice questions were created using the Google Forms platform. In the first questionnaire, the refugees in the study had to indicate which decision criteria were the most and the least important when choosing a resettlement location. The questionnaire was named Best-Worst Identification and it was made available in Spanish, French and Portuguese. This helped to make it easier to answer the form, so as to reduce possible misunderstandings and to reach a wider audience. The responses obtained were aggregated according to the frequency of answers. The criterion with the highest frequency of mentions was selected as the best criterion overall, while the criterion with the lowest frequency of mentions was labeled as the worst among the others. It is important to highlight that the BWM method does not define a procedure for selecting the best and the worst criteria [31].

After determining the best and worst criteria, a second round of evaluation was therefore conducted with the refugees in this study. The aim was to determine the relative importance of the best criterion compared to the other criteria (Best-to-Others importance vector), as well as the importance of the other criteria over the worst one (Others-to-Worst importance vector) [31]. This was done based on a linguistic scale from 1 to 9, as shown in Table 2 [32].

Table 2. Pairwise comparison linguistic scale

Linguistic term	Scale
Equally Important (EI)	1
Intermediate of EI & MI (IEM)	2
Moderately Important (MI)	3
Intermediate of MI & I (IMI)	4
Important (I)	5
Intermediate of I & VI (IVI)	6
Very Important (VI)	7
Intermediate of VI & EXI (IEI)	8
Extremely Important (EXI)	9

Source: [32]

To determine the optimal criteria weight, and satisfy the optimality conditions, the maximum absolute differences between the weights and the preferences should be minimized. In this sense, the following optimization problem represents the optimization model that minimizes these differences [31]:

$$\min \max_{j} \left\{ \left| \frac{W_B}{W_j} - a_{Bj} \right|, \left| \frac{W_j}{W_w} - a_{jW} \right| \right\}$$

s.t.

$$\sum_j W_j = 1$$

$$W_j \geq 0, \text{ for all } j$$

The BWM method is available for free at "bestworstmethod.com/software/" as an Excel file fully operational and ready to use. Its implementation can solve the presented optimization model with the solver module of Excel. Once a solution was obtained, the consistency ratio can be verified to determine whether these results are reliable, as it is automatically calculated in the file and presented as the *Ksi** parameter. In terms of reliability, the closer the consistency ratio is to zero, the more reliable the pairwise comparisons of the decision makers are [33]. The results obtained in this step are the weights of the decision criteria used for setting up TOPSIS application.

Once the criteria weights were properly determined, it was possible to initiate the application of the TOPSIS method [35, 36]. The first step was to build the decision matrix composed by the decision alternatives and the criteria, represented by $X = (x_{ij})_{m\times n}$, where x_{ij} is the performance of an alternative *m* considering a criterion *n*. Each criteria has its specific weight that was determined previously by the BWM method.

To compare the performance of different criteria, it was necessary to eliminate the unit of the performance dimension. This process is called the normalization of the decision matrix and can be done by applying equation 1, where r_{ij} is the normalized performance [35].

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}{}^2}} \quad (1)$$

With the normalized performance stored in the normalized decision matrix, it was possible to calculate the weighted normalized performance. This result demonstrates the adjusted performances of the alternatives after applying the criteria weights (w_j) calculated using the BWM method, which are stored in the weighted normalized decision matrix $V = (v_{ij})_{m\times n}$. Each of the weighted performances (v_{ij}) could be calculated by applying equation 2.

$$v_{ij} = r_{ij} \times w_j \quad (2)$$

From matrix *V*, the ideal (A^+) and anti-ideal (A^-) solutions could be identified. The solution is the one from the weighted normalized decision matrix with the best performance (for maximizing criteria) or the worst performance (for minimizing criteria). While the A^- solution is that one with the worst performance (for maximizing criteria) or the best performance (for minimizing criteria), as demonstrated below by equations 3 and 4 [37].

$$A^+ = v_j^+ = \{\max(v_{ij}), \min(v_{ij})\} \quad (3)$$

$$A^- = v_j^- = \{\min(v_{ij}), \max(v_{ij})\} \quad (4)$$

Using these elements, it was possible to calculate the separation measures, which represent the distances of each alternative to the ideal and anti-ideal solutions, respectively. These calculations can be done by applying equations 5 and 6.

$$D_i^+ = \sqrt{\sum_{j=1}^{n} \left[v_{ij} - (A^+)\right]^2} \quad (5)$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} \left[v_{ij} - (A^-)\right]^2} \quad (6)$$

Finally, the calculation of the relative closeness to the ideal solution was performed with the consideration of the distances obtained. This relative closeness is represented by C_i^*, as demonstrated by equation 7.

$$C_i^* = \frac{D_i^-}{D_i^+ + D_i^-}, \text{ where } i = 1, 2, ..., m. \quad (7)$$

With the calculated relative closeness (C_i^*), it was possible to sort all the alternatives from the values of the best to the worst. Considering that the alternatives in this study are the possible cities for the refugee's resettlement, this process made it possible to identify the best alternative to receive this population.

Results

This section is subdivided according to the methodology section. Firstly, we show the results of the criteria identification. Then we demonstrate the data collection process. Finally, we present the implementation of the MCDM approach.

Decision-making hierarchy for the selection of refugees' resettlement

After interviewing the non-governmental organizations and compiling the whole recordings, the refugees' needs were identified and consolidated. To make it possible to evaluate the decision alternatives in alignment with these needs, the Brazilian public databases were explored to verify the availability of the performance indicators and to select which one could be considered as a decision criterion. Table 3 presents the consolidated needs and the associations made between them and the qualified performance indicators. The data of the indicators were available from 2020 to 2023.

To conduct the multicriteria decision-making process, the performance indicators are used as decision-making criteria to evaluate the decision alternatives. In this way, it was possible to evaluate these alternatives in an objective manner and make it possible to reduce the decision-maker bias. Table 4 summarizes the defined criteria.

