

A MCDM Based on Goal Programming and GIS-Based Risk Assessment for the Evaluation of Educational Locations in Conflict Areas

Jamil Hallak*, Elifcan Göçmen Polat**

Abstract. Conflict is recognized as a major barrier in socio-economic development. In conflict situations, most sectors such as health, food, shelter and education are adversely affected. The provision of education services to conflict-affected children saves them from becoming a lost generation and contributes to community building. Thus, we conducted this research to investigate the potential of a GIS (Geographic Information Systems) approach and risk assessment based multi-criteria decision making (MCDM) for the allocation of displaced dropped-out children to the most appropriate educational centres, taking into account multiple goals related to cost, distance, risk, etc. A two-stage approach was adopted, utilizing a risk assessment approach, and a location-allocation approach. The risk assessment approach was carried out using GIS and F-AHP (Fuzzy Analytic Hierarchy Process) to determine the risk value of each candidate educational centre in the conflict area. In the location-allocation stage, a mathematical model was developed to allocate all demands to the chosen centres. All presented methods were computationally conducted on real case data provided by direct beneficiaries and stakeholders in the 26 sub-districts in the Idleb governorate, Syria. The computational results demonstrate that the proposed approaches ensure practical and theoretical impacts.

Keywords: conflict, risk assessment, dropped-out children, F-AHP, GIS, mathematical model

*PhD, Industrial Engineering Department, Cukurova University, Adana, Turkey, <https://orcid.org/0000-0001-5975-4075>

**Department of Industrial Engineering, Munzur University, Tunceli, Turkey, <https://orcid.org/0000-0002-0316-281X>

1. Introduction

Conflicts and crises have a devastating effect on the socio-economic status, human life, and health of countries. The inability to control conflicts dramatically increases the losses in society. The Syrian conflict is undoubtedly one of the most complicated crises in the current era, and civilians are still suffering the brunt of this conflict. There are more than 6 million IDPs in Syria [1]. The crisis imposes enormous difficulties on civilians and limits their access to the basic requirements of life, such as health, food, education and other services.

One of the most vulnerable groups of IDPs in northern Syria is children affected by the conflict, particularly in educational issues. One of the education problems confronting the children is the lack of access to education for many years: most schools have been destroyed while others are utilized as shelters for displaced persons.

Even where school buildings exist, children's access to education is limited due to the conflict conditions. Explosive hazards also affect the children's and teachers' ability to access schools safely. In this context, the United Nations (UN) and its humanitarian partners have reported that 6 million children (3.2m male, 2.8m female) are devoid of educational services in Syria, of which 5.9 million are under the age of 17 [25]. This situation has revealed the need for effective and efficient provision of education services for children in crisis areas. Thus, researchers and institutions have started to give more attention to finding novel ways to address the educational issues and to increase accessibility in the context of conflict inside Syria.

Providing access to adequate education for IDPs is crucial in each community. Lack of education is the main reason behind child labour, child marriage and a range of mental and physical problems [25]. One significant aspect of providing education in crisis areas is to provide appropriate locations and to allocate drop-out children to those locations. In this context, the current research focuses on a location-allocation solution for displaced children, in order to provide conflict-affected children with education and to alleviate their deprivation.

This study investigates whether the interactions between the selection of education centre locations and the risk assessment process would improve the access to education in conflict-affected zones. This paper seeks an answer to these research questions: What is the risk value of each candidate educational centre? How can we most effectively allocate the children to these centres? The first step of the study was the risk assessment analysis for each candidate location; then the location-allocation model was applied to select the optimum locations according to many criteria.

Spatial data and the geographic environment were also involved in the study to define the spatial attributes of roads and risky regions. The goals and criteria related to cost, distance, risk and other factors were decided in a hierarchical structure and evaluated by experts utilizing F-AHP, where the relative importance of each criterion is determined using triangular fuzzy numbers. The method was applied to a case study in Syria, using real data from the field. The integration of GIS and F-AHP was carried out to obtain the maps. The proposed education centres were then evaluated, taking the created map into consideration. The computational results revealed the efficiency of the presented methods based on the achieved goals in each criterion.

