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Research Article

# The Evaluation of Humanitarian Supply Chain Performance Based On Balanced Scorecard-DEMATEL Approach

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**ABSTRACT**

Measuring the performance of the humanitarian supply chain (HSC) becomes a necessary nowadays regarding to the increasing wars around the world. This study aims to propose an integrated performance evaluation approach for the HSC in the context of war. The proposed framework includes two main stages. The first stage implicates determining the performance indicators by the literature review and classifies the indicators based on the Balanced Scorecard dimensions. The second stage involves prioritizing the Balanced Scorecard dimensions and performance indicators by DEMATEL. According to results of the study, the most important dimension in the performance measurement for the HSC in the context of war is the customer. Moreover, service quality has the highest impact in the HSC performance measurement. This study extends the current state of knowledge, which provides a novel combined method to measure the performance HSC in context of war disaster.

**Keywords:** Balanced Scorecard, DEMATEL, Humanitarian Supply Chain, Performance Indicators

This study is derived from Master thesis titled 'A Framework Proposal For The Evaluation of Humanitarian Supply Chain Performance: Balanced Scorecard-DEMATEL Approach" accepted by Karadeniz Technical University Institute of Social Sciences, prepared by Nermin ABUASAD under the supervision of Prof. Birdoğan BAKİ

# 1. Introduction

People have encountered many disasters such as wars, terrorism which they unable to handle over many years. Humanitarian organizations aim to deliver the collected donations and aid to those affected in order to eliminate the war suffering. Accordingly, humanitarian supply chain (HSC) operations have a significant role in terms of delivering donations and aids materials to the war area quickly, effectively and efficiently.

Throughout history, increasingly frequent disasters, especially wars, caused a great damage to people and nature. Increasing number of deaths, famine, refugee crisis, diseases, air and water pollution have occurred with the increase of wars such as civil war, terror attacks, and conflict. Moreover, between 150 million and one billion lives were lost due to wars (Leitenberg, 2006: 9). In recent years, terrorism, ethnic conflict, civil war and such events affected economies and people in different parts around the world. World Bank (2011:2) reported that interstate war and civil war are still threats in some regions. According to Watson Institute (2020:1), wars that the US involved in among (2001-2020) cost over $6.4 trillion dollars. Over 801,000 people lost their lives due to direct war violence, while over 335,000 civilians killed because of the fighting and 21 million war refugees and displaced persons (Watson Institute, 2020:1).

Humanitarian operations must manage appropriately to respond effectively to disasters because these operations are uncertain and complex. Therefore, disaster management is an important factor that ensures the success of humanitarian operations (Gizaw and Gumus, 2016: 105). Based on this, the difficulties such uncertain demands at critical time and the critical supplies and services have revealed the importance of the humanitarian supply chain (Moe et al., 2007: 786). International NGOs such as the World Food Program, the International Federation of the Red Cross and Red Crescent (IFRC) and Doctors without Borders tended to specialize on supply chain/logistics in the humanitarian sector by developing logistics departments to support them (Vega and Roussat, 2015: 352-353). Accordingly, measuring the performance of the HSC and identifying the indicators that affect its performance has been an important and critical task for both humanitarian organizations and countries.

Performance measurement is a key factor and an important competitive advantage to increase the efficiency and effectiveness of the supply chain. It is necessary to measure the performance of an organization to determine whether it is moving towards the goals (Balcik et al., 2015: 302). Performance measurement also is a critical point for the HSC because effective performance measurement plays an important role in increasing the transparency and accountability of disaster response (Beamon and Balcik, 2008: 5). Performance measurement supports humanitarian organizations to identify bottlenecks in their logistics activities and offer necessary solutions for better perfromance (Balcik et al., 2015: 302-303).

The related literature indicates that there are a few studies on performance measurement of the HSC and a few of them use the Multiple Criteria Decision-Making (MCDM) methods as mentioned in the section 2. In addition, there is no study on the HSC performance measurement in the case of war. Therefore, the main purpose of this study is to provide an integrated performance evaluation approach for the HSC in the context of war. So, the major contributions of this study are twofold:

- Given the findings of the current studies, no previous research has been carried out to assess the performance evaluation of the HSC applications in the case of war.
- This is the first study that combines Balanced Scorecard (BSC) and DEMATEL methods in the HSC literature in the case of war.

In this study, the performance indicators of the HSC in the case of war are determined based on the literature review. Afterward, these indicators are classified according to the Balanced Scorecard method. Finally, BSC dimensions and performance indicators are prioritized by DEMATEL.

The rest of the article are structured as follows. The literature review, section 2, indicates the related studies on supply chain performance measurement and also the techniques used in these studies. Section 3 describes the BSC and DEMATEL methods theoretically. Section 4 presents the proposed methodology and the application results. The last section discusses the results and also refers the concluding remarks.

## 2. Literature Review

### 2.1. Studies on Supply Chain Performance Measurement

Supply chain management has become an important research topic among researchers. Furthermore, performance measurement has also been an area of interest for researchers from different disciplines. So, it can be seen many studies based on logistics and supply chain performance measurement when looking at the related literature. Many of them were conducted by Beamon (1991), Bullinger et al. (2002), Bichou and Gray (2004), Dagdeviren (2006), Bhagwat and Sharma (2007), Keebler and Plank (2009), Chang (2009), Liu et al. (2012), Cebeci (2012), Cakir and Percin (2013), Thunberg and Persson (2014), Tyagi et al. (2014), Huang (2018), Lima-Junior and Carpinetti (2019), Yuanzhu and Hua (2020), and Lima-Junior and Carpinetti (2020).