After consolidating the decision criteria, we accessed the website of the Brazilian Institute of Geography and Statistics (IBGE) and found that 61 cities belong to the state of Amazonas. The decision problem in this study is the selection of resettlement location for refugees in Brazil. Therefore, these cities are potential decision alternatives in this context. With these elements in hand, it was possible to build the decision problem hierarchy, as illustrated in Figure 2.

We conducted a bottom-up evaluation of the decision problem hierarchy, focusing first on analyzing the performance data on resettlement locations (decision alternatives).

Table 3. Refugees' consolidated needs and associated performance indicators

Refugees' consolidated needs	Associated performance indicators
Access to education for children and adolescents	School rate per inhabitants Illiteracy rate
Access to higher education	School rate per inhabitants Illiteracy rate
Basic sanitation	Population with access to water supply (%) Population with access to sewage (%) Population with access to electricity (%)
Chronic disease treatment	Healthcare units per 1,000 inhabitants Hospital beds per 1,000 inhabitants Mortality rate by 1,000 inhabitants
Employment	Unemployment rate (%) Employability (%) Gross Income Per Capita
Food assistance	Unemployment rate (%) Employability (%) Gross Income Per Capita
Improvements in well-being	Population with access to the internet (%) Presence of bus lines in the city
Primary medical care	Healthcare units per 1,000 inhabitants Hospital beds per 1,000 inhabitants
Public protection and safety	Mortality rate by 1,000 inhabitants
Transportation needs	Presence of bus lines in the city

Table 4. Decision criteria consolidation

Decision criteria	
Employability	Population with access to sewage
Gross Income Per Capita	Population with access to the Internet
Healthcare units per 1,000 inhabitants	Population with access to water supply
Hospital beds per 1,000 inhabitants	Presence of bus lines in the city
Illiteracy rate	School rate per inhabitants
Mortality rate by 1,000 inhabitants	Unemployment rate
Population with access to electricity	-

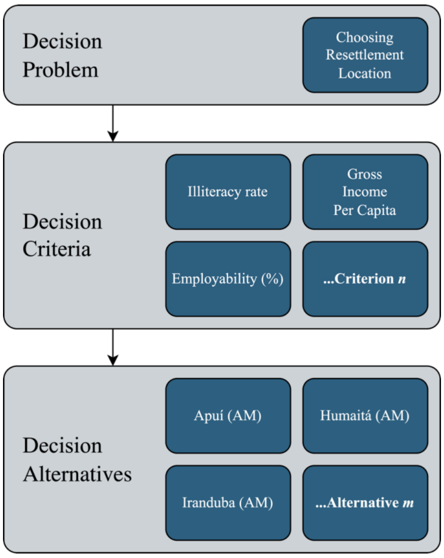

Figure 2. Decision problem hierarchy

Data collection for selection criteria of refugees' resettlement

The initially collected data was used to filter the list of raw decision alternatives, which consists of all cities in the state of Amazonas. From this list, the cities with an HDI < 0.550 were removed due to their low human development. The remaining cities were sorted by their HDI index, from the highest to the lowest. Then, according to the convenience, we selected the first 15 cities with highest HDI from the list and consolidated them as decision alternatives for resettlement location, as shown in Table 5.

The data for each of the decision criteria were collected in the Brazilian public databases where these criteria were identified. All performances can be seen in Table 6.

MCDM implementation for the best selection of refugees' resettlement

To establish a consistent decision procedure, it was necessary to evaluate how the refugees would weight the decision criteria associated with their identified needs. In this way, the BWM method was applied. First, the method recommends that if the decision maker is dealing with more than 9 criteria, it is necessary to group these criteria to simplify the analysis [31]. Therefore, the decision criteria were grouped into Work & Education, Health & Quality of Life and Urban Infrastructure, as shown in Figure 3.

Table 5. Consolidated resettlement locations

Index	City	HDI
1	Apuí	0.637
2	Humaitá	0.605
3	Iranduba	0.613
4	Itacoatiara	0.644
5	Itapiranga	0.654
6	Manacapuru	0.614
7	Manaus	0.737
8	Parintins	0.658
9	Presidente Figueiredo	0.647
10	Rio Preto da Eva	0.611
11	São Gabriel da Cachoeira	0.609
12	Silves	0.632
13	Tabatinga	0.616
14	Tefé	0.639
15	Urucará	0.620

Source: [16]

Table 6. Resettlement locations performances

DECISION ALTERNATIVES	Gross Income Per Capita (BRL)	Employability (%)	Illiteracy rate (%)	Mortality rate by 1,000 inhabitants (Qty)	Population with access to electricity (%)	Population with access to the Internet (%)	Population with access to sewage (%)	Population with access to water supply (%)	Healthcare units per 1,000 inhabitants (Qty)	Hospital beds per 1,000 inhabitants (Qty)	School rate per inhabitants (Qty)	Unemployment rate (%)	Presence of bus lines in the city (0-No / 1-Yes)
	DECISION-MAKING CRITERIA												
Apuí	1092	54.30%	13.20%	7.40	99.60%	60.20%	1.60%	63.50%	0.76	1.24	0.35	9.50%	0
Humaitá	1085	53.10%	10.50%	6.80	98.70%	58.30%	2.40%	68.40%	0.80	1.30	0.40	10.20%	1
Iranduba	1172	51.80%	11.40%	7.10	98.90%	59.70%	3.10%	65.20%	0.85	1.18	0.38	10.80%	1
Itacoatiara	1172	55.20%	12.80%	6.90	99.10%	61.40%	3.50%	66.80%	0.82	1.22	0.39	10.10%	1
Itapiranga	965	53.70%	14.10%	6.50	98.80%	57.90%	2.90%	64.30%	0.78	1.15	0.36	9.80%	1
Manacapuru	965	52.40%	13.50%	6.90	98.90%	58.30%	3.00%	65.70%	0.80	1.20	0.37	9.70%	1
Manaus	1172	56.30%	7.10%	13.60	99.30%	75.40%	30.50%	90.70%	0.88	1.30	0.42	10.40%	1
Parintins	965	55.40%	12.20%	18.20	98.70%	61.50%	4.20%	67.10%	0.79	1.19	0.38	10.10%	1
Presidente Figueiredo	965	52.80%	13.10%	10.68	99.10%	59.40%	3.30%	64.80%	0.77	1.17	0.37	9.60%	1
Rio Preto da Eva	965	51.70%	13.60%	10.15	99.20%	58.90%	3.10%	65.10%	0.78	1.16	0.36	10.20%	1
São Gabriel da Cachoeira	965	47.60%	24.90%	30.95	90.30%	50.70%	1.80%	54.60%	0.62	0.80	0.30	12.50%	0
Silves	965	49.50%	15.40%	12.80	98.20%	55.70%	2.80%	61.30%	0.75	1.10	0.34	11.50%	0
Tabatinga	965	53.20%	14.30%	19.13	98.50%	56.20%	3.50%	63.70%	0.74	1.12	0.35	10.60%	1
Tefé	1172	50.20%	15.70%	12.38	97.90%	59.10%	4.00%	66.30%	0.76	1.14	0.37	10.40%	0
Urucará	965	51.30%	15.80%	10.90	98.30%	56.50%	3.40%	62.80%	0.74	1.12	0.34	11.20%	0