The main contributions of this paper are to integrate GIS and F-AHP and mathematical

models for a decision-making process with a two-stage approach: a risk assessment approach and a mathematical modelling approach using real case data. Until recently, there have been no previous studies of increasing the access to educational services in conflict areas using F-AHP, GIS and mathematical modelling.

The rest of the paper is organised as follows: In section 2, previous studies, including both MCDM methods for facility location allocation problems and MCDM methods of education centre location allocation problems, are reviewed. In section 3, data and methodology are presented. Results and discussion are given in section 4, while conclusions are drawn in section 5.

2. Literature review

Determining the optimal locations from various candidate ones involves the weighting of multiple criteria and the examination of alternative facilities in the real world. Integration between MCDM and GIS is required to solve site selection problems realistically, since GIS is applied to deal with real spatial data and to integrate the results in MCDM [12]. In integrated methods, the most used tool is GIS since it analyses the location allocation problems visually [11].

Recently, MCDM and GIS methods have been increasingly used in different areas and previous studies are presented here to show the research gaps. To the best of our knowledge, regarding this theoretical gap, this study is the first to conduct the selection of the most appropriate educational locations in conflict areas based on risk assessment. Regarding the practical gap, a real case study is addressed to illustrate the validation of the model in the real world. This literature review is divided into two parts: the first covers MCDM methods of facility location allocation problems; the second focuses on MCDM methods in educational centres location allocation problems.

2.1. MCDM methods for facility location allocation problems

Site selection problems have been conducted by many researchers using mathematical modelling and MCDM approaches. Only a few researchers give attention to the effective of facility location on humanitarian logistics. Timperio et al. [22] provided a network design for a disaster relief supply chain in Indonesia using GIS and Fuzzy AHP where a real case study was applied for the proposed approach. Rahman et al. [18] presented flood emergency planning using MCDM and GIS in Northeast Bangladesh. The proposed methods ensured the distribution of emergency centres such as schools, hospitals in flood-prone areas for flood victims. Roh et al. [20] investigated a facility location problem based on MCDM: they designed a decision-making approach and ranked the key factors to select the humanitarian relief locations. Junian and Azizifar [13] studied the location of shelter sites in a disaster-prone area using GIS and MCDM; they evaluated criteria such as the availability of roads, population, and medical centres. Denekos et al. [9] proposed a decision-making approach for siting refugee camps using GIS and MCDM, using criteria to classify and rank the locations.

In addition to humanitarian studies integrating GIS and MCDM, some scholars have investigated facility location problems in other sectors, mostly through optimization using

these methods. Aydi et al. [6] used MCDM with GIS to choose a landfill site. GIS was applied to analyse spatial data, and AHP was used for ranking the importance of criteria. Asakereh et al. [5] used F-AHP and GIS methods for the location of solar energy farms in Iran using solar insolation data. Pourahmad et al. [17] proposed an integration of MCDM with GIS to determine the optimal leisure space in an urban site. Their results demonstrate that GIS ensures the analysis and presentation of spatial data and MCDM provides the weighting of criteria efficiently. Lin et al. [15] applied a fuzzy MCDM method to solve a car-sharing station selection problem. This method was used to decide the rankings of the alternative sites. Messaoudi et al. [16] conducted a hydrogen production installation system problem using MCDM with GIS. They used AHP to assign weights to criteria and GIS to select the optimum locations. Kabak et al. [14] used a GIS-based MCDM method to select bike-share station sites in Turkey. This method was used to decide the criteria weights and to examine alternative bike-share stations. Al Garni and Awasthi [2] used GIS and MCDM methods to select PV (photo voltaic) solar project locations. AHP was used to weight the criteria and to establish a land suitability index. GIS was utilized to compute the solar insolation using atmospheric data. Alkaradaghi et al. [4] used MCDM and GIS to select the most appropriate landfill sites. GIS was used for spatial data to control the large data and MCDM methods were applied for the weightings of the criteria. Erdin and Akbaş [10] compared fuzzy MCDM and GIS to decide the optimum locations of shopping malls in Marmara region-Turkey.

