TINI- SOS

The International New Issues In SOcial Sciences

Number: 5 pp: 323-342 Summer 2017

DISASTER LOGISTICS FACILITY LOCATION PROBLEM: AN APPLICATION FOR TRA1 REGION©

Prof. Dr. Osman DEMİRDÖĞEN[7]
Dr. Hamit ERDAL[8]
Arş. Gör. Fatma Gül YAZICILAR[9]
Arş. Gör. Selin AYKOL[10]

Abstract

Disasters are events that occur outside of human control, which may lead to loss of life and property. Turkey is one of the countries significantly affected by natural disasters, especially earthquakes, floods and landslides. Effective disaster management is needed to reduce the impact of natural disasters.

As a part of risk management, the determination of the locations of the facilities to be used for disaster response (personnel, materials, vehicles, etc.) is a strategic level decision that can directly affect the success of intervention after the disasters.

© *Bu çalışma III. Uluslararası Kafkasya Orta Asya Dış Ticaret ve Lojistik Kongresi'nde özet bildiri olarak sunulmuştur. 19-21 Ekim 2017, Kastamonu, Turkey.*

[7] Ataturk University Faculty of Economics and Administrative Sciences Department of Business Management odemirdogen@atauni.edu.tr

[8] Ataturk University Institude of Social Sciences hamit_erdal@hotmail.com

[9] Ataturk University Faculty of Economics and Administrative Sciences Department of Business Management f.yazicilar@atauni.edu.tr

[10] Ataturk University Faculty of Economics and Administrative Sciences Department of Business Management selin.aykol@atauni.edu.tr

In this study, the problem of locating of distribution center for three provinces in TRA1 Region (Erzurum, Erzincan, Bayburt) was addressed in order to determine the most suitable distribution center location within the scope of disaster logistics. In this context, Stochastic Multiple Criteria Admissibility Analysis-2 (SMAA-2) method was utilized in this study due to difficulties in expressing the preferences of the experts in the interviews and also because the criteria weights and the exact criterion values of alternative province couldn't be reached.

Keywords: Disaster Logistics, Distribution Center, Facility Location Problem, Multi Criteria Decision Making, SMAA-2.

Jel Kodları: C6, H84, Q54

AFET LOJİSTİĞİ TESİS YERİ SEÇİMİ PROBLEMİ: TRA1 BÖLGESİ İÇİN BİR UYGULAMA

Özet

Afetler, büyük oranda insan kontrolü dışında gerçekleşen, can ve mal kayıplarına neden olabilen olaylardır. Türkiye, başta deprem, su baskını ve heyelan olmak üzere doğal afetlerden önemli ölçüde etkilenen ülkeler arasındadır. Doğal afetlerin etkilerini azaltmak için etkin bir afet yönetimine ihtiyaç duyulmaktadır.

Risk yönetiminin bir parçası olarak, afetlere müdahalede kullanılacak kaynakların (personel, malzeme, araç, vb.) bulunacağı tesislerin yerlerinin belirlenmesi, afet sonrasındaki müdahalenin başarısını doğrudan etkileyebilecek, stratejik seviyede bir karardır.

Bu çalışmada, afet lojistiği kapsamında en uygun dağıtım merkezi yerinin belirlenmesi amacıyla TRA1 Bölgesi'ndeki üç il (Erzurum, Erzincan, Bayburt) için dağıtım merkezi yer seçimi problemi ele alınmıştır. Bu kapsamda uzmanlarla yapılan görüşmelerde uzmanların tercihlerini net olarak ifade etmekte zorlanmaları, kriter ağırlıklarının ve alternatif illerin kesin kriter değerlerine ulaşılamaması nedeniyle bu çalışmada, Stokastik Çok Kriterli Kabul Edilebilirlik Analizi-2 (SMAA-2) yöntemi kullanılmıştır.

Anahtar kelimeler: Afet Lojistiği, Dağıtım Merkezi, Tesis Yeri Seçimi Problemi, Çok Kriterli Karar Verme, SMAA-2.

I. INTRODUCTION

Disasters, in the most general expression, are the phenomena occurring within or out of the control of the humans, stopping or hindering the daily life and causing to heavy results both in physical and financial meaning (Ağdaş et.al., 2014: 77).

Disaster has been defined by the United Nations Organization as "*all the nature, technology or human based events causing to physical, economic and social losses for the people, affecting the societies by stopping or hindering the normal life and which could not be handled with natural opportunities*" (Kadıoğlu, 2008:3).

Disasters are mainly classified in two groups as natural and human-based disasters and Turkey is relatively in the position of a country in which natural disasters occur more within the scope of this classification. Earthquake, landslide and flood events as the natural disasters are experienced more when compared to others in our country (Peker et.al. 2016:83).

Tragic losses of lives and properties occurring as a result of the disaster phenomena experienced within the course of history have revealed the need for disaster management. A basic disaster management system could be handled in two dimensions as "*risk management*" covering the activities in the pre-disaster preparation process and "*crisis management*" covering the activities in the process of action after disaster and turning to normal life. The determination of the locations of the facilities in which the disaster response resources such as personnel, materials, equipment and tools will be placed within the scope of risk management activities is one of the strategic disaster logistics decisions that may directly affect the success of the post-disaster response activities (Gümüşbuğa, 2012:8).

