Application of fuzzy DEMATEL – ANP method to solve the allocation problem of refugee camps

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Abstract

Purpose – The purpose of this paper is to identify which sub-criteria have the highest importance for siting the refugee camps.
Design/methodology/approach – This study uses a combination of the fuzzy, DEMATEL, and ANP methods. A comprehensive questionnaire was used for this qualitative research.
Findings – The five main criteria and 20 sub-criteria are defined. The highest-ranking sub-criteria include long-term planning, optimal distribution, and opportunity for growth.
Research limitations/implications –The evaluation is based on human judgment.
Originality/value – Help in selecting suitable locations for refugee camps on the grounds of understanding the importance of particular sub-criteria.

Keywords: Refugee Camps, Settlement, Fuzzy DEMATEL - ANP

Introduction
Every year, the number of refugees and internally displaced people worldwide grows. According to the Office of the United Nations High Commissioner for Refugees (UNHCR), in 2017 there were 22.5 million refugees and 65.6 million forcibly displaced people (2017b). This is the highest number of involuntarily displaced people since at least 1955. Another 10 million people are stateless without any access to education, healthcare, and freedom of movement (UNHCR, 2017b).

These numbers are not final. According to the United Nations Convention to Combat Desertification (2014), by 2020 approximately 60 million people may have moved away from the desertified areas of Sub-Saharan Africa. By 2030, up to 700 million people may be displaced because of intense water scarcity. By 2050, an estimated 200 million people could become permanently displaced environmental migrants. It is important to note, however, that these estimates take into account only displacement caused by climate change. But the strong growth in refugees and displaced people between 2012 and 2015 was driven primarily by the conflicts in Syria, Yemen, and Iraq, as well as in Burundi, the Central African Republic, the Democratic Republic of Congo, South Sudan, and Sudan (UNHCR, 2017). It is critical, therefore to explore which factors have some influence on the existence of refugee camps. In the future, the number of such camps will probably be higher and it is essential to locate them effectively.

A refugee camp is "a temporary space in which refugees may receive humanitarian relief and protection until a durable solution can be found to their situation" (Ramadan, 2012, p. 65). Approximately forty percent of all refugees live in camps, most of them

because there are no other alternatives (UNHCR, 2014b). The camps are frequently perceived as a short-term solution, even though the reality shows that in the past, the average lifespan of camps was seven years and it now stands at twenty years (Kennedy, 2004). The oldest camps for Palestinian refugees have existed for more than 67 years (Dalal, 2015). The spread of the refugee crisis and the lengthening of conflicts worldwide have meant that refugee camps have seen their lifespans steadily extended. Consequently, choosing a suitable location for the refugee camps has become increasingly important.

Refugee camps come into existence in different ways: some of them are planned, while others are self-settled (UNHCR, 2014b). They are isolated in many ways. The most obvious is physical isolation (Werker, 2007) because the camps are often located in remote areas. The host countries give up land that otherwise could have been used for their own objectives, and thus this land does not tend to be of the highest quality (Werker, 2007) and does not have great potential. Werker (2007) mentions the case of the Kyangwali Refugee Settlement in Uganda, which is more than 80 kilometers from the town of Hoima, where refugees can sell their production. While the host community could potentially benefit from the improved infrastructure put in place during the operations of humanitarian organizations, this does not often occur because the camps are sited in isolated areas (Alloush et al., 2017). Indeed, the expenditures in infrastructure are usually lost when the refugees go home because the camps are too remote for the local community to make use of the new infrastructure (UNHCR, 2014b).

The segregation of camps means that refugees are in many cases highly dependent on the distribution of humanitarian aid (Dalal, 2015). Given the financial burden caused by the ever-growing number of passive aid recipients connected with the prolonged existence of refugee camps, the UNHCR proposes self-reliance policy. This is reflected in the UNHCR's Global Shelter and Settlement Strategy (2014a), which mentions two options for a settlement. The first is related to rural areas, where camps can be built, but their existence should be mitigated by settling refugees in existing host communities. The linkages between camp and host community should be ensured and the maximum size of one camp should be 20,000 people. The second option relates to urban settings, where the creation of refugee camps is unlikely. The recommendation is to monitor social and low-cost housing opportunities (UNHCR, 2014a).