2.2. MCDM methods in education centre location allocation problems

Baykasoğlu and Durmuşoğlu [7] addressed a primary school selection problem using MCDM methods. An analytic network process and fuzzy cognitive maps were used to decide the weights of the criteria and the cost/benefit ratio was obtained in order to rank the alternative locations. Uslu et al. [24] proposed a GIS-based AHP method to select a school site in Turkey. They defined the alternative sites as compatible with legal requirements and at an accessible distance from students' homes. Rezaur Rahman et al. [19] used MCDM methods to select secondary school locations in Bangladesh. In the study, users choose best and worse criteria and compared the other criteria within these parameters. Al-Sabbagh [3] investigated the using of GIS and location analysis to improve access to schools in Egypt. The results showed that spatial models integrated with the localization approach ensured effective selection of facility locations. These previous studies mainly utilized the criteria weights obtained and evaluated them using AHP and MCDM. However, there have been no previous studies aimed at finding the optimum educational centres in crisis areas based on risk assessment and mathematical model. The current paper extends previous work in the following ways: utilizing risk assessment to evaluate the locations by GIS and obtaining the risk value for each centre; integrating these risk values into a mathematical model to define the most appropriate centres; allocating the dropped-out children to the chosen centres; and determining the appropriate vehicles to transfer them.

3. Methodology

A two-stage approach was proposed to solve this multi-criteria problem. In the first stage, a

risk assessment approach was utilized to identify the risk value of each candidate educational centre in the conflict area, based on GIS and F-AHP. In the second stage, we utilized multi-criteria method “goal programming” to allocate all demand nodes (nodes containing dropped-out children) to the optimal educational centres, taking into account multiple goals related to cost, distance, and risk. In addition, the type and number of selected vehicles to transfer children from demand node to the chosen centre based on cost and distance are defined. The steps and process in each stage are described in detailed below:

3.1. First stage: risk assessment approach

This stage aims to identify the risk value of each candidate educational centre, using risk assessment as shown in Figure 1. The proposed approach is mainly based on assessing risks in the conflict areas using surveys/FGDs, Fuzzy-AHP, and GIS presented in six main steps as below:

- 1) Data collection: in order to better assess and understand the needs in the conflict area, 426 surveys and interviews (331 about demand nodes + 95 about candidate educational centres) were conducted with different sources, such as direct beneficiaries and stakeholders, to identify potential risks, features of the demand nodes and information about the educational centres (capacities, costs, and proximity to the frontlines/clashes, vendors, child labour areas and workforce). The data were collected among the 26 sub-districts in the Idleb governorate of Syria from May 2019 to August 2019.
- 2) Risk identification: risk is defined here as any hazard, threat, or danger that may occur in the study area and has a potential for harm or adverse consequences at the candidate educational facilities. Three dedicated experts and the beneficiaries’ representative determined the most important and essential risks (such as closeness to frontlines, armed groups, child labour incidents, etc., described in Table 1) to assess the final risk value of each educational centre,

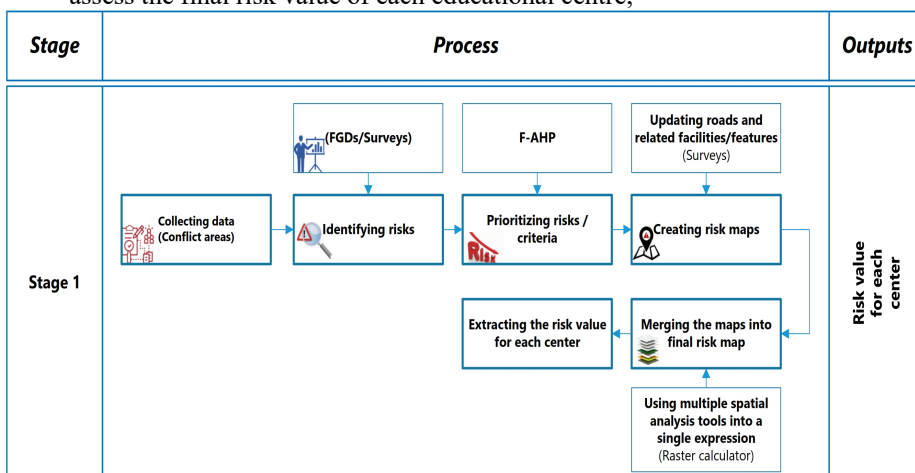


Figure 1. Proposed methodology in the study (stage1)