Disaster logistics is the complement of activities planning, realizing and controlling the rapid and economic flow and storage of the humanitarian aid materials from the production points to the disaster victims for the purpose of relieving the trauma experienced by the disaster victims. Therefore; a healthy cooperation is needed among many governments, non-governmental, national and international organizations working in the disaster zone to be able to turn to the normal life by relieving the wounds of the people and countries affected from the disaster as soon as possible (Maharjan and Hanaoka 2017: 1152). Especially the determination of the most possible location of the place in which the materials necessary for the aid will be stored is vitally important.

Currently, warehouses have started to be established which have previously and strategically been located in worldwide for the purpose of flowing the aid materials to the disaster victims as fast as possible by ensuring the efficient and sufficient aid in a short time by the public institutions and humanitarian aid organizations in an increasing way (Roh et.al. 2013: 104).

When a disaster incident occurs, facilities and infrastructure alternatives should be planned in which the possible easiest and fastest transportation could be provided to the disaster victims by taking into consideration the destruction possible to occur in the post-disaster transportation infrastructure. Because the distribution centers are the facilities whose stable and first installation costs are high, they should be established to the most convenient location which will ensure fast transportation to the possible disaster zones with an efficient planning of disaster logistics (Aslan et.al. 2015: 112).

The purpose of this study is to provide support for decision as to the determination of the most convenient city for the distribution center to be established in one of the three cities (TRA11-Erzurum, TRA12-Erzincan and TRA13-Bayburt) taking place in TRA1 zone within the scope of disaster logistics. Convenient establishment of the distribution center has a significant role in the design of an efficient distribution network and flow of the aid materials to the disaster victims after the disaster. The studies of location problem conducted within the scope of disaster logistics also contain many qualitative and quantitative criteria as in other studies of location problem. The studies of location problem for the facilities conducted within the scope of disaster, humanitarian aid and emergency logistics in the literature have been benefitted in the process of the determination of the decision criteria used in this study.

Some of the criteria to be used in the facility location problem within the scope of disaster logistics may naturally contain uncertain values. The data attained both during and after the disaster may not be clear and correct as well as the non-predictability of the disasters beforehand. For this reason; decision criteria values could be expressed stochastically in the studies to be conducted within the scope of disaster logistics. The method of Stochastic Multi-Criterion Acceptability Analysis-2 (SMAA-2) has been used in this study due to the fact that the decision criteria used in the problem which is handled in this study contain stochasticity and uncertainty. SMAA-2 method may provide opportunities for the expression of the unclear and/or uncertain decision criteria values with stochastic variables.

The studies in which the facility location problem have been examined within the scope of disaster logistics have been scanned in Section 2., SMAA-2 method has been shortly introduced in Section 3., the method has been applied to the problem in Section 4., and the study has been completed with the results part in which suggestions have also been made for the future studies.

II. RELATED LITERATURE

In modern meaning, disaster management with scientific approaches started to be handled towards the end of 1960s. At the beginning, the studies conducted within the scope of disaster management were rather handled within the frame of the social sciences such as the loss of lives and properties, social impacts of the disasters on society, physiological impacts of disasters on the disaster victims and rescue personnel and the design of the management structure (Altay and Green, 2006:476).

An increase has been observed in the next years in the number of the conducted studies together with the application of quantitative decision making techniques to the disaster management. Within this scope; the approaches such as Fuzzy Logic (Esogbue et.al., 1992), Decision Theory (Cret et.al., 1993), Queuing Theory (Artalejo, 2000), Possibility Theory (Coles and Pericchi, 2003), Simulation (Reshetin and Regens, 2003) and Mathematical Programming have started to be benefitted.

Although there are many studies in the literature regarding the facility location problem, it is seen that studies in sufficient amount have not been conducted for the facility location problem within the scope of disaster logistics. This deficiency has also been emphasized in the study conducted by Altay and Gren (2006:479) in which the disaster management stages of the disaster logistics literature conducted until 2004 were reviewed according to the utilized methodologies. The researchers have detected in their studies that 40% of the studies conducted in the literature is related to the decrease of damages before disaster, 21% of them is related to the preparation for disaster, 24% of them is related to response to the disaster and 15% of them is related to recovering after disaster.

The purpose of the studies of facility location problem within the scope of disaster logistics has generally been determined as reaching the disaster zone within the shortest time (Duran, et.al., 2011), minimizing the total cost (Beamon et.al., 2007) and maximizing the number of disaster victims to whom services will be provided from the facilities within the shortest time (Uluğ, 2003).

As a result of the examination of the models developed by the researchers, it has been seen that mostly the maximum coverage models (Karaca, 2003; Dessouky et.al., 2006; Jia et.al., 2007) have been used.

Samples from the studies conducted in the literature are given below. It is assessed that the studies of the researchers could be benefitted for the previous studies due to the fact that the studies conducted before 2004 have been given in the study conducted by Altay and Gren (2006).

Yi and Özdamar (2004) have utilized from the earthquake data prepared for Istanbul and suggested a dynamic and fuzzy logistics coordination model for the efficient management of the post-disaster aid activities. Hale and Moberg (2005) have suggested coverage model for disaster logistics facility location problem according to the pre-disaster planning, decreasing the impacts of disasters, detection, response and rescue criteria.

Dessouky et.al. (2006) have studied facility location problem for the purpose of being able to reach the highest number of disaster victims with the least facilities possible to be opened for the maximum coverage model.

Soon (2007) has suggested a methodology in which post-hurricane humanitarian aid materials distribution location selection models are used hierarchically with a model in which the minimization of the pre-hurricane transportation costs and stock amounts have been determined.