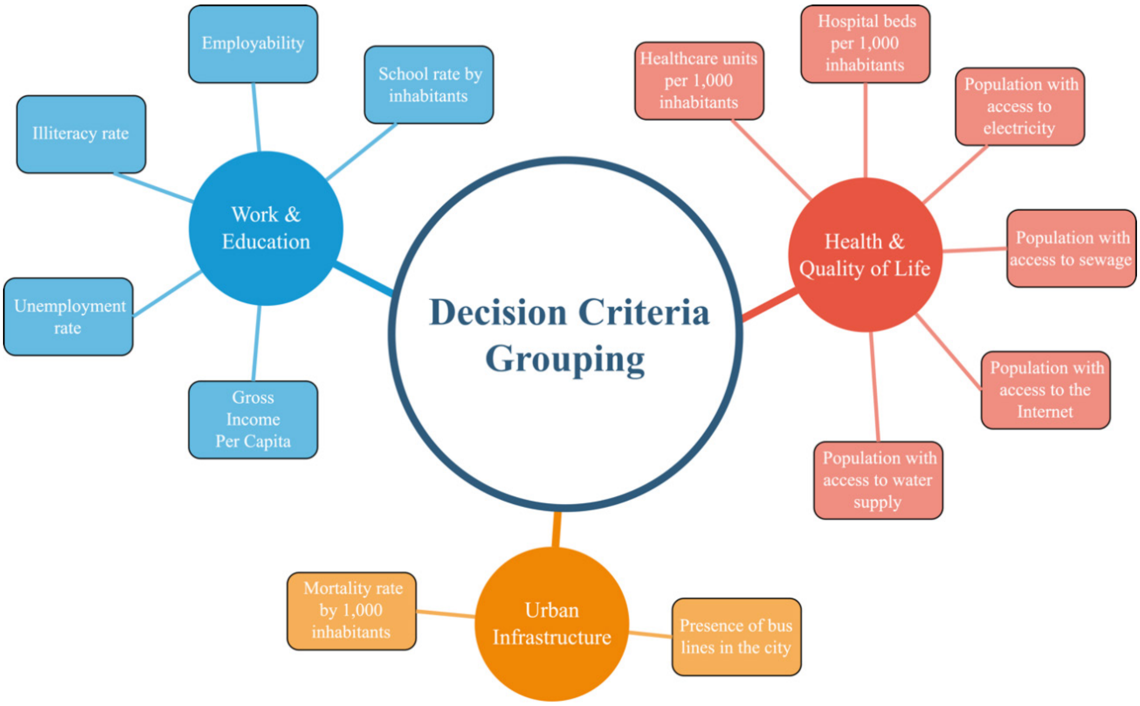

Figure 3. Decision criteria grouping

For each of the groups, the best-worst identification questionnaire was sent to the refugee sample to identify the best and worst criteria. This information is important because it is a prerequisite to the BWM method, as it can be seen in Table 7.

For each of the groups, the BWM method was instantiated at a low level to determine the respective weight of each criterion, and at a higher level to determine the weight of each group. To this end, the criteria importance evaluation questionnaire was sent to the refugee sample so that they could evaluate their individual preferences in relation to the decision criteria through pairwise comparisons. The results were compiled and stored in its respective preference vectors.

For the criteria of work & education, the evaluations can be observed in Table 8, which relate to the best-to-others refugees' preferences.

On the other hand, the evaluations shown in Table 9 are related to the others-to-worst refugees' preferences.

After compiling the refugees' evaluation regarding the health & quality of life group, it was possible to establish its preference vectors. Table 10 shows the best-to-others preferences.

In addition to this result, it is possible to observe the Others-to-worst refugee preferences in Table 11.

The urban infrastructure group consists of only two decision-making criteria. They are associated with urban transportation system and public security. Table 12 shows the refugees' preferences related to these elements.

The last pairwise comparison made focused on identifying the vector of refugees' worst to others preference, which is presented in Table 13.

After collecting and tabulating all these evaluations, the spreadsheet of BWM method was used to solve the method's optimization model and determine the weights of the decision criteria. Figure 4 illustrates how the evaluations were organized in the file in a way that the Excel Solver module could be run.

Table 7. Best and worst criteria identification

	Criteria group		
	Work & Education	Health & Quality of Life	Urban Infrastructure
Best criteria	Employability	Population with access to water supply	Mortality rate
Worst criteria	Illiteracy rate	Population with access to internet	Presence of bus lines in the city

Table 8. Best-to-others preference vector for work & education group

Best-to-others preference vector	Employability
Unemployment rate	3
Gross Income Per Capita	2
Employability	1
School rate per inhabitants	3
Illiteracy rate	6

Table 9. Others-to-worst preference vector for work & education group.