- 3) Risk prioritization: the identified risks/criteria were organized in a hierarchical structure to be evaluated by the experts. The relative importance of each criterion was determined using linguistic variables, which were represented as triangular fuzzy numbers. The final risk weights are given in section 4.1.1.

Table 1. Risk identification

Risk No.	Risk/criterion description
R1	Proximity to areas that reported child labour incidents
R2	Proximity to areas that have educational workforce
R3	Proximity to main streets
R4	Distance from clash lines/frontlines between the conflicting groups
R5	Distance from areas that have encountered interference of armed groups on the education process.
R6	Proximity to the material suppliers/providers

- 4) Risk Maps creation: after identifying risks in step 2, maps were produced by updating the road network using GIS, with the projection of the features related to the considered risk as spatial data on the map for each risk. A risk map was created by classifying the areas which demonstrated each level of risk, from lower to higher. Each identified risk was classified by experts on a scale of 1 to 5, with 1 being the lowest risk and 5 being the highest. A map for each risk was created and these are shown in section 4.1.2.
- 5) Overlapping Risk Maps into a Single Final Risk Map: a single final risk map was created by overlaying the different risk maps built in the previous step (4) using the weights mentioned in step (3) to find out the final risk value of each area in the study location. Equation 1 (below) was employed to calculate the final risk value by multiplying each risk/criteria weight by the respective risk value and then getting the sum of all the products together for each area. This was performed using the GIS package (ArcMap 10.4.1).

$$FRV = \sum_{n \in N} RW_n RV_n,$$

(1)

where N is the set of risk map ($n \in N$), FRV is the final risk value, RW is the risk weight calculated using the F-AHP, and RV is the risk value of each criterion in the area.

- 6) Final Risk Value Extracting and Ranking: we extracted the final risk value for each educational centre in the area according to the facility location in the final risk map, which was obtained from step (5). Then we ranked them from low to high-risk values to enable the decision-makers to consider, as much as possible, the centres with lower risk values in the second stage.

3.1 Second stage: Location-allocation approach

The aim of this stage was to allocate all demand nodes (drop-out children) to the most appropriate educational centres and to select the most cost-effective transport, utilizing a multi-criteria approach as shown in Figure 2. The approach was mainly based on understanding the humanitarian context in Syria from the perspective of people affected by the crisis in the area, goal programming and the risk values obtained from the first stage. The methodology was applied in four basic steps:

- 1- Understanding the context of the current situation of educational centres through a needs assessment to assess the needs of stakeholders and factors from their perspective.
- 2- Identifying goals and restrictions, and then prioritizing them according to the three dedicated experts' evaluation, utilizing F-AHP. As a result of that, each goal was given a weight.
- 3- Updating the roads network dataset for the target region utilizing GIS, to define the possible roads for transferring children from demand nodes to the chosen centre.
- 4- A mixed-integer mathematical model based on goal programming was developed and solved using optimization package software to choose centres and allocate clusters of children.