Ukkusuri and Yushimoto (2008) have examined the routes between the warehouses and possible disaster victims and searched for solutions for the problem of preliminary stock placement with the most trustworthy highway network optimization.

Mete and Zabinsky (2010) have conducted a comprehensive literature review for the location problem and distribution in the process of providing medical materials in disaster management and suggested a stochastic programming model for the solution of the problem.

Duran et.al. (2011) have studied upon the minimization of the transportation time to the disaster victims with the assumption that no problem will occur in the fund supply thanks to both national and international support in the event of the occurrence of any disaster incident.

Multi-criterion decision making (MCDM) methods have also been utilized in the studies of location problem within the scope of the disaster logistics due to the contingent and uncertain nature of the disasters.

Roh et.al. (2013) have determined the most convenient distribution center location with analytic hierarchy process (AHP) method according to the criteria such as location, logistics, national decisiveness, cost and cooperation.

Ağdaş et.al. (2014) have used SMAA-2 method for the determination of the convenient facility location for the distribution centers regarding the flood disaster. In the study, the criteria such as transportation time, flood risk degree, transportation opportunity, distance of the zone to the disaster warehouse and total costs have been taken into consideration.

Roh et.al. (2015) have used AHP and fuzzy TOPSIS methods regarding the problem of where the warehouses will be established both regionally and locally for the humanitarian aid institutions. Researchers have handled the criteria of security, bureau opportunities and warehouse opportunities in micro level and the criteria of convenience for establishment, national stability, cost, cooperation and logistics in macro level.

Peker et.al. (2016) have suggested two-stage hierarchical model for the determination of the most convenient distribution center location within the scope of disaster logistics in the city of Erzincan. At the first stage, the criteria of location, infrastructure and cooperation have been weighted with AHP method and at the second stage, the most convenient distribution center location has been determined with VIKOR method.

Ofluoğlu et.al. (2017) have used Entropive TOPSIS methods for the determination of the most convenient disaster warehouse location by utilizing the methods of Entropi and TOPSIS within the scope of disaster logistics in Trabzon.

In the conducted literature review, no previous study has been encountered for the distribution center location problem within the scope of disaster logistics for TRA1 zone (Erzurum, Erzincan, Bayburt). For this reason; in the event of the occurrence of a disaster in TRA1 zone, the most convenient distribution center location has been examined with the use of SMAA-2 method for the purpose of being able to provide the most efficient and fast service to the disaster victims.

III. SMAA-2 METHOD

The solution results in MCDM problems are significantly dependent on the criterion weights and correct and consistent determination of the values of the alternatives taken according to the criteria and the assessments by the decision makers/experts. Naturally; it is too hard to attain all of these values and also their certain values in real life problems. In addition; it also makes it much harder to correctly detect the mentioned values in the differences between the assessments of the decision makers/experts due to the group decision making procedure (Lahdelma and Salminen, 2001:444).

SMAA method has been suggested by Lahdelma et.al. (1998) for the purpose of obtaining solutions for the real life problems in which the decision criteria weights and the values alternatives take from the decision criteria are uncertain. In this method, the decision criterion values of the uncertain and/or unclear alternative are expressed with stochastic variables and the criterion weights on which no consensus could be established by the decision makers are expressed with composite density function weight distribution. One of the most critical properties of the method is that it could be used without any information on the weights. There are three types of definitive scales as (i) acceptability indice, (ii) central weight vector and (iii) reliability factor used in the assessment of the alternatives in the method algorithm. Numerical techniques, multi dimensional integrals and Monte Carlo simulation are used in the scale calculations (Lahdelma and Salminen, 2001:446).

SMAA method only determines the acceptability of the alternatives instead of ranking the direct alternatives as in other MCDM methods. In time; SMAA-2, SMAA-3, SMAA-O, Ref-SMAA methods have been developed for the selection and ranking problems and SMAA-TRI method has been developed for the classification problems (Demirdöğen et. al., 2017:560).

SMAA-2 method was suggested by Lahdelma and Salminen in 2001 for the intermittent stochastic MCDM problems in which group decision making is essential (Tervonen and Lahdelma, 2007:500). The method could be used to perform the selection of the most convenient alternative and the ranking of the alternatives. In the method; five different scales are used as rank acceptability indice, three types of best rank scales and integrated acceptable indice (Lahdelma and Salminen, 2001; 452-453).

The mathematical expression of the method is given below (Tervonen and Lahdelma, 2007:501-504; Ağdaş et.al., 2014:85-86):

Decision problem is expressed with *m* ea. alternative $\{x_1, x_2, \dots, x_m\}$ assessed according to *n* ea. decision criteria. The preference structure of the decision maker/expert is represented with the value function $u(x_i, w)$ or a benefit with real value. It has been previously told that SMAA-2 method has been developed for the conditions in which the certain criterion values and/or certain criterion weights are unknown. For this reason; uncertain decision criterion values are expressed with $f(\xi)$ density function with integrated possibility distribution and ξ_{ij} stochastic variable. The preferences not certainly known or partly known by the decision makers/experts are represented with the weight distribution with $f(w)$ integrated density function in *W* convenient weight cluster. Total deficiency of the preference information is expressed with the uniform weight distribution within *W* as given in Equation (1).

$$f(w) = 1/vol(W)$$

Weights cannot get negative values and they are the normalized values (Equation (2))

$$W = \left\{ w \in R^n : w \geq 0 \quad and \quad \sum_{j=1}^{n} w_j = 1 \right\}$$