The reality is slightly different, at least in relation to the size of camps. For example, in 2017, the population of the Zaatari camp in Jordan was 79,559 occupants (UNHCR, 2017c) and that of the Kakuma camp in Kenya was 176,872 refugees (UNHCR, 2017a). In 2018, the population of Camp 13 in Cox's Bazar District in Bangladesh stands at 40,919 occupants (UNHCR, 2018c) and that of the famous Dadaab refugee camp in Kenya was 235,269 occupants (UNHCR, 2018b). The UNHCR's strategy is weak in the area of self-settlement. Nowadays, the refugees who self-settle within the host community often live in shared accommodation, in old, non-functional public buildings, in slums, or in informal types of settlements. In addition, self-settled refugees have poor access to humanitarian aid, and can sometimes be completely excluded from aid programs. In the end, the fact that humanitarian assistance is predominantly provided in refugee camps does of course have an impact on whether refugees decide to live in refugee camps or not (Werker, 2007). Therefore, a change in the mindset of the organizations delivering humanitarian aid is necessary.

One example of the consequences of choosing an unsuitable location for a refugee camp is the case of the Kutupalong settlement in Bangladesh in 2018. Up to March 2018, more than 670,000 Rohingya refugees have fled Rakhine State in Myanmar and

settled in the Kutupalong area. This area is prone to monsoon rains that reach a peak in July and August. More than 150,000 residents of this settlement are at the risk of flooding and landslides, and thus the relocation of threatened occupants was begun in March 2018 (Gaynor, 2018). The UNHCR, World Food Programme, and International Organization for Migration are working together in the Site Management Engineering Project, which is an initiative to enhance monsoon preparedness and response (UNHCR, 2018a). Besides, the Kutupalong camp is situated on the traditional migratory path for elephants. In March 2018, several elephants wandered into the camp, damaged shelters, injured their occupants and killed at least 10 refugees (Gluck, 2018). This accident was not the first case. In September 2017, 2 refugees were killed and 7 occupants were injured under the same circumstances (Gaynor, 2017).

Methodology
To find out which criteria have the greatest impact on choosing a suitable location for a refugee camp, a combination of the fuzzy, DEMATEL, and ANP methods was used. These methods are defined below.

The DEMATEL method
This method was developed by Gabus and Fontela in 1972 to solve complex decision-making problems (Celik, 2017). The DEMATEL method is an effective tool for analyzing structure and relations between few alternatives or system components (Gül et al., 2014). The method is based on graph theory and categorizes the influence factors into two groups, cause group and effect group (Hung, 2010).

The DEMATEL method consists of five steps (Tsai et al., 2009). At the beginning, experts evaluate the effects of each pair of criteria. The influence achieves: 0 (zero influence), 1 (moderate influence), 2 (medium influence), 3 (strong influence), and 4 (very strong influence). The pairwise comparisons are made and the direct-relation matrix H is formed. This matrix presents which criteria affect other criteria.

During the second step, the direct-relation matrix is normalized. The normalized direct matrix X is obtained using Equation (1) - (2).

Equation (1):
$X = k.H,$

Equation (2):
$$k = Min\left(\frac{1}{max_{1 \le i \le n} \sum_{j-1}^{n} a_{ij}}, \frac{1}{max_{1 \le j \le n} \sum_{i-1}^{n} a_{ij}}\right), \qquad i,j=1, 2, ..., n.$$

Subsequently, the total-relation matrix T is calculated by Equation (3).

Equation (3):
$T = D(I - D)^{-1}$

The next step includes the creation of a causal diagram. The sum of columns and the sum of rows are presented as vector *r* and vector *c*. These sums are computed by Equation (4) – (6).

Equation (4):
$$T = \left[S_{ij}\right]_{n \times n,} \qquad i,j=1, 2, ..., n.$$

Equation (5):
$$c_j = \sum_{j=1}^{n} S_{ij}, \qquad i,j=1, 2, ..., n.$$

Equation (6):
$$r_i = \sum_{i=1}^{n} S_{ij}, \qquad i,j=1, 2, ..., n.$$

The horizontal axis vector ($r_i + c_j$) is the "influence" vector and shows how great an impact the criterion has. The vertical axis vector ($r_i - c_j$) is the "relation" vector and divides the criteria into an effect group and a cause group. The criterion belongs to the cause group when ($r_i - c_j$) is positive (Hung, 2010, Gül et al., 2014).

The fifth step is focused on generating a cause and effect relation diagram. This diagram visualizes a detailed interrelationship between the criteria (Celik, 2017).

The ANP method
The objective of the ANP method is to evaluate the weights of variations (Hung, 2010). This method is divided into two phases.

During the first phase, the relative importance weights are generated through pairwise comparisons for each of the dependency relationships. The valuation scales are ranked as: 1 (equal importance), 3 (moderate importance), 5 (strong importance), 7 (very strong importance), and 9 (extreme importance). Reciprocal values relate to less importance on a relevant level (e.g., 1/5 as strongly less important). When the pairwise comparisons are finished, the relative importance weight for each component is calculated. These weights are made into a pairwise comparison matrix A (Hung, 2010). The weights are calculated using Equation (7).