There are several other studies focus on the supply chain performance measurement based on the HSC. Chang and Nojima (2001) analyzed the performance of transportation systems after disasters. Davidson (2006) introduced the applicability of logistics operations and performance measurement of military and commercial institutions in the context of humanitarian logistics. Beamon and Balcik (2008) developed applicable performance indicators within the HSC based on Beamon (1991)'s performance measurement framework. De Leeuw (2010) developed a performance measurement strategy for humanitarian organizations based on a concept strategy developed by Kaplan and Norton (1996). Gatignon et al. (2010) evaluated a case study with IFRC to implement a supply chain process and the decentralized supply chain's performance in the context of humanitarian aid. Larrea (2013) measured the logistics performance of two different type of disasters based on Davidson (2006)'s performance measurement model. D'Haene et al. (2015) identified two main factors affecting on HSC performance measurement. Widera et al. (2015) provided a classification of performance indicators and its implementation for HSC. Lu et al. (2016) proposed indicators to measure performance of humanitarian organizations by using SCOR. Sutrisno et al. (2020) presented a categorization of HSC performance indicators. Abidi et al. (2020) aimed to design the supply chain performance management process for humanitarian organisations.

Another group includes the studies using BSC in order to determine the supply chain performance measurement based on the HSC. Moe et al. (2007) used a BSC approach for improving performance of natural disaster projects through a real flood disaster management. Schulz and Heigh (2009) introduced an indicator development tool software based on BSC to improve the performance of the logistics units of International Federation of Red Crescent and Red Cross (IFRC). Widera and Hellingrath (2011) identified that BSC is a useful model for measuring HSC performance. Abidi and Scholten (2015) analyzed BSC, SCOR and Performance Prism models to determine the criteria for performance measurement in HSC. Saur et al. (2016) proposed a performance measurement model for HSC based on BSC. Anjomshoae et al. (2017) identified the dependencies among key performance indicators to develop a dynamic BSC model for HSC.

## 2.2. Techniques Used in the Studies on Supply Chain Performance Measurement

In this section, techniques used in the studies which measure the supply chain performance in context of HSC are examined. For example, Van der Laan et al. (2009), Pettit and Beresford (2009), Chandraprakaikul (2010), Blecken (2010), Abidi et al. (2014), Bag (2016), Nurmala et al. (2017), and Banomyong et al. (2019) conducted the literature review to identify the performance measurement system in context of HSC. However, many researchers (Idris et al., 2014; Bardhan and Dangi, 2016; Tuffa, 2016; Najjar et al., 2018) have tried to measure the HSC performance using various statistical techniques such as ANOVA, Regression Analysis, and Structural Equation Model.

There are many studies using MCDM techniques in this research topic. Torabi et al. (2012) used SCOR model, fuzzy DEMATEL and ANP to measure humanitarian organizations performance. Li et al. (2014) identified the critical success factors to improve the efficiency and effectiveness of the emergency management using DEMATEL. Muhcu (2016) used ANP to evaluate the critical success factors affecting the HSC. Celik and Gumus (2016) evaluated the performance of the NGOs carrying out the humanitarian relief operations using fuzzy AHP and PROMETHEE. Ganguly et al. (2017) developed a hierarchy basis to evaluate HSC performance based on fuzzy logic. Janackovic et al. (2017) utilized a group fuzzy AHP to evaluate operations of HSC. Yadav and Barve (2018) proposed critical success factors for HSC performance using fuzzy DEMATEL. Celik and Gumus (2018) evaluated the performance of humanitarian organizations in Turkey by using fuzzy AHP and TOPSIS. Anjomshoae et al. (2019) proposed an integrated performance measurement model for HSC by using BSC and AHP.

When we look at the related literature generally, it can be concluded that the studies which measure the supply chain performance in the context of HSC mostly focus on disasters without making a clear distinction in terms of disaster types, and infrequently its specific types such as flood, forced-migration, hurricane, and earthquake. Besides, no previous research has been done to use a combined method with BSC and DEMATEL in the HSC literature in the case of war.

# 3. Methods

## 3.1. Balanced Scorecard

Balanced Scorecard (BSC), proposed by Kaplan and Norton (1992), is a performance measurement model which combines financial and non-financial indicators to measure the performance of a business. It has the feature of being flexible and provides an easy evaluation of the general competitiveness of the supply chain (Kaplan and Norton, 1996: 23). BSC model for the commercial sector transforms the organization's missions and strategies into goals with its four dimensions. These four dimensions, customer, internal business process, financial and learning & innovation are explained in Table 1. Their usage in HSC are also presented in this table.

| Dimension | General Description | HSC |
|---|---|---|
| Customer | In the customer dimension, business managers determine the customer and market where the business competes and performs performance measurements. The main performance indicators in the customer dimension are; customer satisfaction, customer retention, new customer acquisition and customer profitability. The customer dimension enables business managers to identify customers and market-based strategies that had better meet their future financial return expectations. | In HSC, the customer dimension consists two customer groups: beneficiaries and donors. The characteristics of beneficiaries are different from those of commercial market customers (product selection, market options, and e-commerce). The donors are the group who provide donations (cash/in-kind) to humanitarian organizations. |
| Internal Business Process | Managers define critical internal processes which a necessary for a business to be successful at. These processes ensure that customers drawn to the targeted market segments and that shareholders meet their excellent financial return expectations. Performance measures of the internal business process dimension focus on internal processes that have the greatest impact on customer satisfaction and bring the business to its financial goals. | Successful processes in the HSC mean fast and effective performance for the beneficiaries and the use of all available resources. |
| Financial | This dimension commonly covers the traditional financial performance measures, which usually related to profitability. BSC evaluates the financial dimension, as it is required for measurable economic actions. The performance financial measures (Operating income return on capital and economic added value) is used to show whether an enterprise's strategies and its implementation contribute to the goal of the business. | In HSC, financial resources consist of donations and public supports. When a disaster occurs, humanitarian organizations organize donation campaigns and invite international humanitarian organizations and donors to participate. In addition, some humanitarian organizations, especially those with a good and strong reputation, have a steady donation source. |
| Learning & Innovation | In this dimension, the infrastructure that needs to be established is determined in order for the enterprise to provide long-term growth and development. Learning and innovation dimension; It includes performance measurements such as training of employees, developments in training, technology use and the organization reputation. | For HSC, humanitarian organizations must be aware of improving the competency of the working team (managers and staff) by building an efficient information network infrastructure and creating a culture of learning from previous lessons. |

**Table 1.** BSC dimensions and their usage in HSC

Source: Kaplan and Norton (1996: 25-28), Bhagwat and Sharma (2007: 15-20), Varma et al. (2008: 346-348), Lee et al. (2008: 97), Moe et al. (2007: 793).