It is benefitted to place the stochastic decision criterion and weight distributions from the value function to $v(\xi_i, w)$ value distributions. The ranking of each alternative (best (=1), worst (=*m*) and integer) is conducted with the ranking function presented in Equation (3) depending on the value distribution. It gets ρ=1 if the ranking is correct and 0 if not.

$$rank(i, \xi, w) = 1 + \sum_{k=1}^{m} \rho(v(\xi_k, w) > v(\xi_i, w))$$

Afterwards, stochastic convenient rank weights cluster analysis is conducted with Equation (4). x_i alternative takes the rank r after the convenient assignment of any weight value for the different alternatives which are $w \in W_i^r(\xi)$.

$$W_i^r(\xi) = \{ w \in W : \text{rank}\ (i, \xi, w) = r\}$$

Rank acceptability indice b_i^r which is the definitive scale firstly developed for SMAA-2 method to be able to perform ranking shows the probability of every alternative to be in that rank. The highest acceptable (the most convenient) alternatives are the ones acceptable in high ratio for the first ranks. This indice takes a value between 0-1. The value 1 expresses that the ranking presented for any determined weight will be always provided and the value 0 expresses that the alternative will never be able to provide the determined ranking. Rank acceptability indice is calculated with Equation (5).

$$b_i^r = \int_{\xi \in X} f_x(\xi) \int_{w \in W_i^r(\xi)} f_{w}(w) dw d\xi$$

Central weight vector w_i^c expresses the preferences of the decision makers/experts for supporting the mentioned alternative. Central weight vector is calculated with Equation (6).

$$w_i^c = \int_{\xi \in X} f_x(\xi) \int_{w \in W_i^1(\xi)} f_{w}(w) w dw d\xi / a_i$$

Reliability factor p_i^c measures how much true the decision criteria are in the separation of the efficient alternatives. Reliability factor is calculated with Equation (7).

$$p_i^c = \int_{\xi \in X: rank(i, \xi, w_i^c) = 1} fx(\xi) d\xi$$

Open source and java-based JSMAA software has been developed for the application of SMAA-2 method (Tervonen, 2014). The application steps of JSMAA program are given in Figure 1. for SMAA-2 m

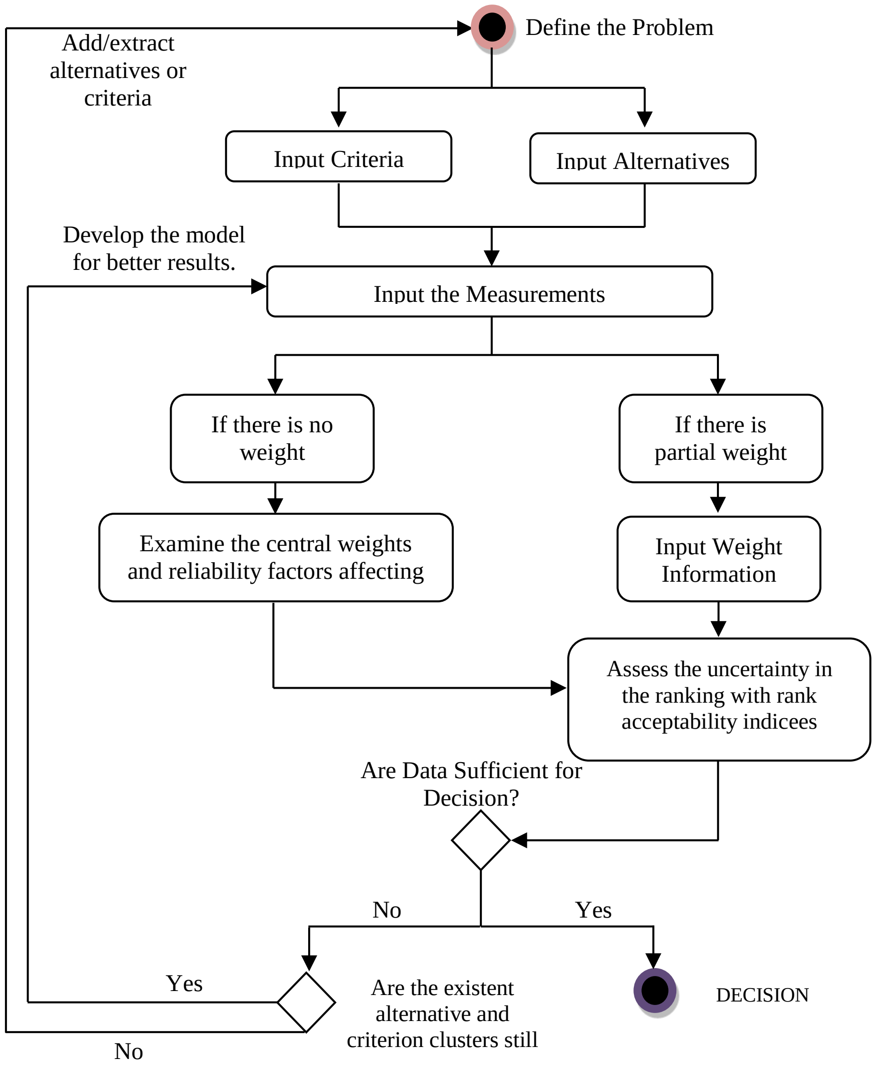


Figure 1. Application Steps of JSMMA Software for SMAA-2 Method

IV. APPLICATION FOR TRA1 ZONE

TRA1 region that is consist of Erzurum, Erzincan and Bayburt cities has an area of 40,842 km² and a population of 1,872,540 (by the end of 2016) and its population density is 26 people / km² (Güzel, 2016:69).