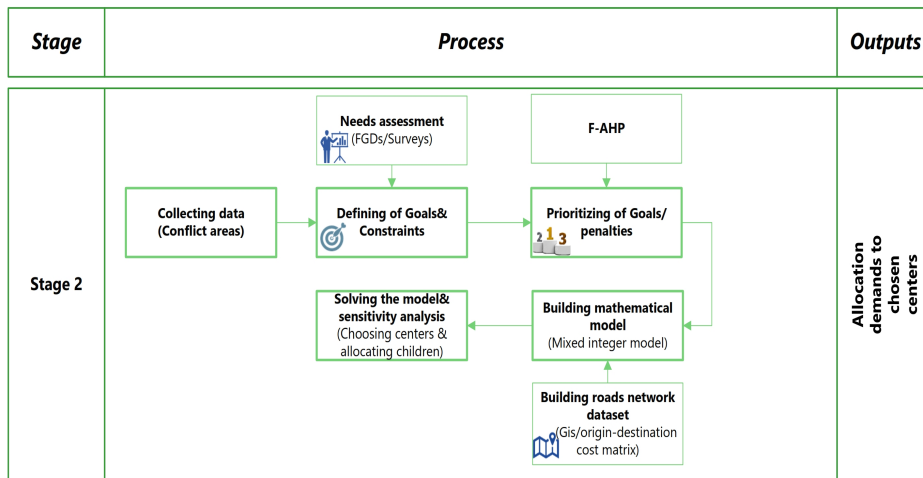


Figure 2. Proposed methodology in the study (stage 2)

3.1.1 Building the model

In this part we proposed a multi-objective model based on goal programming, where we combined many objective functions into one final goal utilizing goal programming. Our objective functions can be summarized as follows:

- 1- Minimizing the total cost, which includes the cost of setting up of educational centres and costs of utilizing vehicles to transport children from their location to the educational centre (described in equation (2)).
- 2- Minimizing the maximum distance between a demand node and the closest facility to the node (described in equation (3)).

- 3- Maximizing the number of chosen facilities that have a basement (described in equation (4)).
- 4- Maximizing the number of chosen facilities that have a water source (described in equation (5)).
- 5- Minimizing the risk values of chosen facilities, in other words the model will strive to select the facilities which have a lower risk value (described in equation (6)).

Objective functions:

$$\text{Minimize } \sum_{j \in J} sc_j X_j + \sum_{i \in I} \sum_{v \in V} Av_{iv} Vc_v \quad (2)$$

$$\text{Minimize } W \quad (3)$$

$$\text{Maximize } \sum_{j \in J} edb_j X_j \quad (4)$$

$$\text{Maximize } \sum_{j \in J} edw_j X_j \quad (5)$$

$$\text{Minimize } \sum_{j \in J} R_j X_j \quad (6)$$

Subject to

$$\sum_{j \in J} Z_{ij} = 1 \quad \forall i \in I \quad (7)$$

$$\sum_{j \in J} d_{ij} Z_{ij} \leq W \quad \forall i \in I \quad (8)$$

$$Z_{ij} \leq X_j \quad \forall i \in I, \forall j \in J \quad (9)$$

$$\sum_{i \in I} Z_{ij} a_i \leq C_j \quad \forall j \in J \quad (10)$$

$$X_j, Z_{ij} \in \{0,1\} \quad (11)$$

$$\sum_{v \in V} Vc_v Av_{iv} \geq a_i Z_{ij} \quad \forall i \in I \quad (12)$$

$$Av_{iv} \text{ integer} \quad (13)$$

Equations (7) to (13) are the constraints of the suggested model. Equation (7) ensures that all demand nodes will be covered. Equation (8) states that each demand can be allocated to a facility that is located within the distance W . Equation (9) ensures that node i cannot be covered unless at least one of the educational centres that can cover node i is chosen. Equation (10) restricts each educational centre to cover less or equal to its capacity. Equation (11) shows the binary variables for the chosen educational centres and covered demand nodes. Equation (12) ensures that the chosen vehicles for each demand node have a

capacity equal or greater than the children existing in the demand node. Equation (13) ensures that the number of vehicles is an integer.