## 3.2. DEMATEL

DEMATEL, developed between the years 1972-1976 by the Science and Human Relations program of the Geneva Battel Memorial organization, is a comprehensive method for creating and analyzing a structural model containing causal relationships between complex criteria (Gabus and Fontela, 1973; Wu, 2008: 830). The advantage of the DEMATEL is that it separates the relevant criteria in the problem into the cause and effect groups and determines the causal relationships between the criteria based on the Graph Theory (Influence-Relation Diagram) (Lin and Tzeng, 2009: 9686). The implementation steps of the DEMATEL detailed below (Wu and Lee, 2007: 501-503; Tsai and Chou, 2009: 1454-1456; Aksakal and Dağdeviren, 2010: 907-910):

(i) Creating the initial direct-relation matrix (Z):

An nxn non-negative matrix created for each respondent by evaluating the direct influence between any two factors by a comparison scale. This scale consists of five levels for creating the direct relationship matrix: No influence (0), low influence (1), medium influence (2), high influence (3) and very high influence (4). The initial direct-relation matrix (Z) computed by calculating the average of comparisons made by the expert group (Equation 1).

$$Z=\begin{bmatrix} z_{11} & z_{12} & z_{13} \\ \vdots & \vdots & \vdots \\ z_{n1} & z_{n2} & z_{nn} \end{bmatrix} \quad (1)$$

(ii) Determining the normalized direct-relation matrix (M):

The normalized direct-relation matrix (M) is calculated the initial direct-relation matrix (Z) with Equations (2) and (3).

$$M = K \times Z \quad (2)$$

$$K=\mathrm{Min}\left(\frac{1}{\max\limits_{1\le i\le n} \sum_{j=1}^{n} |Z_{ij}|}, \frac{1}{\max\limits_{1\le j\le n} \sum_{i=1}^{n} |Z_{ij}|}\right) \quad i,j \in \{1,2,3,\ldots\ldots,n\} \quad (3)$$

(iii) Obtaining the total-relation matrix (S):

After the normalized direct-relation matrix, the total effect matrix (S) is obtained by applying Equation (4) where (I) refers to the unit matrix.

$$S = M + M^2 + M^3 + \ldots = \sum_{i=1}^{\infty} M^I$$
$$= M(I - M)^{-1} \quad (4)$$

(iv) Calculating the cause and effect groups:

Based on Equations (5), (6), and (7), R+C and R-C values calculated for each criterion. R and C demonstrate the sum of rows and sum of columns respectively.

$$= \left[S_{i,j}\right]_{nxn}, \ i,j \in \{1,2,3,\ldots,n\} \quad (5)$$

$$R = \sum_{j=1}^{n} S_{i,j} \quad (6)$$

$$C = \sum_{i=1}^{n} S_{i,j} \quad (7)$$

The R+C value represents the horizontal axis of the influence-relation diagram and the importance of the criterion within the system. (Tsai and Chou, 2009: 1455; Shieh et al., 2010: 279). The R+C value represents the effect sent by the criterion *i*. Also, it presents the total effect that the criterion *i* received from the other criteria in the system (Wu, 2008: 830-831). The R-C value represents the vertical axis of the influence-relation graph diagram. The R-C value indicates the net effect that the criterion (i) contributes to the system and separates the criteria in the system into the cause (sender) and the effect (receiver) groups (Wu, 2008: 830-831). If the R-C value of a criterion is positive, then the criterion belongs to the cause group and has a higher effect and higher significance over the other criteria. However, if a criterion's

R-C value is negative, it is determined that this criterion belongs to the effect group and affected more than the other criteria (Aksakal and Dağdeviren, 2010: 908). Moreover, it considered to have lower priority (Wu, 2008: 830-831; Shieh et al., 2010: 279).

(v) Determining the threshold value and drawing the influence-relation graph diagram:

In order to obtain a suitable influence-relation graph diagram and to reduce some minor and negligible effects, a threshold value must be determined (Tzeng et al., 2007: 1032). The threshold value can be determined by experts or decision-makers (Tzeng et al., 2007: 1032 Shieh et al., 2010: 279). If the threshold value is too low, the influence-relation graph diagram will be too complex to present decision-makers the necessary information. If the threshold value is too high, the criteria will be present independently. Criteria with a higher effect than the determined threshold selected and an influence-relation graph diagram is drawn (Tsai and Chou, 2009: 1449). Relationships between the criteria of the total relation matrix transformed into an influence-relation map (Tzeng et al., 2007: 1032). In this study, the threshold value calculated by taking the average of the total relation matrix (S).

(vi) Weighting the criteria:

Equations (8) and (9) is used to calculate the criteria weights.

$$w_i = \{(R_i + C_i)^2 + (R_i - C_i)^2\}½ \quad (8)$$

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \quad (9)$$

## 4. Application

In this study, an integrated BSC-DEMATEL approach is proposed as shown in Figure 1. This approach represents the evaluating framework of the indicators used in the performance measurement of the HSC in the war context.

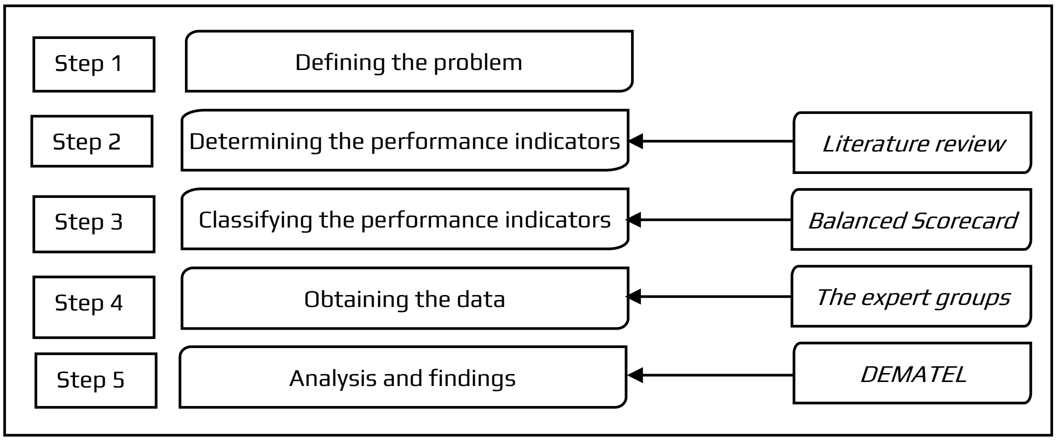


**Figure 1.** The steps of the proposed approach

### 4.1. Defining the problem

Measuring the performance of the HSC becomes a necessary nowadays regarding to the increasing wars frequents around the world. The problem of this study is to propose a framework to evaluate the indicators used in the performance measurement of the HSC in the context of war.