Others-to-worst preference vector	Illiteracy rate
Unemployment rate	4
Gross Income Per Capita	5
Employability	9
School rate per inhabitants	4
Illiteracy rate	1

Table 10. Best-to-others preference vector for health & quality of life group

Best-to-others preference vector	Population with access to water supply
Healthcare units per 1,000 inhabitants	3
Hospital beds per 1,000 inhabitants	1
Population with access to sewage	1
Population with access to water supply	1
Population with access to electricity	1
Population with access to the internet	1

Table 11. Others-to-worst preference vector for health & quality of life group

Others-to-worst preference vector	Population with access to the internet
Healthcare units per 1,000 inhabitants	2
Hospital beds per 1,000 inhabitants	3
Population with access to sewage	3
Population with access to water supply	3
Population with access to electricity	3
Population with access to the internet	1

Table 12. Best-to-others preference vector for urban infrastructure group.

Best-to-others preference vector		
	Presence of bus lines in the city	Mortality rate
Mortality rate	4	1

Table 13. Others-to-worst preference vector for urban infrastructure group

Others-to-worst preference vector	
	Presence of bus lines in the city
Presence of bus lines in the city	1
Mortality rate	4

Criteria Number = 3	Criterion 1	Criterion 2	Criterion 3
Names of Criteria	Work & Education	Health & Quality of Life	Urban Infrastructure

Select the Best	Health & Quality of Life
Select the Worst	Urban Infrastructure

Best-to-Others Preference Vector	Work & Education	Health & Quality of Life	Urban Infrastructure
Health & Quality of Life	2	1	3

Others-to-Worst Preference Vector	Urban Infrastructure
Work & Education	2
Health & Quality of Life	3
Urban Infrastructure	1

Criteria Weights	Work & Education	Health & Quality of Life	Urban Infrastructure
	0.2917	0.5417	0.1667

Ksi*	0.0417

Figure 4. BWM spreadsheet implementation example

The calculations presented in Figure 4 were performed locally in each of the groups to determine the weight of each criterion. Taking these groups of criteria into account, an additional evaluation was conducted which made it possible to determine the specific weight of each group. In this way, the decision criteria can be weighted locally and globally. The local weighting represents the weights of the criteria only in relation to the group to which they belong, while the global weighting represents the weights of the criteria regarding all the decision criteria, regardless of the group to which they belong. If the group weight is *Wg*, and the local weight of the criterion is *Wl*, the global weight (w_j) can be calculated by equation 8.

$$w_j = Wg_k \times Wl_n \tag{8}$$

where n is the criterion index, and k is the group index. The results of the calculation of the local and global weights are demonstrated in Table 14.

After solving the optimization model to determine the criteria weights, it was possible to analyze the consistency ratio for each of the pairwise comparisons. Four different rations were obtained associated with the determination of the groups weights, as well as the local criterion weights, which are illustrated in Table 15.

Table 14. Decision criteria weights calculations

Group	Criterion	Criterion weight	
		Local	Global
Work & Education	Unemployment rate	0,1579	0,0461
	Gross Income Per Capita	0,2368	0,0691
	Employability	0,3947	0,1151
	School rate per inhabitants	0,1579	0,0461
	Illiteracy rate	0,0526	0,0154
Health & Quality of Life	Healthcare units per 1,000 inhabitants	0,1111	0,0602
	Hospital beds per 1,000 inhabitants	0,2063	0,1118
	Population with access to water supply	0,2063	0,1118
	Population with access to sewage	0,2063	0,1118
	Population with access to electricity	0,2063	0,1118
	Population with access to the Internet	0,0635	0,0344
Urban Infrastructure	Mortality rate by 1,000 inhabitants	0,6667	0,1111
	Presence of bus lines in the city	0,3333	0,0556

Table 15. Consistency ratio for pairwise comparisons

Pairwise comparisons	Consistency ratio
Decision Criteria Grouping	0,0417
Work & Education Criteria	0,0789
Health & Quality of Life Criteria	0,0159
Urban Infrastructure Criteria	0,0000

The consistency ratio varies in the range from 0 to 1. The urban infrastructure criteria got the lowest consistency ratio in the pairwise comparisons due to their simplicity. This group has only two criteria, which leads to a simpler evaluation and therefore, improves consistency. Even though the other pairwise comparisons are not perfect, the inconsistencies observed are of small magnitude and do not compromise the evaluation results.

One of the socio-economic barrier to integration faced by refugees is the difficulty of finding employment [8]. Both in the Work & Education group, as well as in the global weighting, it can be observed that the most important criterion for the refugees was employability. This demonstrates the need to discuss and plan public policies to integrate this population group into the Brazilian workforce and, consequently, to overcome the dichotomy of struggling to find employment and employability, with the latter being the most important criterion for the choice of the resettlement location.

For the Health & Quality of Life group, it was found that basic systems such as water supply, sanitation, electricity and available hospital beds got equally importance. This indicates that the basic aspects of daily life, and hospital capacities for, e.g., emergencies, impatient care, and postoperative care, are key elements in this decision-making.

Regarding the Urban infrastructure group, the mortality rate got the highest local weight. This implies that public security, e.g., crime and violence control, traffic safety, emergency response, and public health need to effectively manage these aspects that impact the mortality rate.

After determining the weights of decision criteria, the effective process for selecting the best resettlement location for the refugees in the state of Amazonas could be conducted using the TOPSIS method. The decision matrix for this procedure was built based on the data presented in Table 6, in which each matrix line represents each of the decision alternatives while each column represents a decision criterion. The full decision matrix with the raw data can be seen in Table 16.

The first column and the first row in the decision matrix represent the headers, in which the decision alternatives and the indices of the decision criteria are indicated. To facilitate its reading, Table 17 shows the description of each index.