Model parameters:

- I : Set of demand nodes; $i \in I$
- J : Set of candidate locations; $j \in J$
- V : Set of vehicle types; $v \in V$
- G : Set of targeted goals; $g \in G$
- d_{ij} : Distance between node i and location j (acquired from building road network dataset by GIS)
- a_i : Amount of Demand at node i
- sc_j : setting up cost of locating a shelter at site j
- C_j : Capacity of each candidate location
- R_j : Risk at each candidate location
- Vk_v : Vehicle capacity of each type of vehicle.
- Vc_v : Vehicle cost of using of each type of vehicle in the area.
- p_n^- : Penalty for not achieving the objective related to deviation d_n^-
- p_n^+ : Penalty for not achieving the objective related to deviation d_n^+
- RHS_n : Right-hand sides of targeted goal n according to goal programming
- edb_j : $\begin{cases} 1 & \text{if the educational site } j \text{ has basement} \\ 0 & \text{otherwise} \end{cases}$
- edw_j : $\begin{cases} 1 & \text{if the educational site } j \text{ has water source} \\ 0 & \text{otherwise} \end{cases}$

Model decision variables:

- X_j : $\begin{cases} 1 & \text{if we locate a center at candidate location } j \\ 0 & \text{otherwise} \end{cases}$
- Z_{ij} : $\begin{cases} 1 & \text{if demand at node } i \text{ is allocated to a center at location } j \\ 0 & \text{otherwise} \end{cases}$
- d_n^+ : Positive deviational variable – amount of an overachieved targeted goal n
- d_n^- : Negative deviational variable – amount of an underachieved targeted goal n
- W : maximum distance between demand and the nearest location.
- Ac_{iv} : Number of vehicles of each type to move children to the educational centre.

3.1.2. Goal programming modelling

To solve this multi criteria decision problem we utilized the goal programming method, where all objective functions described by Equations (2) to (6) above were compounded into one final goal according to the goal programming formulation as shown in Equation (14). We minimized the total deviations related to objective functions, taking into consideration the penalty of each objective and percentage normalization according to RHS (right-hand sides of each objective function) of the targeted goals.

$$\text{Minimize } \sum_n (p_n^- d_n^- + p_n^+ d_n^+) \frac{1}{RHS_n} (\%). \quad (14)$$

The main goals were converted to soft constraints by adding to each the positive/negative deviational variable d_n^+, d_n^- .

4. Results and Discussion

4.1. Case Study

We employ the new methodology in a real case study in Idleb in the north of Syria, near the southern borders of Turkey. Idleb has an area of 6,097 km² and a population of around 1,464,000 people. Data was collected about the education situation in the target area and the candidate education centres showed that there are approximately 853,292 school-age children in need (5-17 years) and approximately 17,777 teachers in need. There are approximately 34,155 children at risk of dropping out because they are living in random camps where there is no appropriate, or only a distant, educational centre. This decreases attendance, leads to dropouts, and affects learning outcomes negatively.

The data about candidate centres (such as their exact location in terms of longitude and latitude, costs of setup, their capacity, the availability of a basement and of a water source) as well the data on drop-out children nodes (such as exact location, demand amounts, distance to each candidate educational centre by building a road network dataset) were collected by conducting surveys and interviews. A total of 331 nodes were included in the study. Moreover, 95 candidate educational centres with varied capacities, costs, and proximity to the frontlines/clashes, vendors, child labour areas and workforce were also taken into account in this study.

The risks in each area are described in Table 1, where we classify them according to the distance between the service facility and risk source. The closer the facility is to the risk source/area, the higher risk category it has. These definitions were obtained based on the interviews/surveys with experts and key stakeholders in each related field.

4.1.1. Prioritizing risks using F-AHP

Using F-AHP, the criteria were arranged in a hierarchical structure and evaluated by experts. The relative importance of each criterion was determined using linguistic variables, which were represented as triangular fuzzy numbers, as shown in Figure 3. In this study, the centre of area defuzzification method was used to convert the fuzzy evaluations into their corresponding crisp value.

