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Problems Encountered in Humanitarian Aid Logistics and Solution Suggestions by Integrated QFD Method: The Case of Hatay

Entegre KFG Yöntemi ile İnsani Yardım Lojistiğinde Karşılaşılan Sorunlar ve Çözüm Önerileri: Hatay Örneği

Gülşah AYVAZOĞLU
Corresponding Author | Sorumlu Yazar
Dr. Öğretim Üyesi | Asst. Prof.
Hatay Mustafa Kemal Üniversitesi, Sağlık Bilimleri Fakültesi, Acil Yardım ve Afet Yönetimi Bölümü, Hatay, Türkiye
Hatay Mustafa Kemal University, Faculty of Health Sciences, Department of Emergency Aid and Disaster Management Hatay, Türkiye
gulsahayvazoglu@mku.edu.tr
https://orcid.org/0000-0003-0830-4570

İskender PEKER
Prof. | Prof.
Gümüşhane Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, İşletme Bölümü, Gümüşhane, Türkiye
Gümüşhane University, Faculty of Economics and Administration Sciences, Department of Business Administration, Gümüşhane, Türkiye
İskenderpeker@gumushane.edu.tr
https://orcid.org/0000-0001-6402-5117

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Problems Encountered in Humanitarian Aid Logistics and Solution Suggestions by Integrated QFD Method: The Case of Hatay*

Abstract

In recent years, extraordinary situations and humanitarian crises have increased the number of studies in the field of humanitarian aid logistics. Although various solutions have been tried to be produced for the problems experienced in humanitarian aid logistics in disasters occurring worldwide and, in our country, these solutions have generally not been suitable for regional needs. The aim of this study is to identify the problems encountered in humanitarian aid activities carried out in Hatay province and to develop solutions to these problems. Humanitarian logistics is a complex process involving many actors. This complexity requires a combination of both requirements and decision criteria to be evaluated. In this study, a model that can provide flexible yet effective solutions to the problems encountered in the humanitarian logistics planning process is proposed. This model involves combining qualitative and quantitative data using the Quality Function Deployment (QFD) method. In this study, a model that integrates Delphi and Analytical Network Process (ANP) methods with Quality Function Deployment (QFD) technique has been developed to identify the problems encountered in humanitarian aid logistics in Hatay province and to develop solutions to these problems. In line with the developed model, the study generally consisted of three stages. In the first stage, the Delphi method was used to identify the problems in humanitarian aid logistics by taking into account the relevant literature and the opinions of the representatives of the institutions/organizations providing humanitarian aid services in Hatay. Then, the priority values (weights) of these problems were determined by Analytic Network Process (ANP) method. In the last stage, solution proposals were developed through the Quality Function Deployment (QFD) relationship matrices. In humanitarian aid logistics, 14 problems were identified by Delphi technique. With the prioritisation of the results obtained with ANP, 'Problems Arising from Lack of Continuity-Sustainability' emerged as the most important problem. Then, among the 13 solution suggestions determined by expert opinions, 'Establishing a system to monitor humanitarian aid' was determined as the most effective solution suggestion in eliminating the problems in humanitarian aid logistics. In the future, it would be useful to conduct similar research with the participation of more experts in different regions or countries. In addition, the findings of the study can be compared with different multi-criteria decision-making methods to provide a broader perspective. In this context, the use of integrated methodologies in the field of humanitarian aid logistics will allow for a more comprehensive approach to the problems.

Keywords: ANP, Delphi, Humanitarian aid, Humanitarian aid logistics, QFD

Entegre KFG Yöntemi ile İnsani Yardım Lojistiğinde Karşılaşılan Sorunlar ve Çözüm Önerileri: Hatay Örneği**

Öz

Son yıllarda yaşanan olağanüstü durumlar ve insani krizler, insani yardım lojistiği alanında yapılan çalışmaların sayısını artırmıştır. Dünya genelinde ve ülkemizde meydana gelen afetlerde, insani yardım lojistiğinde yaşanılan sorunlar için çeşitli çözümler üretilmeye çalışılmışsa da bu çözümler genellikle bölgesel ihtiyaçlara uygun olmamıştır. Bu çalışmanın amacı, Hatay ilinde gerçekleştirilen insani yardım faaliyetlerinde karşılaşılan sorunları belirlemek ve bu sorunlara çözümler geliştirmektir. İnsani yardım lojistiği birçok aktörün yer aldığı karmaşık bir süreçtir. Bu karmaşıklık hem gereksinimlerin hem de karar kriterlerinin bir arada değerlendirilmesini gerektirmektedir. Bu çalışmada, insani yardım lojistiği planlama sürecinde karşılaşılan sorunlara esnek ancak etkili çözümler sunabilecek bir model önerilmektedir. Bu model, Kalite Fonksiyon Yayılımı (QFD) yöntemi kullanılarak nitel ve nicel verilerin birleştirilmesini içermektedir. Bu çalışmada, Hatay ili özelinde insani yardım lojistiğinde karşılaşılan sorunların neler olduğunu belirlemek ve bu sorunlara çözüm önerileri geliştirmek üzere Delphi ve Analitik Ağ Süreci (AAS) yöntemlerinin Kalite Fonksiyon Göçerimi (KFG) tekniğine entegre edildiği bir model geliştirilmiştir. Geliştirilen model doğrultusunda çalışma genel itibariyle üç aşamadan oluşmuştur. Birinci aşamada Delphi yöntemi kullanılarak ilgili literatür ve Hatay'da insani yardım hizmeti sunan kurum/kuruluş temsilcilerinin görüşleri dikkate alınarak insani yardım lojistiğindeki sorunlar tespit edilmiştir. Ardından bu sorunların öncelik değerleri (ağırlıkları) Analitik Ağ Süreci (AAS) yöntemi ile belirlenmiştir. Son aşamada ise Kalite Fonksiyon Göçerimi (KFG) ilişki matrisleri sayesinde çözüm önerileri geliştirilmiştir. İnsani yardım lojistiği konusunda 14 sorun Delphi tekniği ile belirlenmiştir. Elde edilen

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sonuçların AAS ile önceliklendirilmesi ile "Süreklilik-Sürdürebilirlik Eksikliğinden Kaynaklanan Problemler" en önemli sorun olarak karşımıza çıkmıştır. Ardından uzaman görüşleriyle belirlenen 13 çözüm önerisi arasından "İnsani yardımların takip edileceği sistem oluşturulması" ise insani yardım lojistiğindeki sorunların bertaraf edilmesindeki en etkili çözüm önerisi olarak belirlenmiştir. Gelecekte benzer araştırmaların farklı bölgelerde veya ülkelerde daha fazla uzmanın katılımı ile gerçekleştirilmesi faydalı olacaktır. Ayrıca, çalışmanın bulguları, farklı çok kriterli karar verme yöntemleri ile karşılaştırılarak daha geniş bir perspektif sağlanabilir. Bu bağlamda, insani yardım lojistiği alanında entegre metodolojilerin kullanılması, sorunların daha kapsamlı bir şekilde ele alınmasına olanak tanıyacaktır.