Table 16. TOPSIS raw decision matrix

	CRITERIA												
ALTERN.	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**
A1	1092	54.30%	13.20%	7.40	99.60%	60.20%	1.60%	63.50%	0.76	1.24	0.35	9.50%	0
A2	1085	53.10%	10.50%	6.80	98.70%	58.30%	2.40%	68.40%	0.80	1.30	0.40	10.20%	1
A3	1172	51.80%	11.40%	7.10	98.90%	59.70%	3.10%	65.20%	0.85	1.18	0.38	10.80%	1
A4	1172	55.20%	12.80%	6.90	99.10%	61.40%	3.50%	66.80%	0.82	1.22	0.39	10.10%	1
A5	965	53.70%	14.10%	6.50	98.80%	57.90%	2.90%	64.30%	0.78	1.15	0.36	9.80%	1
A6	965	52.40%	13.50%	6.90	98.90%	58.30%	3.00%	65.70%	0.80	1.20	0.37	9.70%	1
A7	1172	56.30%	7.10%	13.60	99.30%	75.40%	30.50%	90.70%	0.88	1.30	0.42	10.40%	1
A8	965	55.40%	12.20%	18.20	98.70%	61.50%	4.20%	67.10%	0.79	1.19	0.38	10.10%	1
A9	965	52.80%	13.10%	10.68	99.10%	59.40%	3.30%	64.80%	0.77	1.17	0.37	9.60%	1
A10	965	51.70%	13.60%	10.15	99.20%	58.90%	3.10%	65.10%	0.78	1.16	0.36	10.20%	1
A11	965	47.60%	24.90%	30.95	90.30%	50.70%	1.80%	54.60%	0.62	0.80	0.30	12.50%	0
A12	965	49.50%	15.40%	12.80	98.20%	55.70%	2.80%	61.30%	0.75	1.10	0.34	11.50%	0
A13	965	53.20%	14.30%	19.13	98.50%	56.20%	3.50%	63.70%	0.74	1.12	0.35	10.60%	1
A14	1172	50.20%	15.70%	12.38	97.90%	59.10%	4.00%	66.30%	0.76	1.14	0.37	10.40%	0
A15	965	51.30%	15.80%	10.90	98.30%	56.50%	3.40%	62.80%	0.74	1.12	0.34	11.20%	0

Table 17. Alternatives and criteria indexing

Alternatives		**Criteria**	
Index	**Description**	**Index**	**Description**
A1	Apuí	C1	Gross Income Per Capita
A2	Humaitá	C2	Employability
A3	Iranduba	C3	Illiteracy rate
A4	Itacoatiara	C4	Mortality rate by 1,000 inhabitants
A5	Itapiranga	C5	Population with access to electricity
A6	Manacapuru	C6	Population with access to the Internet
A7	Manaus	C7	Population with access to sewage
A8	Parintins	C8	Population with access to water supply
A9	Presidente Figueiredo	C9	Healthcare units per 1,000 inhabitants
A10	Rio Preto da Eva	C10	Hospital beds per 1,000 inhabitants
A11	São Gabriel da Cachoeira	C11	School rate per inhabitants
A12	Silves	C12	Unemployment rate
A13	Tabatinga	C13	Presence of bus lines in the city
A14	Tefé		-
A15	Urucará		-

To make these data interpretable, the decision matrix was normalized and weighted by combining the application of equations 1 and 2. This combination was made by substituting the equation 1 into the equation 2, as shown below in equation 9.

$$v_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}{}^2}} * w_j \quad (9)$$

where w_j is the global weight of the criterion calculated with the BWM method and the type indicates if the criterion is of maximizing or minimizing type. The normalized and weighted matrix is demonstrated in Table 18.

The equations 3 and 4 were applied to the matrix V to determine the ideal and anti-ideal solutions for each of the criteria. The results are shown in Table 19.

Using these solutions, the equations 5, 6, and 7 were applied to calculate the relative closeness of the alternatives. Therefore, this parameter was sorted from highest to lowest, shedding light on alternatives ranking. This result, presented in Table 20, shows which of the potential resettlement locations would be the best one for the refugee sample to make their secondary movement within Brazilian territory.

Table 18. TOPSIS normalized and weighted decision matrix

		CRITERIA												
		C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**
ALTERN.	***wj*** **=**	0.0461	0.0691	0.1151	0.0461	0.0154	0.0602	0.1118	0.1118	0.1118	0.1118	0.0344	0.1111	0.0556
A1		0.0125	0.0184	0.0274	0.0065	0.0040	0.0157	0.0055	0.0276	0.0282	0.0307	0.0085	0.0260	0.0000
A2		0.0124	0.0180	0.0218	0.0059	0.0040	0.0152	0.0082	0.0297	0.0297	0.0322	0.0097	0.0280	0.0176
A3		0.0134	0.0176	0.0237	0.0062	0.0040	0.0156	0.0106	0.0283	0.0315	0.0292	0.0092	0.0296	0.0176
A4		0.0134	0.0187	0.0266	0.0060	0.0040	0.0160	0.0120	0.0290	0.0304	0.0302	0.0095	0.0277	0.0176
A5		0.0110	0.0182	0.0293	0.0057	0.0040	0.0151	0.0099	0.0279	0.0289	0.0285	0.0087	0.0269	0.0176
A6		0.0110	0.0178	0.0280	0.0060	0.0040	0.0152	0.0103	0.0285	0.0297	0.0297	0.0090	0.0266	0.0176
A7		0.0134	0.0191	0.0147	0.0119	0.0040	0.0197	0.1044	0.0394	0.0326	0.0322	0.0102	0.0285	0.0176
A8		0.0110	0.0188	0.0253	0.0159	0.0040	0.0161	0.0144	0.0292	0.0293	0.0295	0.0092	0.0277	0.0176
A9		0.0110	0.0179	0.0272	0.0093	0.0040	0.0155	0.0113	0.0282	0.0286	0.0290	0.0090	0.0263	0.0176
A10		0.0110	0.0175	0.0282	0.0089	0.0040	0.0154	0.0106	0.0283	0.0289	0.0287	0.0087	0.0280	0.0176
A11		0.0110	0.0161	0.0517	0.0270	0.0036	0.0132	0.0062	0.0237	0.0230	0.0198	0.0073	0.0343	0.0000
A12		0.0110	0.0168	0.0320	0.0112	0.0040	0.0145	0.0096	0.0266	0.0278	0.0273	0.0082	0.0315	0.0000
A13		0.0110	0.0180	0.0297	0.0167	0.0040	0.0147	0.0120	0.0277	0.0274	0.0278	0.0085	0.0290	0.0176
A14		0.0134	0.0170	0.0326	0.0108	0.0039	0.0154	0.0137	0.0288	0.0282	0.0282	0.0090	0.0285	0.0000
A15		0.0110	0.0174	0.0328	0.0095	0.0040	0.0148	0.0116	0.0273	0.0274	0.0278	0.0082	0.0307	0.0000