### 4.2. Determining the performance indicators

In this study, the performance indicators of the HSC are determined by taking into account the studies in the literature. The descriptions of the 21 indicators are presented in Table 2.

| Indicator | Description | Study |
|---|---|---|
| **Donation amounts** | The amount of the donation received from donors. | Van Wassenhove (2006), Beamon and Balcik (2008) |
| **Information sharing and collaboration rate** | The rate of information sharing and collaboration within the humanitarian organization and with other organizations. | De Leeuw (2010), Schiffling and Piecyk (2014), Santarelli et al. (2015) |
| **Information and communication technology using rate** | The organization's rate of using information and communication technology systems in the HSC. | De Leeuw (2010) |
| **Evaluation accuracy** | The accuracy of the assessment by experts working in war situation. | Davidson (2006), Moe et al. (2007), De Leeuw (2010), Torabi et al. (2012), Abidi et al. (2014) |
| **Number of trained personnel** | The number of the trained personnel to work in war context. | Santarelli et al. (2015), Abidi et al. (2014), Celik and Gumus (2016) |
| **Number of beneficiaries** | The number of people served by the organization. | Santarelli et al. (2015) |
| **Volume flexibility** | The ability of the humanitarian organization to serve in different war volume. | Beamon and Balcik (2008), Torabi et al. (2012), Janackovic et al. (2017) |
| **Humanitarian organization image** | The image that occurs in the public mind while organization tries to achieve goals. | De Leeuw (2010) |
| **Mix flexibility** | The ability of the humanitarian organization to provide different products and services in war. | Beamon and Balcik (2008), Torabi et al. (2012); |
| **Logistics learning rate** | Logistical background and information rate in humanitarian and staff environment. | Pettit and Beresford (2009) |
| **Reports and feedback** | Reports prepared by organizations about donations for donors. | Schulz and Heigh (2009), De Leeuw (2010), Schiffling and Piecyk (2014), Celik and Gumus (2016) |
| **Average of fixed donation flow** | Rate of incoming donations (financial/in-kind) | De Leeuw (2010) |
| **Service quality** | Quality of aid supplies and services to beneficiaries. | Moe et al. (2007), Schiffling and Piecyk (2014), Santarelli et al. (2015), Abidi et al. (2014) |
| **Order fulfillment rate** | The rate of aid supplies met from existing stock. | Torabi et al. (2012), Abidi et al. (2014), Lu et al. (2016) |
| **Current stock capacity** | Available stock capacity to supply emergency materials when war starts. | Beamon and Balcik (2008), Schulz and Heigh (2009), Torabi et al. (2012), Abidi et al. (2014) |
| **Availability and compatibility of aid supplies** | Available stock capacity and its suitability for beneficiaries need when war starts. | De Leeuw (2010), Schiffling and Piecyk (2014), Santarelli et al. (2015), Abidi et al. (2014) |
| **Delivery speed** | To fulfill aid supplies as soon as possible and deliver them to the beneficiaries. | Van Wassenhove (2006), Beamon and Balcik (2008), De Leeuw (2010), Torabi et al. (2012), Bolsche (2013), Abidi et al. (2014), Santarelli et al. (2015), Sauer et al. (2016), Lu et al. (2016) |
| **Total distribution cost** | Costs incurred to deliver aid supplies to beneficiaries (staff salaries, materials, etc.). | Beamon and Balcik (2008), Torabi et al. (2012), Santarelli et al. (2015), Lu et al. (2016) |
| **Number of people distributing aid** | Number of staff and volunteers participating in aid distribution. | Beamon and Balcik (2008), Santarelli et al. (2015) |
| **Aid stock turnover rate** | The amount of the aid supplies consumption. | Schulz and Heigh (2009) |
| **Financial value of aid supplies** | Financial value of aid supplies sent to beneficiaries. | Kumar et al. (2009) |

**Table 2.** The proposed performance indicators

## 4.3. The classification of the performance indicators according to BSC

BSC model classifies under four dimensions as financial and non-financial performance indicators according to organization's strategies and vision. Therefore, within the scope of the study, BSC model based on the goals and strategies of humanitarian organizations is selected to classify the HSC performance indicators as shown in Figure 2. The 21 indicators are classified according to BSC dimensions by the authors of this study. In this context, it is aimed that each criterion is placed under only one dimension.