Anahtar Kelimeler: AAS, Delphi, İnsani yardım, İnsani yardım lojistiği, KFG

Introduction

Logistics is recognised as an crucial component of emergency response plans in terms of ensuring that the right goods are available in the right place, at the right time and in the right quantities (Kaptan and Liebiediev, 2017, p.82). In humanitarian terms, logistics aims to effectively procure and distribute resources such as food, water, shelter and medical care, which are the basic needs of disaster victims. This effort is made to prevent and minimise the risk of starvation, disease and death caused by natural, technological or man-made disasters (Blecken, 2010, p.5).

EM-DAT defined the disaster as 'A situation or event which overwhelms local capacity, necessitating a request to the national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction, and human suffering' (URL-1). All essential actions to prevent disasters, reduce their effects, respond to them, and finish the post-disaster recovery process in Turkey fall under the authority of AFAD (The Disaster and Emergency Management Presidency. Turkey Disaster Response Plan (TAMP) is an important tool for effective and rapid response to disasters. The working groups established under this plan have been carrying out a wide range of activities, including humanitarian assistance activities, to meet the basic needs of disaster victims and to save their lives (AFAD, 2022). Numerous national and international humanitarian stakeholders around the world are working towards common goals.

Hatay, a border province, hosts numerous humanitarian aid activities within the provincial borders and in the Syrian field. The Syrian conflict officially turned twelve years old in March 2023. The protracted conflict, which began in 2011 as a response to peaceful protests, has evolved into a complex humanitarian crisis. According to UNOCHA's 'February 2021 Global Humanitarian Overview', there are more than 13 million people in need in Syria, 6.7 million internally displaced and more than 5.6 million refugees in neighbouring countries and the wider region (UNOCHA, 2021). In addition, Hatay, one of the provinces where the devastating effects of the 6 February 2023 Kahramanmaraş earthquakes were felt the most, has been providing intensive humanitarian aid to the earthquake victims since then.

With this study, a model that offers solutions to the problems experienced by institutions and organisations providing humanitarian aid services in humanitarian aid logistics has been created. In this context, the following study questions are sought to be answered within the scope of the research.

SQ 1: What are the problems encountered in humanitarian aid logistics?

SQ 2: Can problems in humanitarian aid logistics be ranked in order of importance?

SQ 3: What are the solutions that can be developed to the problems encountered in humanitarian aid logistics?

In this period when we witness the increasing importance of humanitarian aid day by day, this study, which answers the above-mentioned study questions, makes a significant contribution to both humanitarian aid studies and the literature by offering solutions to the problems experienced in humanitarian aid processes. Humanitarian aid logistics processes involving a large number of stakeholders have a complex structure and differences in implementation. Humanitarian processes that require expert judgement are considered as a decision problem. In this context, an integrated model has been presented with Quality Functional Transformation, which combines qualitative and quantitative research factors, and solutions to the problems experienced in humanitarian aid processes have been sought.

In the second part of this study, the related literature is reviewed and studies are presented. In the third section, the methodology is presented and in this context, the methods included in the research are mentioned respectively. In the following section, the implementation process and findings are followed by a discussion section. Finally, the study is concluded with the conclusion and recommendations section, which includes suggestions that shed light on future studies.

1. Literature Rewiew

Research in the field of humanitarian logistics provides valuable insights into research gaps in humanitarian aid, including an understanding of theoretical concepts and terminology, as well as the use of various research techniques and modelling. Some of these studies include systematic literature reviews using secondary data in the humanitarian field and focus on identifying the state of existing studies. On the other hand, applied studies enriched and modelled with different methods also contribute to the literature in a way to be useful in humanitarian crises.

In general, when the studies in the literature are examined, it is seen that there is limited research on the planning of the humanitarian aid logistics process. Some of these studies were conducted with a focus on humanitarian aid planning and included literature reviews of selected studies with keywords such as "Humanitarian Aid Planning" and "Humanitarian Aid Logistics Planning". In this context, a literature review of the studies emphasising planning through the identified examples is shown in Table 1.

Table 1. Humanitarian Logistics Planning Literature Summary

Year	Author(s)	Aim	Method
2010	Adivar et al.	Create an optimal planning model for an NGO, introducing the social welfare chain concept and tackling decision-making challenges.	General Algebraic Modelling System (GAMS)
2014	Mguis et al.	Meet all demands while minimizing travel distance during natural disasters, humanitarian aid planning.	Genetic algorithm
2017	Gavidia	Propose the use of integrated enterprise resource planning (ERP) as the next step on the path towards the integration of humanitarian supply chains.	Literature review
2018	Kirac and Milburn	Generate interest in a research agenda by emphasizing the need to balance timeliness and accuracy of social data for disaster logistics planning.	Qualitative evaluation of social data and case study
2019	Rezvanian	Characterise response planning and preparedness issues in large-scale humanitarian organisations.	Optimisation and machine learning algorithms
2021	Heyse et al.	Explore the institutional factors influencing evaluations of NGOs' disaster response.	Qualitative Comparative Analysis with Fuzzy Set Theory
2022	Eligüzel et al.	Offer a practical solution for optimizing the UNHRD distribution network, considering reductions in distance, time, and cost through various methods.	P-median, maximum coverage and set covering models
2022	Vosooghi et al.	Developed a scenario-based model to supply medical relief goods to demand points in uncertain conditions, acknowledging their direct impact on survival rates.	Multi-objective optimisation methods (heuristic and meta-heuristic methods)
2022	Timperio et al.	Propose a decision support framework for supply networks addressing resource coordination challenges in disaster response.	Data analysis, Multi-criteria Decision Making Techniques and Simulation

Table 1. (Cont'd)

2023	Cengiz Toklu	Determine an optimum solution that minimizes the travel distance and the number of routes, taking into account the different decision criteria encountered in real-world problems.	The interval type-2 fuzzy TOPSIS and Clarke and Wright savings algorithm.
2023	Tanti et al.	Create an optimal disaster relief model with distribution center locations, demand forecasting, forbidden route mapping, and effective relief supply distribution.	K-Means method and Artificial Neural Networks (ANN)
2024	Ülkü et al.	Conduct a systematic literature network analysis and identify trends in Industry 4.0 and hu manitarian supply chains (HSCs).	Systematic Literature Network Analysis (SLNA)
2024	Venkadesh et al.	Discussed the integration of machine learning into humanitarian aid efforts in terms of its contribution to environmental sustainability.	Machine Learning (ML) and Deep Learning (DL)
2024	Fallahi et al.	Minimize the total cost and total distance the products travel through in humanitarian aid supply chain network design under product differentiation and uncertain demand.	Robust optimization and fuzzy programming-based approach