Table 2. Saaty's Crisp Scale and developed fuzzified scale for pairwise comparison [21]

Saaty's Crisp Scale	Judgment Definition	Triangular Fuzzy Scale	Triangular Fuzzy Reciprocal Scale
1	Equal Importance	(1,1,2)	(1/2,1,1)
2	Least Importance	(1,2,3)	(1/3,1/2,1)
3	Weak Importance	(2,3,4)	(1/4,1/3,1/2)
4	Moderate Importance	(3,4,5)	(1/5,1/4,1/3)
5	Strong Importance	(4,5,6)	(1/6,1/5,1/4)
6	Stronger Importance	(5,6,7)	(1/7,1/6,1/5)
7	Strongest Importance	(6,7,8)	(1/8,1/7,1/6)
8	Extreme Importance	(7,8,9)	(1/9,1/8,1/7)
9	Most Extreme Importance	(8,9,9)	(1/9,1/9,1/8)

A 9-point scale was used to describe the relative importance of criteria with respect to the goals [23], as summarized in Table 2. The weights of different criteria were calculated using the geometric mean method [8].

Fuzzy comparison matrix $\tilde{A}$ representing the fuzzy relative importance of each criterion compared with the others is defined by the equations below [8].

$$\tilde{A} = \begin{bmatrix} 1 & \tilde{r}_{12} & \dots & \tilde{r}_{1n} \\ \tilde{r}_{21} & 1 & \dots & \tilde{r}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{r}_{n1} & \tilde{r}_{n2} & \dots & 1 \end{bmatrix} = \begin{bmatrix} 1 & \tilde{r}_{12} & \dots & \tilde{r}_{1n} \\ 1/\tilde{r}_{12} & 1 & \dots & \tilde{r}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/\tilde{r}_{1n} & 1/\tilde{r}_{2n} & \dots & 1 \end{bmatrix} \quad (15)$$

$$1/\tilde{r}_{12} = (l, m, u)^{-1} = \left(\frac{1}{u}, \frac{1}{m}, \frac{1}{l} \right) \quad (16)$$

The geometric mean method is utilized to get the fuzzy geometric mean $\tilde{r}_i$ with equation 17 given below.

$$\tilde{r}_i = (\tilde{r}_{i1} \times \tilde{r}_{i2} \times \dots \times \tilde{r}_{in})^{\frac{1}{n}} \quad (17)$$

The fuzzy weight $\tilde{w}_i$ of each criterion is calculated with equation 18 given below.

$$\tilde{w}_i = \tilde{r}_i \times (\tilde{r}_1 + \tilde{r}_2 + \dots + \tilde{r}_n)^{-1} \quad (18)$$

To defuzzify the weights, we utilized the centre of area method with the equation below.

$$w_i = \frac{(l + m + u)}{3}$$

(19)

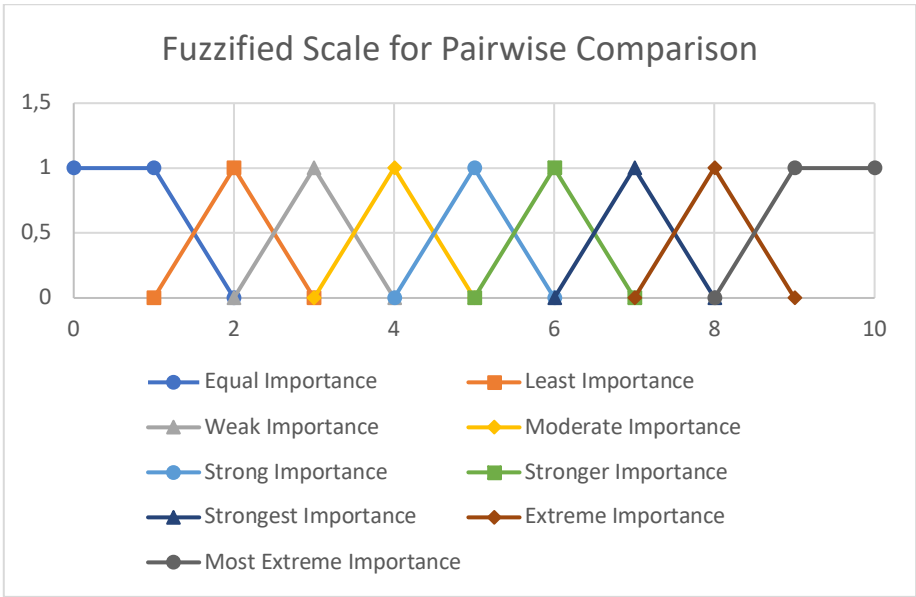


Figure 3. Membership functions for linguistic values

Implementing the F-AHP to find out the weight of each risk compared with the others, we obtained the results as shown in Table 3. We can notice that R4 “Away from clash lines/frontlines between the conflicting groups” occupied the first place, followed by R1 “Close to areas that reported child labour incidents” and then, in third place, R5 “Away from areas that encountered interference of armed groups in the educational process”.