The application steps given in Figure 2. have been followed for the solution of the distribution center location problem planned to be established for the distribution of the post-disaster humanitarian aid materials in TRA1 zone.

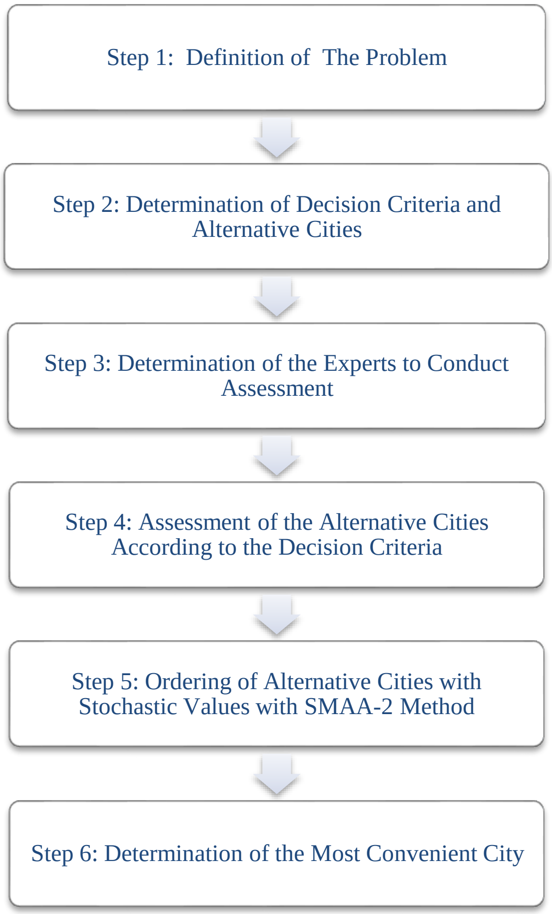


Figure 2. Application steps

Step 1: In this study, the city most convenient for the establishment of the distribution center which will make service after the disaster for the humanitarian aid materials to reach the disaster victims after any disaster possible to occur in any one of the three cities taking place in TRA1 zone. The distribution centers to be established within this scope will be founded to one of the cities of Erzincan, Erzurum or Bayburt and they will make service after disaster for these three cities.

Step 2: 5 of the criteria determined by the experts among the criteria used in the studies conducted in previous years in the literature for the determination of the location of the distribution centers planned to be established within the scope of disaster logistics have been used. The decision criteria used in the study and their explanations are given below.

a. Transportation distance to the disaster victims (km.): It is the transportation distance between the distribution center and the furthest possible disaster zone. Within the scope of this criterion, the total distance to occur in the event that a distribution center to be established precisely in the center of these three cities will make service to the furthest points of other two cities have been revealed.

b. Disaster level of the city: It is the total disaster (earthquake, flood and deluge, landslide and avalanche) number occurring in a city in which distribution center will be established within the scope of disaster logistics. The data belonging to the mentioned disaster numbers have been reached by querying the disaster numbers of the cities from Turkish Disaster Information Bank (TDIB, 2017) taking place in the official internet page of T.R. Prime Ministry Disaster and Emergency Management Presidency. According to the disaster criteria of TDIB, the existence of at least one of the criteria such as (i) at least 10 dead, or (ii) at least 50 injured, or (iii) the existence of at least 100 people affected from the disaster or (iv) the disaster to be efficient in the general life causes the disaster to be included in the archive.

c. Number of possible serviceable disaster victims: It shows the number of disaster victims expected to be helped from the distribution center planned to be established after a possible disaster. The population data belonging to the cities in TRA1 zone have been reached via the population register system (TUIK, 2017) based on the address taking place in the official internet age of Turkish Statistical Institution for this criterion.

d. Opportunities of transportation infrastructure: The existent highway network of the cities in TRA1 zone and their possibility of being able to sustain service after a possible disaster are expressed. Within the scope of this criterion, the experts have been requested to conduct an assessment between the values 1-5 in interval scale for the examination of the alternative cities (1-Certainly insufficient, 2-Insufficient, 3-Medium, 4-Sufficient, 5-Certainly Sufficient).

e. Regional logistics infrastructure opportunities: They are the existent regional infrastructure opportunities that will facilitate the provision of services such as the investments and opportunities of public and private sector and opportunities of logistics service providers taking place in the cities for ensuring support and coordination for the provision of service to the disaster victims by the distribution centers after a possible disaster. Within the scope of this criterion, the experts have been requested to conduct an assessment according to 1-5 scale for the examination of the alternative cities (1-Certainly insufficient, 2-Insufficient, 3-Medium, 4-Sufficient, 5-Certainly Sufficient).

There are three alternative cities in TRA1 zone for the settlement of the distribution center planned to be established. These are the cities of TRA11-Erzurum, TRA12-Erzincan and TRA13-Bayburt.

Step 3: Four managers (experts) have been determined who are responsible for the planning and coordination of the disaster logistics of the institutions and organizations as the decision making group. The assessments of the experts have been requested as to use in the determination of the importance degrees (weights) of the criteria to be used in the distribution center location problem.

Step 4: At this stage, the alternatives given by the experts have been subjected to evaluation according to the decision criteria. A consensus has been reached among the expert groups during the evaluations. The values attained as a result of the evaluations and consisting of the real values are given in Table 1.