The main objectives of the studies in this literature summary on humanitarian logistics planning can be expressed as distance, cost and response time reduction, accuracy and timeliness of social data, development of response plans, use of technological applications and case studies. When we analyse planning-oriented studies in the field of humanitarian aid, it is seen that researchers use various methods together and enrich them with case examples. Studies are classified according to methodology; literature review, modeling (General Algebraic Modelling System (GAMS), Genetic algorithm, optimisation and machine learning algorithms, heuristic and meta-heuristic methods, machine learning (ML) and deep learning (DL), robust optimization), qualitative evaluation (P-median, maximum coverage and set covering models, P-median, maximum coverage and set covering models), case study, multi-criteria decision making as different qualitative and quantitative studies.

As the world continuously struggles with humanitarian crises, researchers use various study techniques to focus on the study of humanitarian logistics in practice and academia. However, there is a lack of comprehensive research that analyses humanitarian logistics approaches and practices and combines them in an end-to-end perspective. In other words, humanitarian aid logistics processes, stakeholders and collaborations have not been addressed in a comprehensive research model, and there is still a need to identify the problems in this field and put forward solutions.

This study aims to identify the problems encountered in the humanitarian aid logistics process in Hatay, a border province of Turkey, and to develop solutions to these problems. In addition, it can be said that this study makes an important contribution to the literature by expressing how the identified solution suggestions will be implemented and suggesting the development of a system in which the results are continuously monitored.

2. Method

Recent extraordinary situations and humanitarian crises have increased the number of studies in the field of humanitarian logistics. When recent studies are analysed, there is a significant increase in the number of studies in which more than one method is used together. However, in the literature on humanitarian logistics, the number of studies that combine two or more methods as a solution methodology by using the QFD method is very limited.

Humanitarian aid logistics is a complex process involving many actors. This complexity requires a combination of both requirements and decision criteria to be evaluated. In this study, a model that can offer flexible yet effective solutions to the problems encountered in the humanitarian logistics planning process is proposed. This model involves combining qualitative and quantitative data using the QFD method.

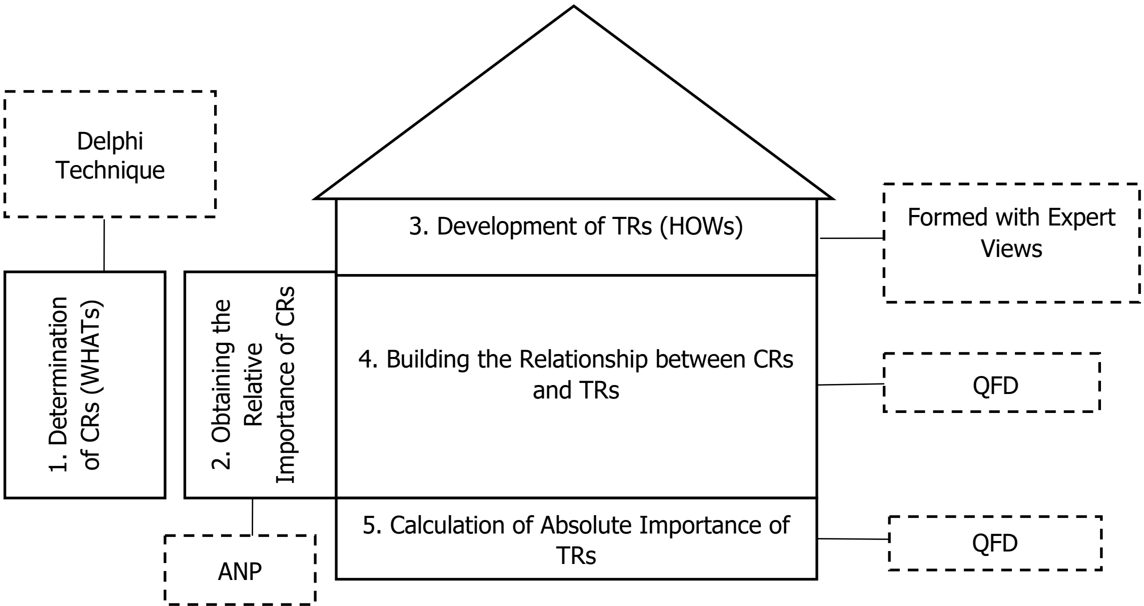
2.1. Quality Function Deployment (QFD)

QFD was first developed as a quality system by Prof. Yoji Akao and Prof. Shigeru Mizuno in Japan in the late 1960s. Akao defined QFD as "methods for transforming user demands into design quality, distributing the functions that constitute quality, and delivering design quality to subsystems, components and specific elements of the manufacturing process" (Patro and Prasad, 2013, p.2966). The aim of the QFD is to improve products and services and respond to the needs of stakeholders. This method starts with a process of identifying the needs of stakeholders and then translates these requirements into design features (Dursun and Karsak, 2013, p.5867).

QFD is a comprehensive design tool that transforms Customer Requirements (CRs) into Technical Requirements (TRs) using a matrix called the House of Quality (HOQ) (Yang et al., 2012, p.147). A common use of the QFD is to support decision-making by setting objectives when prioritising the TRs according to the CRs (Abdel-Basset et al., 2018, p.20; Ocampo et al., 2020, p.6; Haiyun et al., 2021, p.2).

Within the scope of the quality house, WHATs refer to CRs, while HOWs refer to TRs (Bottani and Rizzi, 2006). The QFD matrix contains judgements and evaluations including importance, correlation and linguistic variables. (Lin et al., 2004, s.225). The quality house or planning matrix is the relationship matrix in which the interconnection between CRs and TRs is displayed. The quality house (Hauser and Clausing, 1988, p.62) is presented in Figure 1 and its steps are explained respectively (Patro and Prasad, 2013, p.2969):

Figure 1. Quality House Proposed Method Framework



QFD can commonly be integrated with one or more Multi-Criteria Decision Making (MCDM) methods to determine the relative importance of CRs and/or rank alternatives. Analytical Network Process (ANP) is a very responsive tool combined with QFD to rank customer requirements in case of interdependencies (Bottani et al., 2018, p.9; Chang and Cho, 2019, p.273; Pusparani et al., 2020, p.355; Ghannadpour et al., 2021, p.3410; Liu et al., 2021, p.9). In the light of this information, as shown in Figure 1, while the problems encountered in the humanitarian aid planning process were identified with the Delphi technique within the framework of the QFD method, the interdependencies between these problems were addressed with the ANP method and their importance levels were determined.