Table 19. Ideal and anti-ideal solutions

	CRITERIA													
		C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**
SOLUTIONS	***Type***	MAX	MAX	MIN	MIN	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MIN	MAX
Ideal (A+)		0.0134	0.0191	0.0147	0.0057	0.0040	0.0197	0.1044	0.0394	0.0326	0.0322	0.0102	0.0260	0.0176
Anti-ideal (A-)		0.0110	0.0161	0.0517	0.0270	0.0036	0.0132	0.0055	0.0237	0.0230	0.0198	0.0073	0.0343	0.0000

Table 20. Relative closeness of alternatives to the ideal solution

		RELATIVE CLOSENESS			
ALTERNATIVES		**D+**	**D–**	***Ci****	**RANK**
A1	Apuí	0.1021	0.0354	0.25765	10
A2	Humaitá	0.0971	0.0441	0.31233	2
A3	Iranduba	0.0951	0.0421	0.30716	3
A4	Itacoatiara	0.0939	0.0410	0.30414	4
A5	Itapiranga	0.0965	0.0385	0.28496	8
A6	Manacapuru	0.0959	0.0396	0.29224	5
A7	Manaus	0.0067	0.1108	0.9432	1
A8	Parintins	0.0920	0.0378	0.29148	6
A9	Presidente Figueiredo	0.0949	0.0383	0.28737	7
A10	Rio Preto da Eva	0.0957	0.0374	0.28098	9
A11	São Gabriel da Cachoeira	0.1114	0.0007	0.00611	15
A12	Silves	0.0995	0.0275	0.21636	14
A13	Tabatinga	0.0954	0.0328	0.25566	11
A14	Tefé	0.0952	0.0294	0.23625	12
A15	Urucará	0.0975	0.0285	0.22648	13

Analysis and discussion

The cities in the state of Amazonas with the best infrastructure in terms of work & education, health & quality of life, and urban infrastructure to receive the Venezuelan refugees arriving in Brazil are Manaus, Humaitá and Iranduba. The state capital, Manaus, obtained the best rating compared to the other cities. The city stands out mainly because its population with access to sewage is 526% higher than the average rate to the pool of alternatives. Additionally, the population with access to water supply is 37% higher than the average. The per capita gross income of this alternative is 13% higher than the other available alternatives. Although these performances must be highlighted, the alternative weakness is that the mortality rate is 13% higher than average, which contradicts the refugees' need for public safety.

Humaitá occupies the second position in the ranking. The city proved to be a viable location as the mortality rate is 43% lower than the average rate among the potential resettlement location. In terms of the number of available hospital beds, it has a performance 12% better than that of average alternative. The most prominent weakness of the city is a 51% lower performance in population with access to sewage.

The third position in the rank is the city of Iranduba. It has a mortality rate 41% lower than the average rate of the alternatives considered. Among the cities evaluated, it has a gross income per capita 13% higher than the average value. However, the number of healthcare units is 10% higher than the average of the alternatives. The biggest weakness of the city is that its population with access to sewage is 36% lower than the average rate.

It can be seen that the first three alternatives have their performances converging to the refugees' goals. This population strives for socio-economic integration, safety and the satisfaction of basic needs in their new living location. As these three alternatives show good performances in satisfying these aspects, they can be qualified as coherent and adherent alternatives for choosing a resettlement location that meet the identified needs.

The city with the lowest ranking was São Gabriel da Cachoeira. The alternative showed deficiencies in important decision criteria when compared to the average performance. Its mortality rate is 157% higher, its population with access to sewage is 63% lower, its available hospital beds are 31% lower, and its healthcare units are 20% lower. All these aspects deviate from the refugees' goal, so this alternative is not recommended as a resettlement location.

Conclusions

With the increase in the number of political and social crises and consequently the growth in the number of refugees, choosing the best city to receive them is a major challenge for governments not only in Brazil, but also worldwide. Previous studies on this topic have not focused on refugees in Brazil. Research on the international refugee population in Brazil, which focuses on understanding refugees' perceptions of their needs, challenges and opportunities in their new country, is a suggested topic for further local studies.

In line with the general objective of the study, a hybrid multicriteria decision-making approach was proposed to choose the best cities in the state of Amazonas to receive Venezuelan refugees arriving in Brazil. The study allowed, by interviews with the non-governmental organizations and the refugees themselves, to understand their main needs in choosing the resettlement location.

The methods used were efficient in enabling the ranking and selection of the best cities in the state of Amazonas. The results of the TOPSIS method showed that Manaus, Humaitá and Iranduba must be recommended as feasible locations for the resettlement of the refugees. Therefore, these are the decision alternatives that are most likely to satisfy the refugees' needs. They are comprehensively described by the 13 decision criteria, which cover areas of great significance for human development and quality of life.