Table 1. Decision Criterion Values for Alternative Cities

	Distance to disaster victims (km.)	Disaster level of the city (ea.)	Possible serviceable number of disaster victims (person)	Opportunities of transportation infrastructure (1-5 interval)	Opportunities of regional logistics (1-5)
Erzurum	480	45	762.021	3-5	4
Erzincan	560	41	226.032	3-4	3
Bayburt	600	10	90.154	2-3	1

Step 5: Solutions have been reached without including the criterion weights to the problem because the experts could not reach a certain justification in the issue of the weights of the criteria due to the fact that the problem is a certainly unforeseeable and a public decision problem. The data submitted in Table 1. have been entered to JSMAA program and the problem has been solved. Rank acceptability indice conducts the convenience ranking of the alternatives according to the expert assessments entered according to each decision criterion for every alternative. Rank acceptability indice belonging to the model formed for the problem is given in Figure 3.

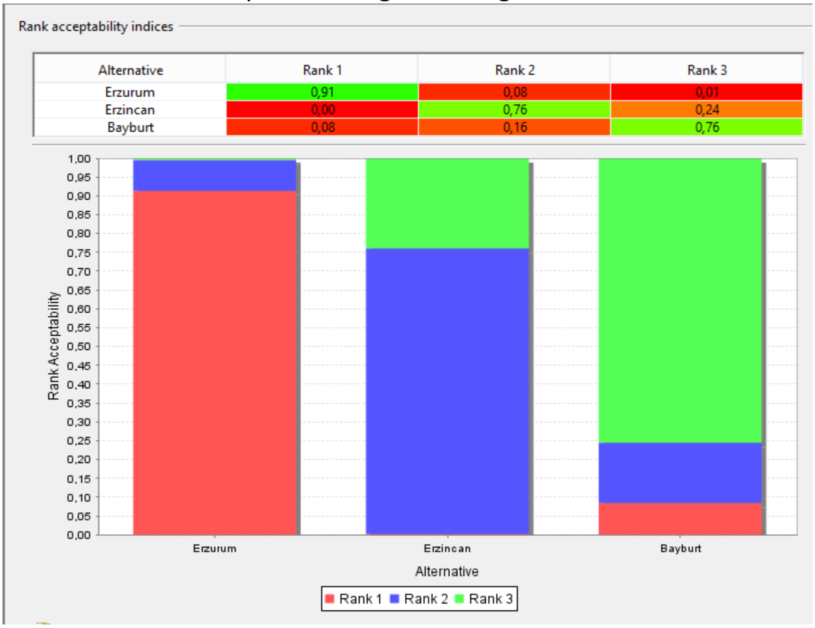


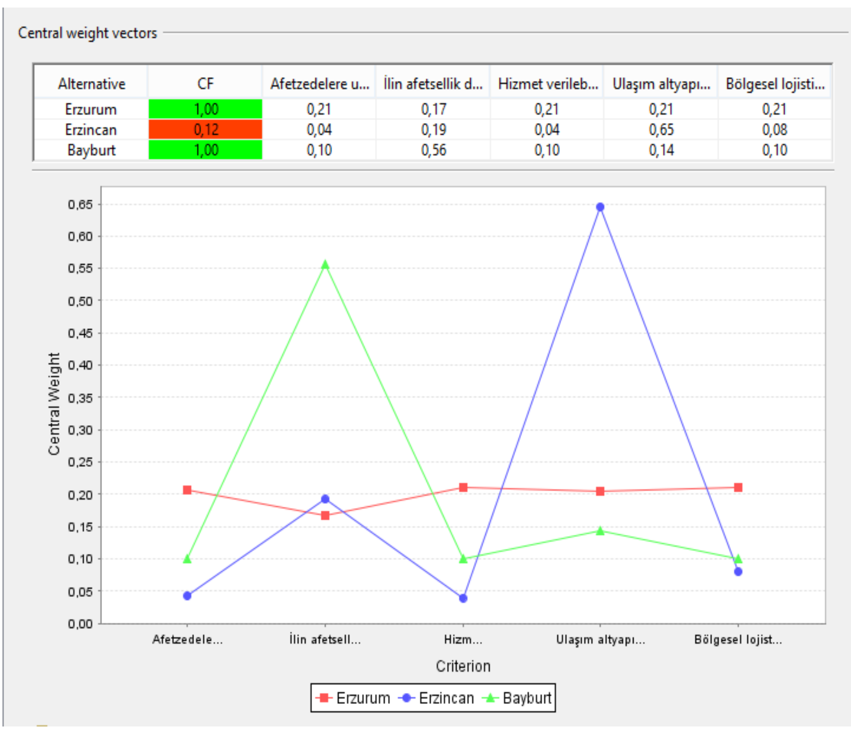
Figure 3. Rank Acceptability Indices of the Alternative Cities

The city of Erzurum has been selected as the alternative most convenient for the establishment of a distribution center at first rank with the probability of 91%. The first ranking probability of the city of Bayburt has been calculated as 8% and that of the city of Erzincan has been calculated as 0%.

The most convenient alternative for the second rank is the city of Erzincan with the probability of 76%. The second ranking probability of the city of Bayburt is 16%.

The least preferred alternative city for the establishment of distribution center is Bayburt. With a reverse point of view, the worst alternative among the alternative cities in which distribution center will be established within the scope of disaster logistics is the city of Bayburt with the ratio of 76%.

Again; the attained reliability factor and central weight vector values belonging to the model are given in Figure 4.