2.1.1. Stage 1: Determination of CRs (WHATs) with Delphi

CRs (WHATs): The first step in creating the House of Quality is the stage where CRs are collected for the relevant product or service. In this study, the problems encountered in humanitarian aid logistics were considered as CRs and the Delphi Technique was used to determine these problems.

2.1.1.1. DELPHI Technique

The Delphi technique is a methodology developed by Olaf Helmer and his colleagues at Rand Cooperation in the 1950s (Rossman and Carey, 1995, p.233). The Delphi technique is a method used to reach consensus on controversial issues and is applied through carefully prepared questionnaires instead of traditional approaches (face-to-face discussion) (Smarandache et al., 2020, p.206). This methodology is favoured because it reduces the psychological effects of persuasion, deception and reluctance by eliminating a dominant party influencing the opinion of the majority (Van Notten et al., 2003, p.424). The Delphi method is known for enabling a group of experts to think independently (Şahin, 2001, p.219; MacCarthy and Atthirawong, 2003, p.799). In this technique, in which the ideal group size is recommended to be between 10-20, consecutive questionnaires are administered to the participants until a consensus is reached (Rowe and Wright, 2001, p.128). The results obtained after each application are communicated to the participants (Broomfield and Humphris, 2001, p.929; Humphrey-Murto et al., 2017, p.1491).

The Delphi technique has a number of advantages, including bringing together geographically distributed panel experts, avoiding face-to-face or direct discussions, promoting fair evaluation free from group bias, and being cost-effective, flexible and adaptable (Hung et al., 2008, p.192; Palter et al., 2011, p.252; Prinsen et al., 2014, p.2; Yurt and Kadıoğlu, 2019, p.49).

Although the Delphi technique is a qualitative method, efforts were made to process its results within a measurable and rational framework. Usually the experts' responses are recorded, mostly on a 5-point Likert scale. Table 2 exemplifies the percentage agreement of a Delphi survey that shows the degree of consensus among experts on a particular topic.

Table 2. Degree of Consensus Among Delphi Experts

Percentage (%)	Consensus Level
>65	Strong consensus
50-65	Consensus
40-50	Weak consensus
<40	No consensus

Source: (Profillidis and Botzoris, 2019, p.130)

The stages followed when applying the Delphi technique are: Determining the Problem, Determining the Experts, Sending the First Delphi Survey to the Experts, Answering the First Delphi Survey and Editing the Results and Sending the Results to the Experts. The survey is repeated until consensus is reached. In the Delphi surveys created, the importance level of each question is determined by Median (Md), First Quarter (Q1), Third Quarter (Q3) and Range (R).

2.1.2. Stage 2: Obtaining the Relative Importance of CRs with ANP

Importance of WHATs: This section covers the evaluation or prioritization of CRs (WHATs). Input from stakeholders should be weighted to eliminate relatively less important needs and create the opportunity to focus on more important ones. As shown in Figure 1, ANP was used in this study to determine the relative importance of CRs.

2.1.2.1. Analytical Network Process (ANP)

Analytic Hierarchy Process (AHP) and Analytic Network Process (ANP) were introduced to the literature by Thomas L. Saaty. AHP is a widely used method to solve Multi-Criteria Decision Making (MCDM) problem (Saaty, 1987, p.161). AHP tries to solve the problem by modeling it in a hierarchy system, and if the problem is too complex to be handled in a hierarchical structure, ANP is used (Saaty and Vargas, 2006, p.8).

The weight coefficients of the criteria (global priority vector) are obtained by exponentiating the special case and limit supermatrix, which takes into account the interdependencies between the criteria, the structure of the ANP feedbacks and the control hierarchy (Cheng and Li, 2004, p.1023).

The step algorithm for ANP's selection problem is given below (Saaty, 2006):

Step 1. Defining the decision problem: In this step, the purpose of the decision problem, criteria, sub-criteria and decision makers are defined in detail.

Step 2. Identifying dependencies: In this step, the general network of the ANP problem is first established. Customer requirements are divided into sets of criteria to create the overall network of components. All internal and/or interdependencies between clusters and nodes are determined with the help of literature review and experts. The decision is made by reaching the consensus of the expert group.

Step 3. Pairwise comparisons: Pairwise comparison surveys are created according to the internal and interdependencies between clusters and nodes. The evaluations made by experts are converted into numerical data using the importance scale suggested by Saaty, and the two factors are compared with each other to determine how much they contribute or affect the goal. In this step, pairwise comparisons are made according to Saaty's 1-9 scale (Table 3). Pairwise comparisons are performed as a group decision based on consensus. Alt derece başlığın gövde metni bu şekilde yazılmalıdır. Alt derece başlığın gövde metni bu şekilde yazılmalıdır. Alt derece başlığın gövde metni bu şekilde yazılmalıdır. Alt derece başlığın gövde metni bu şekilde yazılmalıdır. Alt derece başlığın gövde metni bu şekilde yazılmalıdır. Alt derece başlığın gövde metni bu şekilde yazılmalıdır.

Table 3. Fundamental Scale of Absolute Numbers

Point Value	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one activity over another
5	Strong importance	Experience and judgment strongly favor one activity over another
7	Very strong demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate Numbers	Used to represent the compromise between the priorities listed above

Source: (Saaty, 2006, p.558)

After all binary matrices are created, eigenvectors or relative weights, global weight vector and maximum eigenvalue (λmax) are calculated for each matrix. After all binary matrices have been created, attention should be paid to any inconsistencies. The discrepancy rate is calculated with the following equations (see Equation (1), Equation (2), and Equation (3)). Eigenvectors and maximum eigenvalue (λmax) are used to measure consistency.

Considering that X is the eigenvector of the comparison matrix A representing the relative weights of n elements at level k (i = 1, 2, ..., n), the maximum eigenvalue is calculated using Equation 1.

$$\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n}\frac{(AXi)}{Xi} \quad (1)$$

Using Equation 2, we calculate the consistency index (CI) for each matrix of order n.

$$CI=(\lambda max-n)/(n-1) \quad (2)$$

The Consistency Ratio (CR) is used to perform the consistency analysis. CR is the Consistency Index (TI) divided by the Random Index (RI).

The consistency ratio (CR) is calculated using Equation 3.

$$TO=TI/(RI(n)) \quad (3)$$

Here RI(n) is known as the random consistency index obtained from a large number of simulation runs and varies according to the order (n) of the matrix. Table 4 shows the list of random index values.