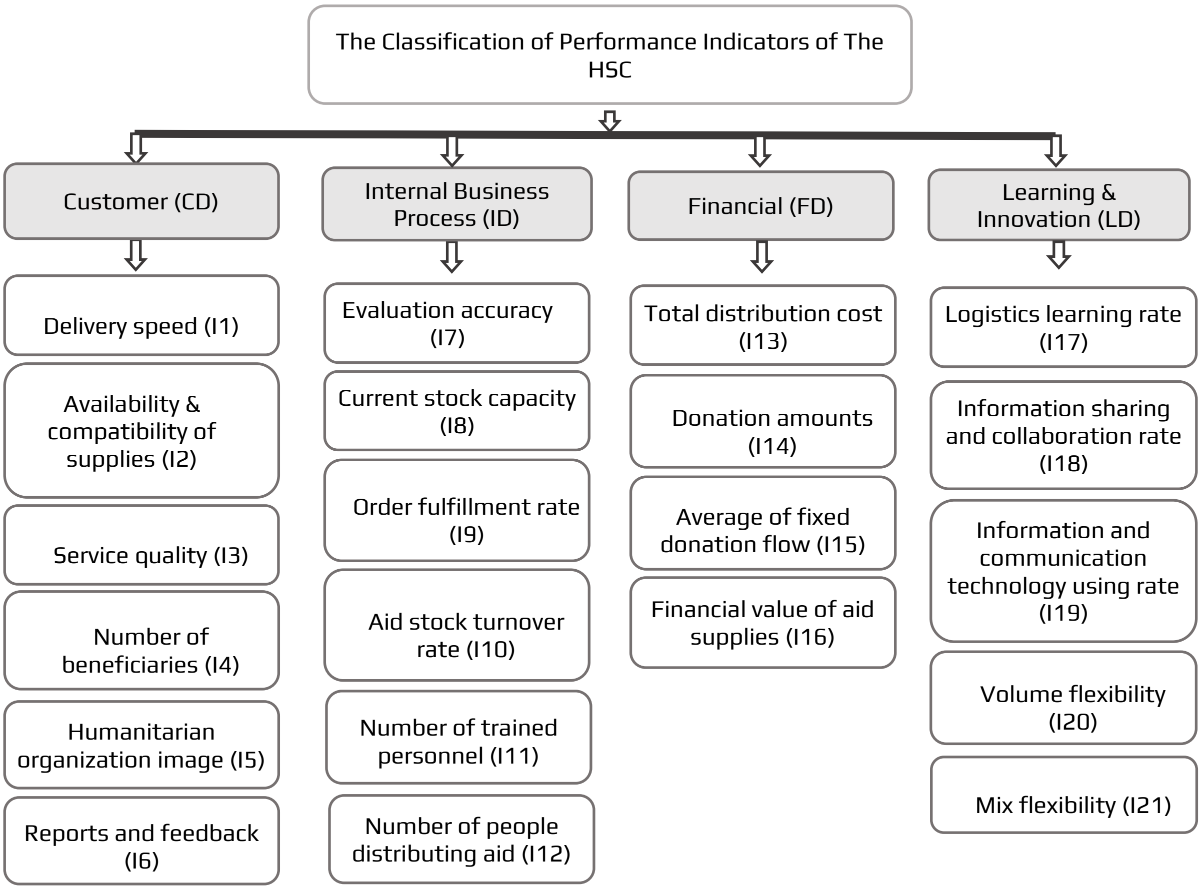

**Figure 2.** The classification of the HSC performance indicators according to BSC model

## 4.4. Obtaining the data

The data used in the study is collected by applying a questionnaire to nine experts who have competency and experience about HSC. Three of them work on humanitarian organizations the case of the war in The Turkish Red Crescent. Two of them, working the International Committee of The Red Cross, are experience on humanitarian organizations the context of the war. The rest of them is the academicians having experience on humanitarian logistics and supply chain.

## 4.5. Analysis and findings

In this stage, DEMATEL method is performed to prioritize the BSC dimensions and performance indicators. DEMATEL implementation steps in third section are applied for both BSC dimensions and performance indicators.

Creating the initial direct-relation matrix: The initial direct-relation matrix of BSC dimensions and performance indicators are computed. The results obtained for the BSC dimensions are presented in Table 3.

| | CD | ID | FD | LD |
|---|---|---|---|---|
| **CD** | 0 | 2.888 | 3.222 | 2.666 |
| **ID** | 2.333 | 0 | 2.77 | 2.555 |
| **FD** | 2.444 | 1.666 | 0 | 2.333 |
| **LD** | 2.666 | 3.00 | 1.66 | 0 |

**Table 3.** Initial direct-relation matrix of the BSC dimensions

Determining the normalized direct-relation matrix: The normalized direct-relation matrix of BSC dimensions and performance indicators are calculated by using the Equations (2) and (3). The results obtained for the BSC dimensions are given in Table 4.

| | CD | ID | FD | LD |
|---|---|---|---|---|
| **CD** | 1.517 | 1.778 | 1.822 | 1.766 |
| **ID** | 1.575 | 1.378 | 1.636 | 1.606 |
| **FD** | 1.418 | 1.376 | 1.226 | 1.423 |
| **LD** | 1.572 | 1.614 | 1.535 | 1.356 |