Equation (7):
$$Aw = \lambda_{max} w. \ \lambda_{max}$$

The second phase is focused on the calculation of the supermatrix. The calculation of the supermatrix is split into three steps: formation, normalization, and convergence to a solution. The supermatrix is composed of the priority vectors of each pairwise comparison matrix. The convergence to a solution is created by giving a priority ranking to each of the variations (Hung, 2010).

The fuzzy DEMATEL-ANP methods
Decision-makers work in the real world. In daily situations, the goals and consequences of possible conducts are often unknown or are not known exactly (Bellman and Zadeh, 1970). According to Hung (2010, p. 9057), "the goals of the decision makers may be fuzzy for the consideration of flexibility and vagueness in the preferences". Therefore, the main goal of fuzzy theories is to remove this vagueness of human thinking and decision-making.

The disadvantage of the DEMATEL method is presented by using crisp values for a description of the systems and their relationships. In the real world, crisp values are insufficient (Büyüközkan and Cifci, 2011). This is why an application of fuzzy theory to the DEMATEL method is beneficial for many types of multiple criteria decision-making problems.

The ANP method uses ratio scales measurements based on pairwise comparisons without a strict hierarchical structure (Büyüközkan and Cifci, 2011). The essence of the ANP method is the evaluation of the weights of variations according to experts'

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judgment. However, human judgment on preferences is frequently unclear and it is hard to represent this estimation through exact numerical values (Büyüközkan and Cifci, 2011). Again, fuzzy theories are needed to handle problems characterized by imprecision.

The indispensable step is defuzzification. The method most used is the CFCS method (Converting Fuzzy Numbers into Crisp Scores). This method has five steps described as: normalization, computing left and right normalized values, computing a total normalized value, computing crisp values, and integrating crisp values (Kazançoğlu and Aksoy, 2011). For calculation, it is necessary to reflect the fuzzy linguistic scale contained in Table 1.

Table 1 – The fuzzy linguistic scale (amended from Tabrizi et al., 2016, p. 2949)

Linguistic term	Triangular fuzzy numbers
zero influence	(0; 0; 0.25)
moderate influence	(0; 0.25; 0.5)
medium influence	(0.25; 0.5; 0.75)
strong influence	(0.5; 0.75; 1)
very strong influence	(0.75; 1; 1)

Case study

Firstly, the criteria are determined. Five main criteria and twenty sub-criteria were defined according to expert judgment and also on the basis of literature review (Cetinkaya et al., 2016, Celik, 2017). Table 2 contains the complete list of criteria and sub-criteria used in this case study.

Table 2 – The list of main criteria and sub-criteria (amended from Cetinkaya et al., 2016, p. 220, Celik, 2017, p. 261)

Main Criteria	Sub-criteria
A – Geographical Criteria	A1. Area A2. Opportunity for growth* A3. Distance to water sources A4. Groundwater* A5. Slant
B – Infrastructural Criteria	B1. Distance to roadway B2. Distance to airports B3. Distance to ports B4. Distance to facilities*
C – Danger Related Criteria	C1. Distance to conflict areas C2. Danger of aggression* C3. Flood danger C4. Drought danger
D – Social Criteria	D1. Distance to local population D2. Distance to country of origin* D3. Cultural adequacy
E – Operational Criteria	E1. Economic aspects* E2. Long-term planning* E3. Comfort E4. Optimal distribution

* sub-criteria were defined according to expert judgment

The detailed description is as follows:

- A1. **Area** – the potential location for a refugee camp has to be large enough in relation to the number of refugees, e.g., 30 m^2 per person (Cetinkaya et al., 2016),
- A2. **Opportunity for growth** – refugee camps are often not constructed for a large number of people and this makes life conditions for refugees much worse,
- A3. **Distance to water sources** – this sub-criterion reflects the problem of a lack of clean water for the refugee population inside the camps,
- A4. **Groundwater** – another source of water for people in the camps,
- A5. **Slant** – the area for refugee camps should be a plane with a gradient lower than 7% (Cetinkaya et al., 2016),
- B1. **Distance to roadway** – refugee camps should be situated near a main or at least a bigger roadway,
- B2. **Distance to airports** –refugee camps should be situated near airports,
- B3. **Distance to ports** – refugee camps should be situated near ports,
- B4. **Distance to facilities** – refugee camps should be situated near facilities (such as warehouses or distribution centers) and also near educational or health facilities,
- C1. **Distance to conflict areas** – refugee camps should be located in a safe and secure place (e.g., far away from conflict zones, without landmines, etc.)
- C2. **Danger of aggression** – even if refugee camps are situated in a secure area, there is still a danger of aggression (demonstrated in 2017 in some security incidents),
- C3. **Flood danger** – refugee camps should be situated far away from areas where there is a danger of flooding,
- C4. **Drought danger** – refugee camps should be located outside of zones susceptible to drought,
- D1. **Distance to local population** – refugee camps should be located near the host community for the prevention of exclusion,
- D2. **Distance to country of origin** –refugee camps should be situated closer to the country of origin if there is a significant will of refugees to return,
- D3. **Cultural adequacy** – it is necessary to understand the culture and habits of the refugees and the host community,
- E1. **Economic aspects** – refugee camps have an impact on the economic environment of the host country,
- E2. **Long-term planning** – there is a significant possibility that the camps will exist for a longer period of time than the initial estimate,
- E3. **Comfort** – refugee camps should be able to provide thermal comfort and protect refugees against sun, rainfall, or frost,
- E4. **Optimal distribution** – the location of refugee camps should take into consideration the effort to minimize the travel distance between the camp and other important points in the region (e.g., markets, other refugee camps, etc.).

These criteria and sub-criteria take into consideration common complications connected with refugee camps. According to field workers who worked in a refugee camp, the two main problems are a lack of space for refugees and a lack of clean water. Some sub-criteria are interconnected. For example, cultural adequacy can influence the danger of aggression, or the distance to water sources can have an impact on flood danger. These links have to be taken into account when siting a camp.

The research itself has two phases. The first phase was focused on the DEMATEL method. The aim was to determine whether each criterion belongs to the cause or effect group. Each respondent made the pairwise comparisons from which the direct-relation matrices were formed. The second phase includes the evaluation of the weights of sub-criteria according to the ANP method. The respondents received the questionnaire with a verbal formulation of valuation. This valuation was converted to numerical values later by the author.

In total, six respondents participated in this study. All of the respondents work for a humanitarian organization. They were selected on the grounds of their work experience and level of knowledge about refugee camps and the refugee situation. The combination of field staff and personnel from HQ is also deliberate.

This paper does not afford an opportunity for specific analysis of differences between the judgement of the field and HQ staff. However, the data obtained has potential for future research. Table 3 contains the profiles of the respondents.

Table 3 – Profiles of experts (personal collection)

Expert	Occupation	Education level	Placement	Experience (years)
X^1	Director	Graduate	HQ/Field	25
X^2	Logistics Manager	Graduate	Field	8
X^3	HR Manager	Undergraduate	HQ/Field	23
X^4	Fundraising Specialist	Undergraduate	HQ/Field	3
X^5	Logistician	Undergraduate	Field	12
X^6	Logistician	Graduate	Field	6

Discussion of findings

The application of the DEMATEL method shows that the geographical criteria and danger related criteria fall into the cause group. The cause and effect relation diagram is depicted in Figure 1 below.
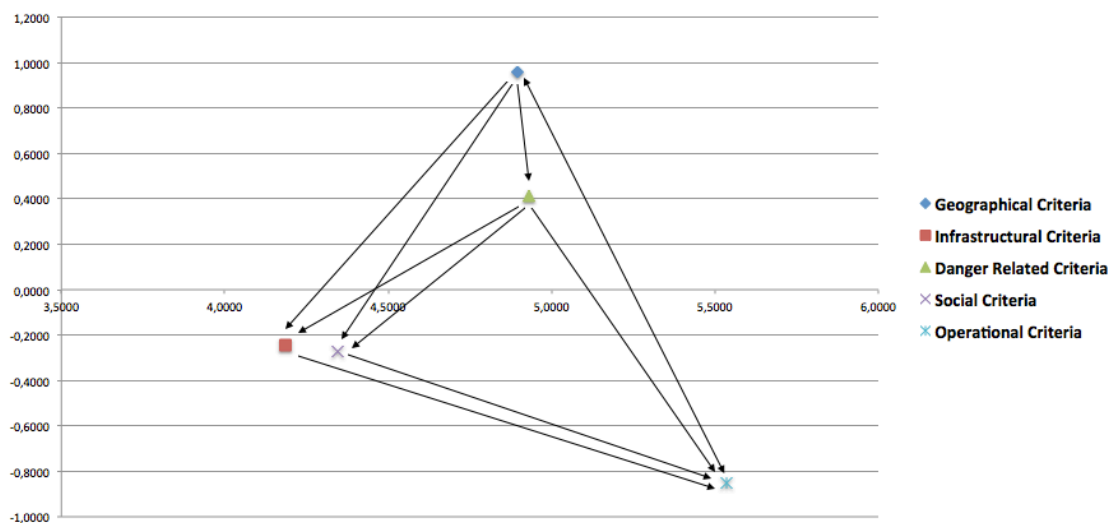