Table 4. Random Index Values For Consistency Ratio

Number of Elements (n)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Random Index (RI)	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Source: (Özdemir, 2002, p.6)

If the consistency ratio (CR) value is greater than 0.1, inconsistencies are reduced by making pairwise comparisons. (Eren and Özbek, 2013, p.103). If the consıstency ratıo value is less than 0.1, the result is considered consistent (Saaty, 2004, p.9).

Step 4. Constructing the unweighted supermatrix: It is a matrix of superiority vectors in which all interactions between the criteria, sub-criteria and alternatives that constitute the problem are included in the calculation (Saaty, 2001, p.378). In this step, it is formed by clusters and nodes that are vertically to the left and horizontally above according to their sequence numbers.

The general form of the unweighted matrix is shown in Equation (4), where Cm denotes the mth cluster and emn denotes the mth item in the mth cluster. Wij denotes the main eigenvector of the effect of the items in the jth cluster compared to the ith cluster.

$$
\mathbf{W}= \begin{array}{cc|cccccccccc|}
 & & C_1 & & & C_2 & & & \cdots\cdots & C_m & & \\
 & & e_{11} & \cdots & e_{1n1} & e_{21} & \cdots & e_{2n2} & & e_{m1} & \cdots & e_{mnmn} \\
 & e_{11} & & & & & & & & & & \\
C_1 & \cdots & W_{11} & & & W_{12} & & & \cdots\cdots & W_{1m} & & \\
 & e_{1n1} & & & & & & & & & & \\
 & e_{21} & & & & & & & & & & \\
C_2 & \cdots & W_{21} & & & W_{22} & & & \cdots\cdots & W_{2m} & & \\
 & e_{2n2} & & & & & & & & & & \\
\vdots & & \vdots & & & \vdots & & & \cdots\cdots & \vdots & & \\
 & e_{m1} & & & & & & & & W_{mn} & & \\
C_m & \cdots & W_{m1} & & & W_{m2} & & & \cdots\cdots & & & \\
 & e_{mnmn} & & & & & & & & & &
\end{array} \qquad (4)
$$

Step 5. The weighted supermatrix: In order to perform solution operations on the unweighted supermatrix, the matrix must be stochastic (Saaty, 2006, p.14). In this case, it is necessary to ensure that the column sums are equal to 1 by weighting the supermatrix. Thus, the stochastic supermatrix emerges. The calculated weight of each element in each cluster is multiplied by the corresponding cluster weight and the results are used to calculate the weighted supermatrix. Then, normalisation of the matrix is performed, which is obtained by summing the columns and dividing each element by the column sum.

Step 6. The limit supermatrix: The weight priorities of the alternatives can be found by calculating the limit supermatrix. The entries of the weighted supermatrix show the direct effect of any element on any other element. However, one element may influence a second element indirectly through its influence on a third element. There are potentially many third elements. It is necessary to consider every such possibility of a third element. All indirect effects are obtained by taking the powers of the weighted supermatrix. (Saaty, 2006, p.15). The final weights are calculated with the limit supermatrix $(\lim_{k\to\infty}(W)^n$. The process of taking the power of the supermatrix is continued until the weights converge and remain constant, up to a sufficiently large value. With this process, the weights of the criteria and alternatives are obtained.

Step 7. Determination of the most appropriate decision option: In order to select the best alternative or (in this case) to obtain the final ranking of the alternatives, the limit supermatrix and the criteria weights are considered. According to the ranking values among the options, the most appropriate option is decided by listing them from large to small.

2.1.3. Stage 3: Improving TRs (HOWs) with Expert Opinion

TRs (HOWs): TRs are also known as design attributes, design requirements, engineering features, or engineering attributes. The HOW is the answer to how to fulfil customer requirements and therefore HOWs are closely related to customer needs. Technical features have a very important role in producing a product or service that meets the needs of customers. In the current study, TRs are solution suggestions developed for the problems encountered in the humanitarian aid process. These solution suggestions were obtained through face-to-face interviews with experts and a comprehensive literature review.

2.1.4. Stage 4: Creating the Relationship Matrix Between CRs and TRs

Relationship between WHATs and HOWs (Relationship Matrix): The relationship matrix is an essential part of the house of quality as it shows whether TRs influence CRs and to what extent each TR affects each CR. In this section, decision makers are asked to evaluate the relationship. The question "What is the strength of the relationship between TR and CR?" is sought to be answered. A defined scale is used to measure the relationship. The relationship between a CR and a TR is indicated as a score in the corresponding matrix cell. After the CRs and TRs of the matrix are determined, the degree of relationship between them, in other words, the relationship matrix is formed by quantifying them. When determining the degree of relationship, as shown in Table 5; 9 indicates a strong relationship, 3 means a medium relationship, 1 means a weak relationship, and 0 or empty means no relationship.

Table 5. Scale for Evaluation of Degrees of Relationship Between CRs and TRs

Relationship Degree	Definition	Explanation
0/Null	No Relationship	The WHAT factor is not related to the HOW factor.
1	Weak relationship	The WHAT factor is weakly correlated with the HOW factor.
3	Medium relationship	The WHAT factor is moderately related to the HOW factor.
9	Strong relationship	The WHAT factor is strongly related to the HOW factor.

Source: (Bacın, 2018, p.64)

2.1.5. Stage 5: Calculation of Absolute Importance of TRs

Prioritisation of HOWs: Importance is calculated for each technical characteristic (HOW), also referred to as TR weights. The hesitant weight of TRs is calculated using Equation (5). The normalised weight (or overall importance) of each TR calculated using Equation (6). This stage is considered as the last step of the quality house (Tavana et al., 2017, p.8).

Assuming that there are n technical requirements (TRs) that fulfil m customer requirements (CRs), the raw score, Wj, is calculated by the sum of the sum multiplied by the weights of the customer requirement, Ci, and the relational strength, Rij. It is given in Equation (5).

$$W_j = \sum_{i=1}^{m} RijCi \qquad (5)$$

Wj, j. the importance or "raw score" of the technical feature (j = 1, 2, ..., n);

Rij, i with customer requirement j. relational strength between feature (i = 1, 2, ..., m; j =1, 2, ..., n);

Ci, i. weight of customer requirement (i = 1, 2, ..., m).