**Table 5.** Total relation matrix of the BSC dimensions

| | *I1* | *I2* | *I3* | *I4* | *I5* | *I6* | *I7* | *I8* | *I9* | *I10* | *I11* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***I1*** | 0.154 | 0.187 | 0.232 | 0.220 | 0.220 | 0.164 | 0.151 | 0.190 | 0.210 | 0.196 | 0.144 |
| ***I2*** | 0.217 | 0.157 | 0.249 | 0.231 | 0.236 | 0.158 | 0.170 | 0.205 | 0.224 | 0.198 | 0.161 |
| ***I3*** | 0.211 | 0.204 | 0.194 | 0.239 | 0.244 | 0.182 | 0.183 | 0.195 | 0.221 | 0.194 | 0.165 |
| ***I4*** | 0.210 | 0.210 | 0.238 | 0.187 | 0.234 | 0.169 | 0.181 | 0.206 | 0.229 | 0.208 | 0.167 |
| ***I5*** | 0.187 | 0.180 | 0.223 | 0.211 | 0.169 | 0.161 | 0.166 | 0.172 | 0.192 | 0.184 | 0.152 |
| ***I6*** | 0.209 | 0.207 | 0.246 | 0.231 | 0.237 | 0.137 | 0.196 | 0.193 | 0.215 | 0.198 | 0.163 |
| ***I7*** | 0.212 | 0.209 | 0.240 | 0.227 | 0.227 | 0.186 | 0.137 | 0.195 | 0.215 | 0.194 | 0.160 |
| ***I8*** | 0.199 | 0.187 | 0.215 | 0.205 | 0.210 | 0.154 | 0.156 | 0.138 | 0.197 | 0.179 | 0.136 |
| ***I9*** | 0.183 | 0.182 | 0.215 | 0.209 | 0.212 | 0.149 | 0.148 | 0.182 | 0.151 | 0.184 | 0.134 |
| ***I10*** | 0.180 | 0.177 | 0.200 | 0.201 | 0.204 | 0.139 | 0.137 | 0.165 | 0.187 | 0.134 | 0.127 |
| ***I11*** | 0.233 | 0.209 | 0.263 | 0.250 | 0.253 | 0.191 | 0.197 | 0.197 | 0.236 | 0.211 | 0.135 |
| ***I12*** | 0.183 | 0.171 | 0.216 | 0.210 | 0.199 | 0.137 | 0.148 | 0.165 | 0.194 | 0.184 | 0.134 |
| ***I13*** | 0.168 | 0.158 | 0.192 | 0.183 | 0.179 | 0.131 | 0.128 | 0.155 | 0.178 | 0.159 | 0.124 |
| ***I14*** | 0.210 | 0.203 | 0.241 | 0.228 | 0.228 | 0.158 | 0.167 | 0.189 | 0.222 | 0.201 | 0.156 |
| ***I15*** | 0.175 | 0.159 | 0.193 | 0.194 | 0.197 | 0.131 | 0.142 | 0.166 | 0.186 | 0.173 | 0.128 |
| ***I16*** | 0.176 | 0.179 | 0.198 | 0.194 | 0.201 | 0.145 | 0.142 | 0.170 | 0.183 | 0.175 | 0.132 |
| ***I17*** | 0.187 | 0.170 | 0.207 | 0.201 | 0.200 | 0.156 | 0.159 | 0.167 | 0.181 | 0.167 | 0.146 |
| ***I18*** | 0.201 | 0.194 | 0.231 | 0.222 | 0.220 | 0.171 | 0.172 | 0.184 | 0.199 | 0.193 | 0.151 |
| ***I19*** | 0.216 | 0.203 | 0.239 | 0.227 | 0.234 | 0.190 | 0.184 | 0.193 | 0.213 | 0.205 | 0.162 |
| ***I20*** | 0.173 | 0.164 | 0.202 | 0.190 | 0.192 | 0.135 | 0.140 | 0.162 | 0.180 | 0.165 | 0.130 |
| ***I21*** | 0.139 | 0.133 | 0.166 | 0.160 | 0.163 | 0.103 | 0.116 | 0.137 | 0.149 | 0.134 | 0.106 |

**Table 6.** Total relation matrix of performance indicators (please follow next page)

| | *I12* | *I13* | *I14* | *I15* | *I16* | *I17* | *I18* | *I19* | *I20* | *I21* |
|---|---|---|---|---|---|---|---|---|---|---|
| ***I1*** | 0.164 | 0.191 | 0.182 | 0.176 | 0.150 | 0.151 | 0.167 | 0.143 | 0.165 | 0.147 |
| ***I2*** | 0.185 | 0.189 | 0.182 | 0.181 | 0.164 | 0.154 | 0.177 | 0.161 | 0.183 | 0.161 |
| ***I3*** | 0.181 | 0.209 | 0.198 | 0.204 | 0.181 | 0.163 | 0.184 | 0.171 | 0.187 | 0.164 |
| ***I4*** | 0.205 | 0.209 | 0.201 | 0.199 | 0.176 | 0.161 | 0.180 | 0.168 | 0.184 | 0.164 |
| ***I5*** | 0.173 | 0.171 | 0.189 | 0.182 | 0.166 | 0.147 | 0.169 | 0.153 | 0.167 | 0.149 |
| ***I6*** | 0.182 | 0.203 | 0.201 | 0.199 | 0.183 | 0.159 | 0.189 | 0.173 | 0.182 | 0.164 |
| ***I7*** | 0.186 | 0.199 | 0.192 | 0.188 | 0.170 | 0.158 | 0.178 | 0.162 | 0.174 | 0.159 |
| ***I8*** | 0.158 | 0.172 | 0.177 | 0.163 | 0.154 | 0.140 | 0.160 | 0.143 | 0.170 | 0.147 |
| ***I9*** | 0.167 | 0.175 | 0.167 | 0.159 | 0.145 | 0.139 | 0.145 | 0.132 | 0.168 | 0.149 |
| ***I10*** | 0.162 | 0.172 | 0.168 | 0.163 | 0.146 | 0.130 | 0.140 | 0.132 | 0.164 | 0.147 |
| ***I11*** | 0.198 | 0.211 | 0.195 | 0.197 | 0.185 | 0.183 | 0.201 | 0.188 | 0.197 | 0.175 |
| ***I12*** | 0.125 | 0.175 | 0.165 | 0.170 | 0.147 | 0.138 | 0.146 | 0.139 | 0.157 | 0.138 |
| ***I13*** | 0.157 | 0.125 | 0.150 | 0.150 | 0.135 | 0.124 | 0.148 | 0.140 | 0.155 | 0.131 |
| ***I14*** | 0.184 | 0.190 | 0.148 | 0.189 | 0.177 | 0.154 | 0.165 | 0.164 | 0.178 | 0.166 |
| ***I15*** | 0.151 | 0.160 | 0.161 | 0.121 | 0.144 | 0.121 | 0.140 | 0.128 | 0.156 | 0.132 |
| ***I16*** | 0.153 | 0.160 | 0.165 | 0.161 | 0.114 | 0.130 | 0.144 | 0.135 | 0.158 | 0.145 |
| ***I17*** | 0.150 | 0.177 | 0.157 | 0.159 | 0.143 | 0.108 | 0.160 | 0.149 | 0.155 | 0.143 |
| ***I18*** | 0.174 | 0.190 | 0.179 | 0.172 | 0.158 | 0.148 | 0.132 | 0.162 | 0.171 | 0.156 |
| ***I19*** | 0.188 | 0.201 | 0.187 | 0.188 | 0.166 | 0.163 | 0.182 | 0.130 | 0.187 | 0.162 |
| ***I20*** | 0.147 | 0.166 | 0.154 | 0.148 | 0.138 | 0.130 | 0.148 | 0.137 | 0.118 | 0.134 |
| ***I21*** | 0.116 | 0.140 | 0.131 | 0.120 | 0.115 | 0.110 | 0.110 | 0.107 | 0.120 | 0.086 |