This study can be a starting point for discussing the integration of public policies to support the secondary movement of refugees in order to address the socio-economic problems more smoothly and efficiently. The proposed model fulfills its objective and can be used in other states or regions of the country to facilitate the choice of resettlement location. Our approach can also drive negotiations with the local government to support refugees or even create temporary accommodation.

For future work, it is suggested to apply this method in other states and to investigate proposals for improvement, as a complement to this study. It is also recommended to conduct a study based on probabilistic sampling to improve the statistical understanding of the phenomenon of refugee resettlement location selection.

The main difficulty encountered in conducting this study was the outdated data of the human development index published by IBGE and the construction of the refugees sample. Nowadays, the performance of the series may differ from that illustrated by the available data. This would completely change the results. Regarding the refugee sample, it was difficult to obtain a larger number of people who were available to compose our sample. Some strategies in partnership with the non-governmental organizations should be outlined to recruit respondents for future studies.

Authors' contributions

N.M.C. conducted the investigation, data curation, formal analysis and wrote the original draft; P.F.D.O.G. performed the formal analysis, the work of validation and visualization; and writing review and editing; R.B. wrote the original draft; and D.M.D.G.C. was responsible for conceptualization, methodology, project administration, supervision, validation, writing review and editing.

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Conflict of interest

The authors declare no conflict of interest.

References

[1] United Nations High Commissioner for Refugees. *Convention and Protocol Relating to the Status of Refugees*. Available from: https://www.unhcr.org/media/convention-and-protocol-relating-status-refugees. [Accessed 20th July 2024].

[2] Pesch R, Ipek E. Understanding of refugees in management studies and implications for future research on workplace integration. *European Management Review*. 2023. doi: doi.org/10.1111/emre.12593.

[3] Lee ES, Szkudlarek B, Nguyen DC, Nardon L. Unveiling the Canvas Ceiling: A Multidisciplinary Literature Review of Refugee Employment and Workforce Integration. *International Journal of Management Reviews*. 2020; 22(2):193-216. doi: doi.org/10.1111/ijmr.12222.

[4] Searle C, van Vuuren JH. Modelling forced migration: A framework for conflict-induced forced migration modelling according to an agent-based approach. *Computers, Environment and Urban Systems*. 2021; 85:101568. doi: 10.1016/j.compenvurbsys.2020.101568.

[5] Kavak S, Hamza M, Gammeltoft-Hansen T, Stone RA. Refugee agency in secondary mobility decision-making: a systematic literature review. *Frontiers in Human Dynamics*. 2024; 6. doi: 10.3389/fhumd.2024.1376968.

[6] Qaralleh AS. Jordan and Syrian humanitarian refugees' dilemma: international law perspective. *Heliyon*. 2022; 8(5):e09377. doi: 10.1016/j.heliyon.2022.e09377.

[7] Lee ACK, Khaw FM, Lindman AES, Juszczyk G. Ukraine refugee crisis: evolving needs and challenges. *Public Health*. 2023; 217:41-5. doi: 10.1016/j.puhe.2023.01.016.

[8] Inter-agency Coordination Platform for Refugees and Migrants from Venezuela. *R4V Latin America and the Caribbean, Venezuelan Refugees and Migrants in the Region - May 2024*. Available from: https://www.r4v.info/en/document/r4v-latin-america-and-caribbean-venezuelan-refugees-and-migrants-region-may-2024. [Accessed 20th July 2024].

[9] Bulley D. Everyday immigration ethics: Colombia, Venezuela and the case for vernacular response. *Critical Review of International Social and Political Philosophy*. 2024; 1-24. doi: 10.1080/13698230.2024.2311563.

[10] Fernández-Rodríguez N, Freier LF. Latin American immigration and refugee policies: a critical literature review. *Comparative Migration Studies*. 2024; 12(1): 15. doi: 10.1186/s40878-024-00377-0.

[11] Silva GJ, Cavalcanti L, Oliveira T, Macedo M. Refuge In Numbers 5ª Edition (in Portuguese) [Internet]. Brasília, DF: OBMigra: Observatory of International Migrations; Ministry of Justice and Public Security/National Committee for Refugees; 2020. Available from: https://www.gov.br/mj/pt-br/assuntos/seus-direitos/refugio/refugio-em-numeros-e-publicacoes/anexos/refugio_em_numeros-5e.pdf. [Accessed 21th July 2024].

[12] Silva GJ, Cavalcanti L, Oliveira T, Costa LFL, Macedo M. Refuge In Numbers 6ª Edition (in Portuguese) [Internet]. Brasília, DF: OBMigra: Observatory of International Migrations; Ministry of Justice and Public Security/National Committee for Refugees; 2021. Available from: https://www.gov.br/mj/pt-br/assuntos/seus-direitos/refugio/refugio-em-numeros-e-publicacoes/anexos/refugio_em_numeros-6e.pdf . [Accessed 21th July 2024].

[13] Silva GJ, Cavalcanti L, Oliveira ATR, Silva BG. Refuge In Numbers 7ª Edition (in Portuguese) [Internet]. Brasília, DF: OBMigra: Observatory of International Migrations; Ministry of Justice and Public Security/National Committee for Refugees; 2022. Available from: https://www.gov.br/mj/pt-br/assuntos/seus-direitos/refugio/refugio-em-numeros-e-publicacoes/anexos/RefugioemNumeros.pdf. [Accessed 22th July 2024].