It is assumed that there are n technical features (TRs) that fulfil m customer requirements (CRs). The normalised weight is calculated as the raw score of the jth technical attribute Wj divided by the sum of the total raw scores. Equation (6) is as follows:

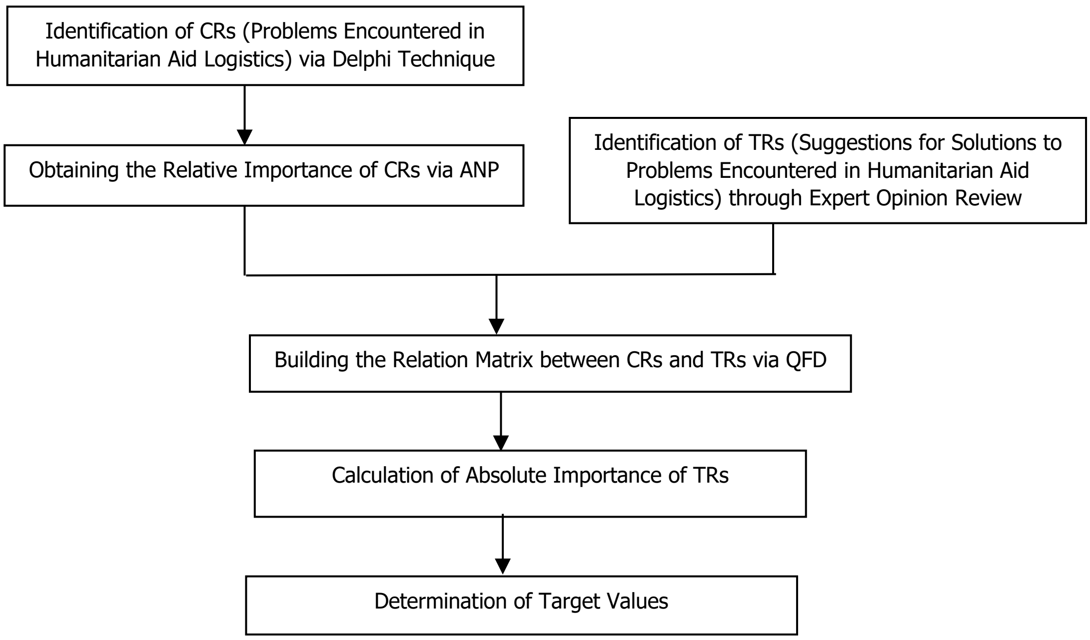
$$\sim W_{j} = \frac{Wj}{\sum_{j=1}^{n} Wj} \quad (6)$$

~W, normalised weight of the jth technical feature (j = 1, 2, ..., n)

3. Application

This hierarchical decision framework for solving problems in humanitarian logistics is presented. Problems in humanitarian aid logistics are identified via Delphi method and the relative importance of these problems is obtained via ANP. Solutions to the problems encountered in humanitarian aid logistics are identified through expert opinion review. The Relationship Matrix was created via QFD method, the Absolute Importance of the Solutions to the Problems Encountered in Humanitarian Aid Logistics was calculated and Target Values were determined. In the implementation phase of this study, the process in Figure 2 was followed:

Figure 2. Hierarchical Decision Framework



3.1. Identification of CRs (Problems Encountered in Humanitarian Aid Logistics) with Delphi Technique

The first part of the quality house includes the identification of the CRs. In this study, the problems encountered in the humanitarian aid logistics process are addressed as CRs (WHATs). At this stage, the Delphi Technique was used and the stages that reveal the approach of the expert group on the subject studied and continue until consensus is reached were followed as follows (Şahin, 2001, p.216; McGeary, 2009, p.32).

1. Identification of the problem: The problems experienced in the field of humanitarian aid logistics were tried to be identified using the Delphi technique.

2. Identification of Experts: The expert group in our study consisted of 12 people (3 Hatay Provincial Disaster and Emergency Management Presidency (Hatay AFAD) personnel, 2 Red Crescent employees, 4 other NGO employees and 3 academicians). The high experience, qualifications and long-term exposure to the researched problem of the participants are effective in the selection of experts, while this perspective increases the reliability of the results.

3. Sending the First Delphi Questionnaire to the Experts: In the first Delphi application of this study, experts were asked to answer the open-ended question "What are the problems encountered in humanitarian aid logistics in Hatay?" by brainstorming through an unstructured form (Yurt and Kadıoğlu, 2019, p.50).

4. Answering the First Delphi Questionnaire and organising and sending the results to the experts: The First Delphi Application was completed when each participant listed their thoughts on the question asked and sent them back anonymously.

5. Sending the Second Delphi Questionnaire to the Experts: A structured questionnaire form was prepared by combining the identical items and gathering some items under the same heading and sent to the experts.

6. Answering the second Delphi Questionnaire and organising and sending the results to the experts: The experts expressed their opinions on each decision item with a 5-point Likert scale in the second Delphi questionnaire and the second Delphi was completed after the results were received by the researcher.

7. Analysing the second Delphi Survey and sending the results to the experts: Various statistical values (first quarter, third quarter, median and range of change) were calculated for each item of the questionnaire.

8. Sending the Third Delphi Questionnaire to the Experts: The third Delphi questionnaire was the same as the second Delphi questionnaire, but the first quarter, third quarter, median and range of change values calculated for each item were also included in this questionnaire.

9. Answering the Third Delphi Questionnaire: At this stage, the experts were asked to tick their old decisions if they insisted on their old decisions, otherwise they were asked to write their new decisions. In addition, if the participants had any new ideas, they were asked to add them to the questionnaire form. In this way, the questionnaire form was answered and sent to the researcher and the Third Delphi Application was completed.

10. Analysing the Third Delphi Survey and Interpreting the Results: In the last stage, the analyses were completed according to the feedback from the experts. The problems experienced in the context of humanitarian aid logistics in Hatay and their explanations are presented in Table 6.

Table 6 shows that the problems in humanitarian aid logistics (CRs) were expressed as 14 criteria with the consensus of the expert group.

Table 6. CR (WHATs) Problems and Explanations in the Context of Humanitarian Aid Logistics

	Criteria (Problems)
CR_1	Legislation-Customs Sourced Problems
CR_2	Needs Analysis (Supply-demand assessment) Problems arising from not being done correctly
CR_3	Communication Related Problems
CR_4	Labour Related Problems
CR_5	Problems Arising from Lack of Infrastructure
CR_6	Problems arising from inefficiency of the supply-distribution network
CR_7	Problems arising from Security
CR_8	Problems arising from abuse
CR_9	Problems Arising from Lack of Continuity-Sustainability
CR_{10}	Management-Organisation related problems
CR_{11}	Problems Arising from Uncertainty
CR_{12}	Cost Related Problems
CR_{13}	Problems Arising from Lack of Humanitarian Aid Awareness
CR_{14}	Problems arising from the Covid-19 Effect

3.2. Obtaining the Relative Importance of CRs by ANP

As a result of Delphi analyses, CRs were identified and each CR is shown as a criterion and defined in detail in Table 6. The general network of the ANP problem was established with the criteria determined as a result of Delphi analysis. All (exogenous) interdependencies between the criteria were identified with the participation of Delphi experts.