**Table 6.** Total relation matrix of performance indicators

Calculating the cause and effect groups: The cause and effect groups for the BSC dimensions and performance indicators are obtained by Equations (6) and (7). According to it, the R+C and R-C values of the BSC dimensions and performance indicators are presented in Table 7 and Table 8 respectively.

| | *R* | *C* | *R+C* | *R-C* |
|---|---|---|---|---|
| ***CD*** | 7.228 | 6.394 | 13.622 | 0.834 |
| ***ID*** | 6.508 | 5.967 | 12.476 | 0.541 |
| ***FD*** | 5.720 | 7.182 | 12.903 | -1.462 |
| ***LD*** | 6.537 | 6.450 | 12.987 | 0.087 |

**Table 7.** R+C and R-C values for BSC dimensions

| **Dimension** | **Performance Indicators** | *R* | *C* | *R+C* | *R-C* |
|---|---|---|---|---|---|
| ***CD*** | *I1* | 3.705 | 4.022 | 7.727 | -0.318 |
| | *I2* | 3.944 | 3.844 | 7.787 | 0.100 |
| | *I3* | 4.073 | 4.600 | 8.673 | -0.527 |
| | *I4* | 4.086 | 4.420 | 8.506 | -0.335 |
| | *I5* | 3.663 | 4.457 | 8.120 | -0.794 |
| | *I6* | 4.069 | 3.248 | 7.317 | 0.821 |
| ***ID*** | *I7* | 3.966 | 3.320 | 7.285 | 0.646 |
| | *I8* | 3.561 | 3.724 | 7.286 | -0.163 |
| | *I9* | 3.494 | 4160 | 7.654 | -0.666 |
| | *I10* | 3.375 | 3.836 | 7.211 | -0.461 |
| | *I11* | 4.305 | 3.014 | 7.319 | 1.290 |
| | *I12* | 3.440 | 3.503 | 6.943 | -0.063 |
| ***FD*** | *I13* | 3.170 | 3.792 | 6.962 | -0.622 |
| | *I14* | 3.920 | 3.651 | 7.570 | 0.269 |
| | *I15* | 3.257 | 3.589 | 6.847 | -0.332 |
| | *I16* | 3.369 | 3.259 | 6.628 | 0.110 |
| ***LD*** | *I17* | 3.443 | 3.010 | 6.453 | 0.432 |
| | *I18* | 3.778 | 3.368 | 7.145 | 0.410 |
| | *I19* | 4.019 | 3.118 | 7.137 | 0.901 |
| | *I20* | 3.252 | 3.496 | 6.748 | -0.244 |
| | *I21* | 2.663 | 3.118 | 5.781 | -0.454 |

**Table 8.** R+C and R-C values for performance indicators

When the R-C values examined (Table 7), the Financial dimension with a negative R-C value is in the effect group. This result shows that it affected more by the other dimensions. For the Customer, Internal Business Process and Learning & Innovation dimensions with their positive R-C values are included in the cause group, which indicates that these dimensions have more impact on the Financial dimension. Furthermore, it seen that the Customer dimension, based on the weights of the BSC dimensions, is in the first place with the largest weight (0.261). The Financial dimension with an equal weight with the Learning & Innovation dimension takes the second place. The least important dimension is the Internal Business Process with the lowest weight value (0,239).

Meanwhile, for R + C and R-C values of performance indicators (Table 8), the R + C values, show that service quality (I3), the number of beneficiaries (I4) and humanitarian organization image (I5) are more connected to other indicators and considered as the most important indicators. Meanwhile, number of trained personnel (I11), information and communication technology using rate (I19) and reporting and feedback (I6) with a positive R-C values have a higher impact on the other indicators and belong to the cause group. In contrast, humanitarian organization image (I5), order fulfillment ratio (I9) and total distribution cost (I13) indicators with negative R-C values are more influenced by other indicators and belong to the effect group.

Determining the threshold value and drawing the influence-relation digraph: In the total relationship matrix, not all the relationships between indicators shown. For this, an appropriate threshold value must be determined in order to draw a suitable influence-relation digraph. In the total relationship matrix, indicators with a higher influence level than the determined threshold value chosen and presented at the influence-relation digraph. In this study, the threshold value calculated by taking the average of the total relation matrix. The threshold value of BSC dimensions and performance indicators are 1.5373 and 0.1736 respectively. Based on the threshold values obtained from BSC dimensions and performance indicators, the influence-relation digraph of BSC dimensions is obtained as shown in Figure 3.

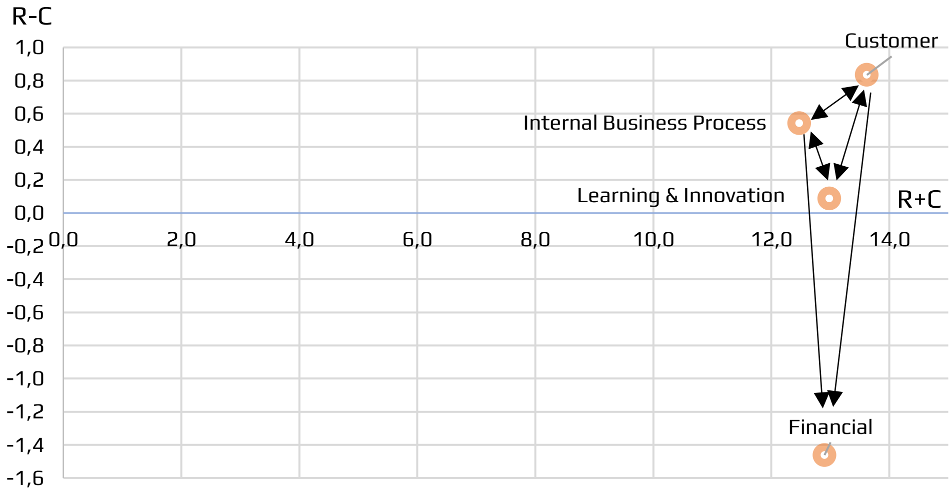


**Figure 3.** Influence-relation digraph of BSC dimensions

Weighting the BSC dimensions and performance indicators: The weights of BSC dimensions and performance indicators obtained by using Equations (8) and (9) are shown in Table 9 and 10 respectively

| Dimension | Weight (w) | Overall Weight (W) | Ranking |
|---|---|---|---|
| Customer | 13.647 | 0.262 | 1 |
| Internal Business Process | 12.487 | 0.240 | 3 |
| Financial | 12.986 | 0.249 | 2 |
| Learning & Innovation | 12.986 | 0.249 | 2 |