[14] Silva GJ, Cavalcanti L, Lemos SS, Tonhati T, Costa LFL. Refuge In Numbers 8ª Edition (in Portuguese) [Internet]. Brasília, DF: OBMigra: Observatory of International Migrations; Ministry of Justice and Public Security/National Committee for Refugees; 2023. Available from: https://portaldeimigracao.mj.gov.br/images/Obmigra_2020/OBMIGRA_2023/Refúgio_em_Números/Refugio_em_Numeros_-_final.pdf. [Accessed 22th July 2024]

[15] Silva GJ, Cavalcanti L, Lemos SS, Oliveira ATR. Refuge In Numbers 9ª Edition (in Portuguese) [Internet]. Brasília, DF: OBMigra: Observatory of International Migrations; Ministry of Justice and Public Security/National Committee for Refugees; 2024. Available from: https://portaldeimigracao.mj.gov.br/images/Obmigra_2020/OBMIGRA_2024/Ref%C3%BAgio%20em%20N%C3%BAmeros%20-%209ed/Ref%C3%BAgio%20em%20N%C3%BAmeros%209%20edicao%20-%20final.pdf. [Accessed 23th July 2024].

[16] IBGE - Brazilian Institute of Geography and Statistics. IBGE Cities [Internet]. 2023. Available from: https://cidades.ibge.gov.br/brasil/rr/panorama. [Acessed 20th July 2024].

[17] Rocha CA, Bitencourt CD. The importance of the logistics transportation function for the deployment of the operation Acolhida. Doutrina Mil Terrestre Ver [Internet]. 2020 Jun;1(21):28-37. [Accessed 15th July 2024].

[18] Drakaki M, Gören HG, Tzionas P. An intelligent multi-agent based decision support system for refugee settlement siting. *International Journal of Disaster Risk Reduction*. 2018; 31: 576-88. doi: 10.1016/j.ijdrr.2018.06.013.

[19] Bozorgi-Amiri A, Khorsi M. A dynamic multi-objective location-routing model for relief logistic planning under uncertainty on demand, travel time, and cost parameters. *The International Journal of Advanced Manufacturing Technology*. 2016; 85:1633-48. doi: 10.1007/s00170-015-7923-3.

[20] Rottkemper B, Fischer K. Decision making in humanitarian logistics-A multi-objective optimization model for relocating relief goods during disaster recovery operations. *International Conference on Information Systems for Crisis Response and Management (2013)*.

[21] Chakraborty S. TOPSIS and Modified TOPSIS: A comparative analysis. *Decision Analytics Journal*. 2022; 2:100021. doi: 10.1016/j.dajour.2021.100021.

[22] Ramík J. Applications in Practical Decision-Making Methods: PROMETHEE and TOPSIS. *Pairwise Comparisons Method: Theory and Applications in Decision Making*. 2020: 213-28. doi: 10.1007/978-3-030-39891-0_7.

[23] Roszkowska E. Multi-criteria decision making models by applying the TOPSIS method to crisp and interval data. *Multiple Criteria Decision Making*. 2011; 6(1): 200-30.

[24] Parida PK. A general view of TOPSIS method involving multi-attribute decision making problems. *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*. 2019; 9(2): 3205-14. doi: 10.35940/ijitee.B7745.129219.

[25] Pamučar D, Ecer F, Cirovic G, Arlasheedi MA. Application of improved best worst method (BWM) in real-world problems. *Mathematics*. 2020; 8(8):1342. doi: /10.3390/math8081342.

[26] Bafail OA, Abdulaal RM. A Combined BWM-TOPSIS Approach versus AHP-TOPSIS Approach: An Application to Solid Waste Management. In: *2022 The 3rd International Conference on Industrial Engineering and Industrial Management*. 2022 :27-33. doi: 10.1145/3524338.3524343.

[27] Atan T, Temur GT. A Unified Multiplicative Group Best-Worst Method with a New Assessment Approach for Dissimilar Markets. *Informatica*. 2023; 34(3): 465-89. doi: 10.15388/23-INFOR528.

[28] Wu Q, Liu X, Zhou L, Qin J, Rezaei J. An analytical framework for the best-worst method. *Omega*. 2024; 123: 102974. doi: 10.1016/j.omega.2023.102974.

[29] Adeoye-Olatunde OA, Olenik NL. Research and scholarly methods: Semi-structured interviews. *Journal of the American College of Clinical Pharmacy*. 2021; 4(10):1358-67. doi: 10.1002/jac5.1441.

[30] Inter-Agency Coordination Platform for Refugees and Migrants from Venezuela. *RMNA 2022 - Refugee and Migrant Needs Analysis*. Available from: https://www.r4v.info/en/document/rmna-2022-refugee-and-migrant-needs-analysis. [Accessed 30th July 2024].

[31] Naderifar M, Goli H, Ghaljaie F. Snowball Sampling: A Purposeful Method of Sampling in Qualitative Research. *Strides in Development of Medical Education*. 2017; 14(3). doi: 10.5812/sdme.67670.

[32] REZAEI, J. Best-worst multi-criteria decision-making method. *Omega*. 2015; 53: 49-57. doi:10.1016/j.omega.2014.11.009 .

[33] Liang F, Brunelli M, Rezaei J. Consistency issues in the best worst method: Measurements and thresholds. *Omega*. 2020; 96:102175. doi: 10.1016/j.omega.2019.102175.

[34] Hasan MdG, Ashraf Z, Khan MF. Multi-choice best-worst multi-criteria decision-making method and its applications. *International Journal of Intelligent Systems*. 2022; 37(2): 1129-56. doi: 10.1002/int.22663.

[35] Behzadian M, Khanmohammadi Otaghsara S, Yazdani M, Ignatius J. A state-of the-art survey of TOPSIS applications. *Expert Systems with Applications*. 2012; 39(17): 13051-69. doi: 10.1016/j.eswa.2012.05.056.

[36] Papathanasiou J, Ploskas N. TOPSIS. In: Papathanasiou J, Ploskas N, editors. *Multiple Criteria Decision Aid : Methods, Examples and Python Implementations*. Cham: Springer International Publishing; 2018. p. 1-30. doi: 10.1007/978-3-319-91648.

[37] Madanchian M, Taherdoost H. A Comprehensive Guide to the TOPSIS Method for Multi-criteria Decision Making. *Sustainable Social Development*. 2023; 1(1): 2220. doi:10.54517/ssd.v1i1.2220.