In this study, with the ANP questionnaire containing the criteria determined to find the priorities of the CRs, pairwise comparisons were made by the experts identified in the Delphi technique. All mathematical calculations of the ANP method were made in Excel 2013. The limit supermatrix was calculated (Table 7). Table 7 shows the relative importance ranking among MRs.

Table 7. Limit super matrix

	CR_1	**CR_2**	**CR_3**	**CR_4**	**CR_5**	**CR_6**	**CR_7**	**CR_8**	**CR_9**	**CR_{10}**	**CR_{11}**	**CR_{12}**	**CR_{13}**	**CR_{14}**
CR_1	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
CR_2	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073
CR_3	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043
CR_4	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049
CR_5	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085
CR_6	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102	0.102
CR_7	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128
CR_8	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052
CR_9	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136
CR_{10}	0.107	0.107	0.107	0.107	0.107	0.107	0.107	0.107	0.107	0.107	0.107	0.107	0.107	0.107
CR_{11}	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044
CR_{12}	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056
CR_{13}	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
CR_{14}	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035

As shown in Table 7, among the fourteen criteria (CR), "Problems arising from Lack of Continuity-Sustainability" (CR9) has the highest importance with a weight of 0.136, followed by "Problems arising from Security" (CR7) with a weight of 0.128. "Legislation-Customs Sourced Problems" (CR1) has emerged as the least important criterion with an importance level of 0.03. In other words, the ANP results revealed that problems arising from lack of continuity-sustainability (CR9) are the most important obstacles to humanitarian logistics planning. Lack of Continuity (CR9) is the uninterrupted continuation of all vital activities in an organization when a problem occurs. In order to ensure that humanitarian aid in Syria is not interrupted, the lack of continuity of donors and the unsustainability of humanitarian aid activities, the time it takes for project revisions, and the long approval process of projects cause humanitarian aid to be delayed in meeting the needs (such as seasonal needs). The lack of donor continuity and sustainability of humanitarian aid efforts, time-consuming project revisions, and lengthy project approval processes cause delays in humanitarian assistance. The view that the obstacles and bureaucracy in humanitarian aid and customs legislation (CR1) in Hatay, where cross-border aid is provided, prevent the urgency of the humanitarian aid process and cause problems is the least important.

3.3. Identification of TRs (suggestions for solutions to problems encountered in humanitarian aid logistics) Through Expert Opinion

The third part of the quality house is to develop the TRs. In this study, solutions to the difficulties encountered while carrying out humanitarian aid activities are addressed as TRs (HOWs). The group of experts (3 Hatay AFAD personnel, 1 Turkish Red Crescent employee, 3 NGO employees and 3 academicians) who gave their opinions for the TRs working in the field of humanitarian aid consists of 10 people. Expert opinions were obtained by face-to-face interviews through a semi-structured form.

According to the feedback from the experts, the solution suggestions regarding the problems experienced in the context of humanitarian aid logistics in Hatay, which were determined in the previous stage, were determined and expressed with explanations as in Table 8.

Table 8. TRs (HOWs) Suggestions for Solutions to Problems in the Context of Humanitarian Aid Logistics

	HOWs -Solution suggestions
TR_1	Working on legislation specific to humanitarian aid activities
TR_2	Establishment of a vocational training unit for humanitarian aid workers
TR_3	Establishment of an inter-institutional (Public-NGO-Donor) cooperation and coordination commission
TR_4	Carrying out the needs analysis in co-operation with the exploration-identification teams
TR_5	Providing psychosocial support to personnel working in the field of humanitarian aid
TR_6	Establishment of human resources selection criteria (experience, merit, local staff)
TR_7	Improvement of infrastructure services
TR_8	Establishing a system to monitor humanitarian aid
TR_9	Establishment of security focal points
TR_{10}	Co-operation with local actors
TR_{11}	Policy development for sustainable permanent projects
TR_{12}	Preparation of aid products in accordance with standards
TR_{13}	Establishing an action plan against epidemics and secondary risks such as Covid-19

3.4. Building the Relationship Matrix Between CRs and TRs by QFD

In order to calculate the relationship scores between CRs and TRs, the opinions of a group of 6 experts (2 Hatay AFAD personnel, 2 NGO employees and 2 academicians) were taken and the degree of relationship was determined, in other words, numerically represented. The extent to which the TRs fulfil the CRs was evaluated by the decision makers. Expert opinions are shown in the matrix in Table 9.

Table 9. Relationship Matrix Between CRs and TRs

	TR_1	TR_2	TR_3	TR_4	TR_5	TR_6	TR_7	TR_8	TR_9	TR_{10}	TR_{11}	TR_{12}	TR_{13}
CR_1	9	9	3	1	1	9	3	3	3	1	3	3	3
CR_2	3	9	9	9	3	9	3	9	3	9	3	9	1
CR_3	3	9	3	3	9	9	3	9	3	9	9	3	3
CR_4		3	1	3	9	3	3	9	1	9	3	3	3
CR_5			1	3	3	1	9	9	1	3	3	1	1
CR_6	1	3	3	3	1	3	3	9	3	9	9	3	3
CR_7	1	3	1	3	3	3	3	9	9	9	9	1	3
CR_8	1	3		9	9	9	3	9	3	9	3		1
CR_9			3	1	1	9		9	1	3	9	1	3
CR_{10}	3	9	9	3	9	9	3	9	2	9	9	3	3
CR_{11}	3	3	3	3		3		9	1	3	9		3
CR_{12}	3	1	9	3		9	3	9	3	9	3	1	3
CR_{13}	3	3	3	3	3	9		9	1	3	3		1
CR_{14}	3	1	1	3	1	3	1	9	1	9	1		9

3.5. Calculation of Absolute Importance of TRs

Prioritisation of HOWs: The importance, also referred to as TR weights, was calculated for each TR. In determining these relationship levels, while calculating the technical importance score and technical importance percentage, the common opinion of the decision makers was taken as the geometric mean of the numerical expressions of the experts and the results are shown in Table 10.

Table 10. Technical Importance Score and Percentage

	TR_1	TR_2	TR_3	TR_4	TR_5	TR_6	TR_7	TR_8	TR_9	TR_{10}	TR_{11}	TR_{12}	TR_{13}
Technical importance score	2.637	4.989	4.332	3.762	3.212	4.333	3.045	6.443	3.298	5.665	5.073	3.130	3.110
Technical importance percentage	0.049	0.094	0.081	0.070	0.060	0.081	0.057	**0.121**	0.062	0.106	0.095	0.059	0.058

Considering the technical importance score and technical importance percentage given in Table 10, "Establishing a system to monitor humanitarian aid" (TR8) is the most important solution suggestion.