Central weight vectors

Alternative	CF	Afetzedelere u...	İlin afetsellik d...	Hizmet verileb...	Ulaşım altyapı...	Bölgesel lojisti...
Erzurum	1,00	0,21	0,17	0,21	0,21	0,21
Erzincan	0,12	0,04	0,19	0,04	0,65	0,08
Bayburt	1,00	0,10	0,56	0,10	0,14	0,10

Figure 4. Reliability Factors and Central Weight Vectors

Reliability factor used for the separation of the efficient alternatives shows whether the assessments and measurements conducted for the decision criteria healthy and/or correct enough or not. The reliability ratio of the fact that the city of Erzurum with the highest value for the reliability factor is the first and the city of Bayburt is the last is 100%. When the central weight vector of the alternative cities have been considered, it could be seen that the mentioned four criteria has high relative importance for this alternative with the ratio of 21% for all the decision criteria except for disaster level for the city of Erzurum, the criterion of the opportunities of transportation infrastructure has the highest relative importance with the ratio of 65% for the city of Erzincan and finally, the disaster level criterion of the city has the highest relative importance degree with the ratio of 56% for the city of Bayburt. In other words, these are the criteria with the highest impact on the selection of the distribution center in the related ranks for each alternative city within the scope of disaster logistics.

Step 6: The city with the highest rank acceptability value among the alternative cities for the distribution center planned to be established within the scope of disaster logistics in TRA1 zone has been determined as Erzurum. For this reason; it is assessed that the city of Erzurum to be the most convenient city as an establishment location will be convenient. In the event that the establishment of a second distribution center is brought to the agenda, the selection of the city of Erzincan will be a suitable decision. Also when the reliability factor and central weight vectors have been examined, it could be seen that the ranks determined for the alternative cities are also supported by these distinguishing scales.

V. CONCLUSION

There occur some uncertainties when where the distribution center to be used in the provision of efficient support to the disaster victims will be established is left to the individual decisions in the event of the occurrence of the disaster. The use of methods with numerical content in the deciding of the distribution center establishment location rather than other methods facilitates the works of the decision makers and it becomes more reassuring.

The convenient establishment of the distribution centers has a significant role in the flow of the aid materials to the disaster victims and in the design of an efficient distribution network after the disaster. In this study, SMAA-2 method has been utilized due to the fact that the distribution center location problem has criteria with stochastic, unclear and uncertain values within the scope of the disaster logistics. JSMAA software has been used for the attainment of the results of solutions.

SMAA-2 method has been suggested for MCDM problems in which both the certain values of decision criteria and the certain weight values cannot be determined and also, the certain assessments of the decision makers/experts cannot be attained due to various reasons. The method allows the expression of both the preference values taken by the alternatives in terms of criteria and the criterion weight values as probable and interval values in accordance with the principles of the group decision making.

The decision makers cannot comfortably reach their decisions by thinking about the impact and propriety their decisions will form in public opinion in the disaster plannings in which uncertainty and unforeeability are intensive. SMAA is a method developed for such kinds of decision problems. In this method, experts submit to the decision makers which alternatives are selectable at what ratio instead of submitting the best among the alternatives. The final decision is reached by the decision maker. Therefore, it has been assessed that SMAA-2 method is a proper MCDM method for the distribution center location problem within the scope of disaster logistics.

As a result of the study; by the ratios, the most convenient alternative for the establishment of the distribution center within the scope of disaster logistics in TRA1 zone has been determined as the city of Erzurum.

Different methods could be used for the distribution center location problem in future studies and a comparative analysis could be conducted with the same data. The similarly used criteria could be varied and the impact of the criteria on the problem could be examined.

REFERENCES

Ağdaş, M., Bali, Ö. and Ballı, H. (2014). "Location Selection for Distrubution Center in Disaster Logistics: an Application with SMAA-2 Method" *Journal of the Academy Beykoz,* 2(1), 75-95.

Altay, N., & Green, W. G. (2006). "OR/MS Research in Disaster Operations Management" *European Journal of operational Research,* 175(1), 475-493.

Artalejo, Jesus R. (2000) "G-networks: A Versatile Approach for Work Removal in Queueing Networks" *European Journal of Operational Research,* 126, 233-249.

Aslan, H. M., Yıldız, M. S., & Uysal, H. T. (2015). "Application of Fuzzy TOPSIS Method on Location Selection of Disaster Stations: A Location Analysis in Düzce" *Journal of Politics, Economics and Management Research,* 3(2) 111-128.

Beamon, O. and D. Krass, M. B. C. Menezes. (2007) "Facility Reliability Issues in

Network P-Median Problems: Strategic Centralization and Co-Location Effects", Operations Research, LV, 2, 332-350.

Coles, S. and L. Pericchi. (2003) "Anticipating Catastrophes Through Extreme Value Modelling", *Journal of the Royal Statistical Society: Series C (Applied Statistics),* LII, 405-416

Cret, L. and F. Yamazaki, S. Nagata, T. Katayama. "Earthquake Damage Estimation and Decision Analysis for Emergency Shut-Off of City Gas Networks Using Fuzzy Set Theory", Structural Safety, XII, 1, 1993, 1-19.

Demirdöğen, O., Erdal, H. and Kul, S. (2017). "Dağıtım Merkezi Yer Seçimi Problemine Stokastik Bir Model Önerisi: TRA Bölgesinde Bir Uygulama", Atatürk Üniversitesi İktisadi ve İdari Bilimler Dergisi, 31(3), 555-570.