**Table 9.** The weights of the BSC Dimensions

| Dimension | Dimension Weight | Performance Indicator | Weight (w) | Overall Weight (W) | Ranking |
|---|---|---|---|---|---|
| **Customer** | 0.262 | I1 | 0.0504 | 0.0132 | 5 |
| | | I2 | 0.0507 | 0.0133 | 4 |
| | | I3 | 0.0566 | 0.0148 | 1 |
| | | I4 | 0.0554 | 0.0145 | 2 |
| | | I5 | 0.0531 | 0.0139 | 3 |
| | | I6 | 0.0479 | 0.0126 | 6 |
| **Internal Business Process** | 0.240 | I7 | 0.0476 | 0.0114 | 12 |
| | | I8 | 0.0475 | 0.0114 | 13 |
| | | I9 | 0.0500 | 0.0120 | 8 |
| | | I10 | 0.0471 | 0.0113 | 15 |
| | | I11 | 0.0484 | 0.0116 | 11 |
| | | I12 | 0.0452 | 0.0108 | 18 |
| **Financial** | 0.249 | I13 | 0.0455 | 0.0113 | 14 |
| | | I14 | 0.0493 | 0.0123 | 7 |
| | | I15 | 0.0446 | 0.0111 | 16 |
| | | I16 | 0.0432 | 0.0108 | 19 |
| **Learning & Innovation** | 0.249 | I17 | 0.0421 | 0.0105 | 20 |
| | | I18 | 0.0466 | 0.0116 | 10 |
| | | I19 | 0.0468 | 0.0117 | 9 |
| | | I20 | 0.0440 | 0.0110 | 17 |
| | | I21 | 0.0378 | 0.0094 | 21 |

**Table 10.** The weights of the performance indicators

As shown in Table 9, the most important dimension in the performance measurement for the HSC in the context of war is the Customer. Financial and Learning & Innovation are in the second rank with equal importance and Internal Business Process Dimension is with the least important rank.

According to Table 10, the three indicators of the highest impact in the performance measurement regarding the HSC in context of war are the service quality (I3), the number of people (I4) and humanitarian organization image (I5). The indicators that have the lowest impact are mix flexibility (I21), logistics learning rate (I17) and financial value of the aid supplies (I16) respectively.

## 5. Discussion and Conclusion

With the increase of wars in recent years, the number of people faced with problems such as food shortage, diseases increase, insufficient water resources and lack of accommodation needs. Humanitarian organizations aim to eliminate or alleviate such problems by delivering donations and aids to those affected. Accordingly, logistics and supply chain activities are among the most important activities of humanitarian organizations to deliver aid quickly and effectively to those affected by the war. According to variable war conditions, performance evaluation should made by choosing the most appropriate performance indicators according to the characteristics of the HSC.

According to the related literature, several studies on the HSC performance measurement exist but no study found in the context of war disaster. Therefore, this study aims to present an integrated performance evaluation approach for the HSC in the context of war. Based on this, the performance indicators of the HSC was determined by the related literature and then classified according to the four dimensions of the BSC. Then, the relationships between BSC dimensions and the performance indicators are determined using the DEMATEL. In addition, the BSC dimensions and performance indicators weights are ranked by DEMATEL.

According to the results, the most important performance dimension to take into consideration in the HSC performance measurement is the Customer. Followed by the Financial and Learning & Innovation dimension in the second place. Finally, the Internal Business Process dimension is determined to be in the last place regarding HSC performance measurement. These results on BSC dimensions are similar to the results of Anjomshoae et al. (2019) and Schiffling and Piecyk (2014). They also lead to the importance of the customer dimension in the HSC. This emphasizes that the main purpose of HSC activities is to deliver emergency supplies to beneficiaries.

For performance indicators, service quality, number of beneficiaries and humanitarian organization image are the most important indicators, which all belong to the Customer dimension as the most important dimension. In addition, the least important performance indicators respectively are mix flexibility, logistics learning rate and financial value of aid supplies. In addition, the weights of the performance indicators classified under the other three BSC dimensions are close to each other. Moreover, the Anjomshoae et al. (2019)'s results are in line with the results of this study in terms of determining the service quality indicator as the most important performance indicator.

Based on the BSC dimensions and ranking of performance indicators in the HSC performance approach, some conclusions summarized as follows:

- The Customer dimension has the first ranking within the BSC dimensions. In the HSC, the Customer dimension includes both the beneficiaries and donors. In this context, the main purpose of the Customer dimension is to focus on HSC activities to deliver aid supplies to those affected by the disaster and to give feedback to the donors.
- The necessity for financial resources is not exclusive only for the commercial organizations; it is also a need for the continuity of humanitarian organizations (Kovács and Spens, 2007: 1042). This supports the results of this study, which is identified the importance of the Financial dimension for the humanitarian sector.
- The main customers (beneficiaries and donors) of the HSC management seek for service quality. Beneficiaries need quality tangible outcomes and donors need efficient relief operations and feedbacks (Schiffling and Piecyk, 2014: 110). It reinforces the results of this study, which emphasized that service quality is the most important indicator.

Results of the research can contribute to academics and researchers to utilize the indicators to be considered in measuring HSC performance in case of war. It also extends the current state of knowledge, which provides a novel combined method to measure the performance HSC in context of war disaster. So, the results of this study also provide important considerations for decision makers. Effective and accurate decisions on HSC management process are significant components for policy makers to enhance their national HSC management performance.

In this study, experts who were consulted in performance evaluation elaborate in the same humanitarian organization, which consider as a limitation of this study. Another limitation is that the performance evaluation using the DEMATEL method depend only on the expert opinions. As a final remark, note that the question of how this model should be implemented in the other disaster is beyond the scope of this study. Thus, this research questions should be answered in future studies.

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