3.6. Determining Target Values

After determining the order of importance of the TRs (solution suggestions for the problems encountered in the humanitarian aid logistics process) determined for CRs (problems encountered in humanitarian aid logistics), target values were determined. Targets were determined for each TR as a result of a 2-hour round table meeting with a group of 6 experts working in the field of humanitarian aid (2 Hatay AFAD personnel, 2 NGO employees and 2 academicians).

As an example of the targets set by the expert group, for the solution suggestion for TR1 (Working on legislation specific to humanitarian aid activities), "Establishing a working group that includes the opinions of all stakeholders and then working on legislation in a 6-month period" was determined as the target value. As a result of the meeting with the experts, each solution proposal (TR) regarding the problems experienced in the context of humanitarian aid logistics in Hatay was analysed one by one and the targets were determined and expressed as shown in Table 11.

Table 11. Target Setting for TRs (HOWs)

	Targets
TR_1	Establishing a working group that includes the views of all stakeholders and then working on legislation in a 6-month period
TR_2	Preparing training modules by taking into account the best practices and accredited trainings in the sector 1 year to ensure that all personnel complete the trainings.
TR_3	To hold a planned cooperation and coordination meeting every month To ensure the establishment of commission working offices and the definition of authority and responsibility. Thus, to ensure the transfer of knowledge and experience
TR_4	Within 3 months to form exploration and survey teams Identification of nearly 100 per cent qualified needs, receiving feedback from the field
TR_5	To conduct training and seminar programmes, group work and psychological information meetings for psychosocial support on a monthly basis To ensure that field personnel have a regular psychologist/social worker interview every month
TR_6	Meeting the need for qualified personnel within 1 year, completing the training of existing personnel within 6 months
TR_7	Provision of infrastructure/maintenance services for sustainable assistance within 1 year
TR_8	Implementation of a web-based humanitarian aid programme within 6 months
TR_9	Within 3 months, in cooperation with law enforcement agencies, to ensure that training is received from public or private institutions for security counselling
TR_{10}	Within 6 months, establishing/activating offices where cooperation with local actors will be carried out
TR_{11}	Determining the humanitarian aid policy, working on mission and vision Professional project consultancy in the field of humanitarian aid is available
TR_{12}	Within 1 year, minimum standards should be determined by taking international and local standards into consideration. Ready technical specifications should be prepared and audit and quality control units should be established.
TR_{13}	Preparation of emergency plans within 1 year, taking into account the risk and hazard analyses of the region

Conclusion

Unexpected humanitarian aid in the best way makes it necessary to identify the problems encountered in the field of humanitarian aid logistics and to find solutions to these problems. Conducting this study in Hatay is a good example for both our country and the world in terms of identifying the problems encountered in humanitarian aid activities and providing solutions to the problems. The findings of this study were obtained with integrated QFD. Firstly, the problems encountered in the field of humanitarian aid were obtained as a result of the compilation of open-ended comments provided by 12 Delphi participant experts and the ongoing 3 Delphi rounds. In the following stage, the problems were ranked according to their importance levels by ANP method. Finally, solutions to the problems identified by following the QFD stages are presented.

There may be hundreds of humanitarian organisations at the scene of a crisis at any one time, including local and international humanitarian agencies, private sector companies, governments, the military and individuals (Besiou et al., 2018, p.78). Accordingly, the large number of stakeholders in the aid chain, their different ideologies and religious beliefs, conflicting goals and interests, and lack of coordination pose significant challenges to the identification and prioritisation of objectives in aid operations.

The problems encountered in the field of humanitarian aid were categorised under 14 headings and when ranked by applying the ANP, Problems Arising from Lack of Continuity-Sustainability emerged as the most important criterion in relative terms. The relationship between the solution proposals determined by taking expert opinions and using them together was determined by the Quality Function Deployment (QFD) technique and the solution proposal "Establishing a system to monitor humanitarian aid" was prioritised according to the technical importance score and technical importance percentage. Again, our field studies and our own observations support this conclusion, as the recording of humanitarian aid activities carried out in the Syrian Arab Republic and the insufficiency of field personnel in this sense have led to the fact that it is seen as essential for the solution of many problems. Similarly, Grass et al. (2023) focuses on addressing critical issues in humanitarian logistics and decision-making processes, particularly in contexts of high uncertainty and complexity such as disaster response.

Using the Delphi technique, the problems encountered in humanitarian aid logistics were determined, and according to the results obtained, the criterion of Problems Arising from Not Conducting Needs Analysis (Supply-Demand Assessment) Correctly is one of the problems encountered. This problem was expressed by more than one expert as "Not providing aid in accordance with the traditions and habits (taste, diet, religious beliefs) of the geography to which aid is provided". In addition, our field studies and our own observations support this conclusion and show that Syrian citizens consume Syrian bread, also known as Arabic bread, instead of white bread. Similarly, Trapp (2016) traces food aid through sensory taste biographies, arguing that refugees do not inherently possess or acquire a taste for necessity.

Many reasons that make humanitarian aid processes difficult have been shown by studies, but this complexity has not yet been resolved. Humanitarian crises and unpredictable conditions persist despite science and technology. International aid organisations and ongoing disasters, emergencies and some very slow processes indicate that the need for humanitarian assistance will increase in the coming years.

One of the main limitations of this study is that the field of humanitarian logistics is by its very nature assessed using a variety of quantitative and qualitative criteria involving a large number of stakeholders. One of the limitations of this study is the inevitable time-consuming repetitive rounds of the traditional Delphi Method and the fact that collecting data in the current methodology requires considerable time for both the researcher and the expert group. In addition, the fact that the expert group consisted of people actively working in the field within the borders of the Syrian Arab Republic and their work intensity made the data collection process difficult. As another constraint, the Covid-19 pandemic has delayed/prevented face-to-face interviews with experts through processes such as precautions and quarantine. Further evaluation will be needed to apply the results of this study in different organisations and countries.

More obstacles and challenges in the field of humanitarian aid logistics can be identified with integrated methodologies by interviewing more experts in different provinces of Turkey or other countries. Future studies can be evaluated by using different MCDM methods or by fuzzy MCDM methods. When the findings of the study are evaluated one by one, the results obtained by using different methods (Artificial Neural Networks, Multiple Regression, Monte-Carlo Simulation, etc.) and new technological applications such as blockchain can be compared with the results of the current study.

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