Dessouky, M. and F. Ordonez, H. Jia, Z. Shen. "Rapid Distribution of Medical Supplies" R. HALL (Ed.), Delay Management in Healthcare Systems, New York, Springer, 91, 2006, 309-338.

Duran, S. and M. A. Gutierrez, P. Keskinocak, (2011) "Pre-positioning of Emergency Items Worldwide for CARE International", Interfaces.

Esogbue, A.O. and M. Theologidu, K. Guo. (1992) "On the Applications of Fuzzy Sets Theory to the Optimal Flood Control Problem Arising in Water Resources Systems", Fuzzy Sets and Systems, XLVII, 2, 155-172.

Gümüşbuğa, F. (2012). Risk Based Plant Site Selection with Error Tree Analysis in the Scope of Disaster Management, (Unpublished Master Thesis), Military Academy, Defense Science Institute, Ankara.

Güzel, D. (2016). *Yeniliğin İşletme Performansına Etkisi: İmalatçı Kobi'lerde Bir Araştırma*. Ankara: İmaj Publisher.

Hale, T., & Moberg, C. R. (2005). "Improving Supply Chain Disaster Preparedness: A Decision Process for Secure Site Location" *International Journal of Physical Distribution & Logistics Management*, 35(3), 195-207.

Reshetin, V.P. and J. L. Regens. "Simulation Modeling of Anthrax Spore Dispersion in Bioterrorism Incident", Risk Analysis, XXIII, 6, 2003, 1135-1145.

Jia, H. and F. Ordonez, M. Dessouky. (2007) "Solution Approaches for Facility Location of Medical Supplies for Large-Scale Emergencies", Computers & Industrial Engineering, LII, 2, 257-276.

Kadıoğlu, M. (2008). "The Basic Principles of Modern, Integrated Disaster Management", within the Basic Principles of Disaster Mitigation (der. M. Kadıoğlu and E. Özdamar), 1-34, Ankara: JICA Turkey Office.

Karaca, Murat. (2003) "Optimization of locating logistic supply coordination centers (LSCC) of Turkish Land Forces in an earthquake region", Ankara, (Published Master Thesis), İhsan Doğramacı Bilkent University Institute of Engineering and Science.

Lahdelma, R., & Salminen, P. (2001). SMAA-2: Stochastic Multicriteria Acceptability Analysis for Group Decision Making. Operations Research, 49(3), 444-454.

Lahdelma R., Hokkanen J. and Salminen P., (1998). "SMAA-Stochastic Multiobjective Acceptability Analysis." *European Journal of Operational Research,* 106, 137-

143.

Maharjan, R., & Hanaoka, S. (2017). "Warehouse Location Determination for Humanitarian Relief Distribution in Nepal". *Transportation Research Procedia*, 25, 1151-1163.

Mete, H. O., & Zabinsky, Z. B. (2010). Stochastic Optimization of Medical Supply Location and Distribution in Disaster Management. *International Journal of Production Economics*, *126*(1), 76-84.

Ofluoğlu A., Baki B., Ar İ.M., "The Warehouse Location of The Disaster Logistics Using Entropy and Topsis Approaches: the Case of Trabzon", 17-19 Mayıs 2017, ss.311-323.

Peker, İ., Korucuk, S., Ulutaş, Ş., Okatan, B. S., & Yaşar, F. (2016). "Optimal Location Selection for Distrubution Centers in Disaster Logistics Using Integrated Ahp-Vikor Method: Case of Erzincan". *Journal of Management and Economics Research*, 14(1), 82-103.

Roh, S. Y., Jang, H. M., & Han, C. H. (2013). Warehouse Location Decision Factors in Humanitarian Relief Logistics. *The Asian Journal of Shipping and Logistics*, *29*(1), 103-120.

Roh, S., Pettit, S., Harris, I., & Beresford, A. (2015). The Pre-Positioning of Warehouses at Regional and Local Levels for a Humanitarian Relief Organisation. *International Journal of Production Economics*, *170*, 616-628.

Soon, S. V. (2007) A Two-Stage Scenario-Based Stochastic Programming Approach to Pre-Positioning Hurricane Supplies, Master Thesis, Alabama: Auburn University, Department of Industrial and Systems Engineering.

TDIB (2017). Turkey Disaster Information Bank, https://tabb-analiz.afad.gov.tr/ Erişim Tarihi: 18.07.2017.

Tervonen, T. and R. Lahdelma, (2007) "Implementing Stochastic Multicriteria Acceptability Analysis". *European Journal of Operational Research*, 178, 2, 500-513.

Tervonen, T. (2014). "JSMAA: Open Source Software for SMAA Computations". *International Journal of Systems Science*, *45*(1), 69-81.

TUIK (2017). Turkish Statistical Institute Adrese Based Population Registration System http://www.tuik.gov.tr/PreTablo.do?alt_id=1059, Erişim Tarihi: 18.07.2017.

Uluğ, Murat. "Location of Natural Disasters Search and Resque (SAR) Units in Sectors", Ankara, (Published Master Thesis), İhsan Doğramacı Bilkent University Institute of Engineering and Science, 2003.

Yi, W., & Ozdamar, L. (2004). Fuzzy Modeling for Coordinating Logistics in Emergencies. International Scientific Journal of Methods and Models of Complexity-Special Issue on Societal Problems in Turkey, 7(1), 20.

Ukkusuri, Satish V. and Wilfredo F. Yushimito (2008) "Location Routing Approach for the Humanitarian Prepositioning Problem", *Transportation Research Record: Journal of the Transportation Research Record*, 2089(1),