Figure 1 – The cause and effect relation diagram (personal collection)

Thereafter, the relative importance weights are generated through the pairwise comparisons for each of the dependency relationships. These values are gained through application of the ANP method. The sub-criterion *long-term planning* held the highest weight (0.119). This is a very interesting finding because this sub-criterion was not covered in previous research focused on the siting of refugee camps. Also, as was mentioned before, refugee camps are usually considered as a temporary solution. The high weighting denotes the importance of this sub-criterion in practice. Even though, building infrastructure in an unsuitable area is an inappropriate and costly process, primarily on a long-term horizon. The lowest weights were held by the sub-criteria *distance to airports* and *distance to ports* (both 0.013).

The application of the CFCS method for defuzzification did not significantly change the values of the weights. The weights of only five sub-criteria were changed: *opportunity for growth*, *distance to water sources*, *distance to local population*, *cultural adequacy*, and *long-term planning*. These variances are less than 0.01. The new weight of the *long-term planning* sub-criterion is 0.118. The completed list of values of the weights after defuzzification is shown in Table 4 below.

Table 4 – The weights of sub-criteria (personal collection)

Sub-criterion	Weight	Sub-criterion	Weight
A1. Area	0.071	C2. Danger of aggression	0.024
A2. Opportunity for growth	0.080	C3. Flood danger	0.022
A3. Distance to water sources	0.076	C4. Drought danger	0.017
A4. Groundwater	0.073	D1. Distance to local population	0.047
A5. Slant	0.050	D2. Distance to country of origin	0.023
B1. Distance to roadway	0.043	D3. Cultural adequacy	0.039
B2. Distance to airports	0.013	E1. Economic aspects	0.079
B3. Distance to ports	0.013	E2. Long-term planning	0.118
B4. Distance to facilities	0.034	E3. Comfort	0.057
C1. Distance to conflict areas	0.024	E4. Optimal distribution	0.096

The value of the weight of the *country of origin* sub-criterion is also fascinating. The generally valid opinion seems to be that refugee camps should be located near the country of origin (or place of origin when it comes to internally displaced people). As a result, refugee camps are often situated in remote areas, as mentioned earlier. On the other hand, the *distance to local population* sub-criterion has double the value of weight than the *country of origin* sub-criterion. Obviously, these two sub-criteria are contradictory.

In some ways, it could be more beneficial to compare only sub-criteria in the same group of criteria, or to compare the sub-criteria that are somehow connected. This could have a greater impact on concrete potential locations with specific parameters.

Conclusions and avenues for future research
This paper has some limitations. The first is the elementary substance of the combination of the fuzzy, DEMATEL, and ANP methods. The DEMATEL method and ANP method are based on human judgment. Despite the defuzzification, the values of weights are reliant on expert evaluations. On the other hand, decision-makers in the real world and during real humanitarian operations are people. There could also be a higher number of experts involved in the research, although the values would average themselves out from a certain number of respondents. For future research, it would be beneficial to also involve workers from relevant civil services, UN agencies (UNHCR, UNRWA), refugees, and internally displaced people. Only a clear understanding of their needs can improve the living conditions inside the camps.

The sub-criteria with the highest weight are *long-term planning*, *optimal distribution*, *opportunity for growth*, *economic aspects*, and *distance to water sources*. Even though the *distance to airports* and *distance to ports* sub-criteria have the lowest value of

weights, their importance is covered by the impact of the optimal distribution sub-criterion. Obviously, suitable infrastructure plays a key role in optimal distribution.

The purpose of this paper was to identify which sub-criteria have the highest importance for siting refugee camps. The analysis of interdependences between sub-criteria and the evaluation of the weights is just a first step. The data obtained could be used to rate existing refugee camps and also to rate potential locations, for example by using geographic information system software.

The associated purpose is to bring attention to this topic. Up to now, only two papers have been focused on the problem of locating refugee camps (Cetinkaya et al., 2016) or temporary shelters (Celik, 2017). The Office of the United Nations High Commissioner for Refugees (2014b) admits that the need to build refugee camps will not disappear. Many governments do not allow to refugees live outside the camps, and, at the onset of emergencies, camps could be a necessary solution. Thus the best practices for building refugee camps should be set out and, which is perhaps even more important, followed in practice. In the end, the substance of the question of refugee camps is not statistics or estimates but humans. The effort to provide shelter and dignified living conditions, even for a short time, should be standard.

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