Table 3. Fuzzy and normalized weight obtained from F-AHP

Risk No.	Fuzzy weights $\widetilde{w}_i$	Weights w_i	Normalized weight	Ranking of risk/criterion
R1	(0.131,0.247,0.46)	0.279	0.247	2
R2	(0.048,0.093,0.182)	0.107	0.095	4
R3	(0.037,0.059,0.118)	0.071	0.063	5
R4	(0.218,0.39,0.659)	0.422	0.374	1
R5	(0.081,0.156,0.302)	0.179	0.159	3
R6	(0.033,0.059,0.118)	0.069	0.062	6
Sum		1.127		

4.1.2. Creating Risks maps

An overview of the displaced and dropped-out children in Idleb/Syria can be obtained as shown in Figure 4. Green icons depict IDPs where the demand nodes are distributed in different random camps throughout the 26 sub-districts in Idleb-Syria and vary from 20 children in some small camps to 997 children in the biggest camp.

The density of displaced drop-out children is represented with blue shading, in which the darker the colour the higher the density. When we extract the total numbers of drop-out children in each sub-district to demonstrate how many children each district contains, we can see that only one district doesn't include drop-out children living in random camps, whereas in other districts we find from 1,505 to 13,687 children.

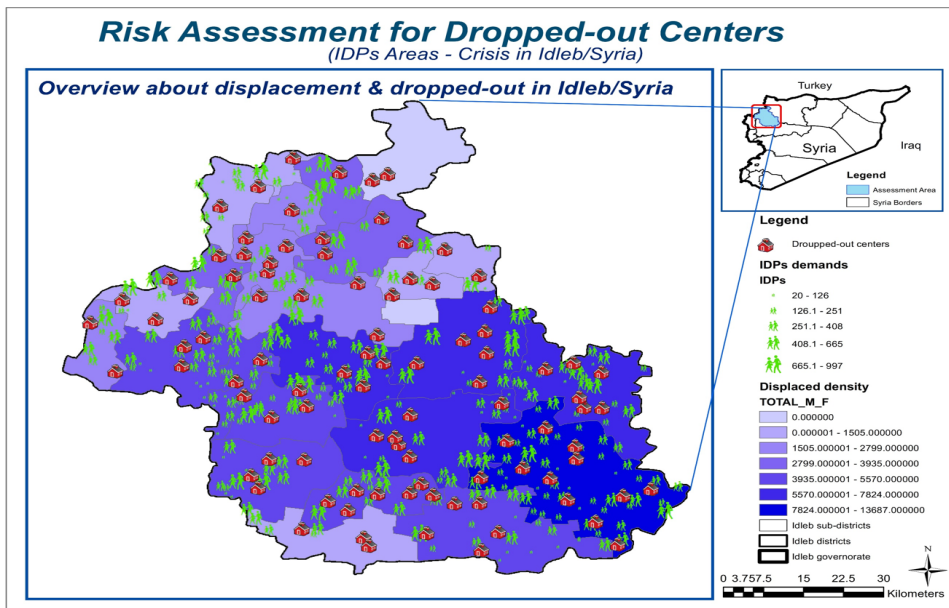


Figure 4. Overview of displacement and dropped-out children in Idleb/Syria

In Figure 5, we show risk areas that reported child labour incidents as various colours on the map. Risks are classified based on the number of incident reports issued in each area. For example, the red regions demonstrate a higher numbers of child labour incident reports, while the light blue shows a lower number of incident reports. In our model, we tried to select facilities in the red coloured areas, inasmuch as this was possible, in order to increase awareness and to improve educational opportunities in those regions.

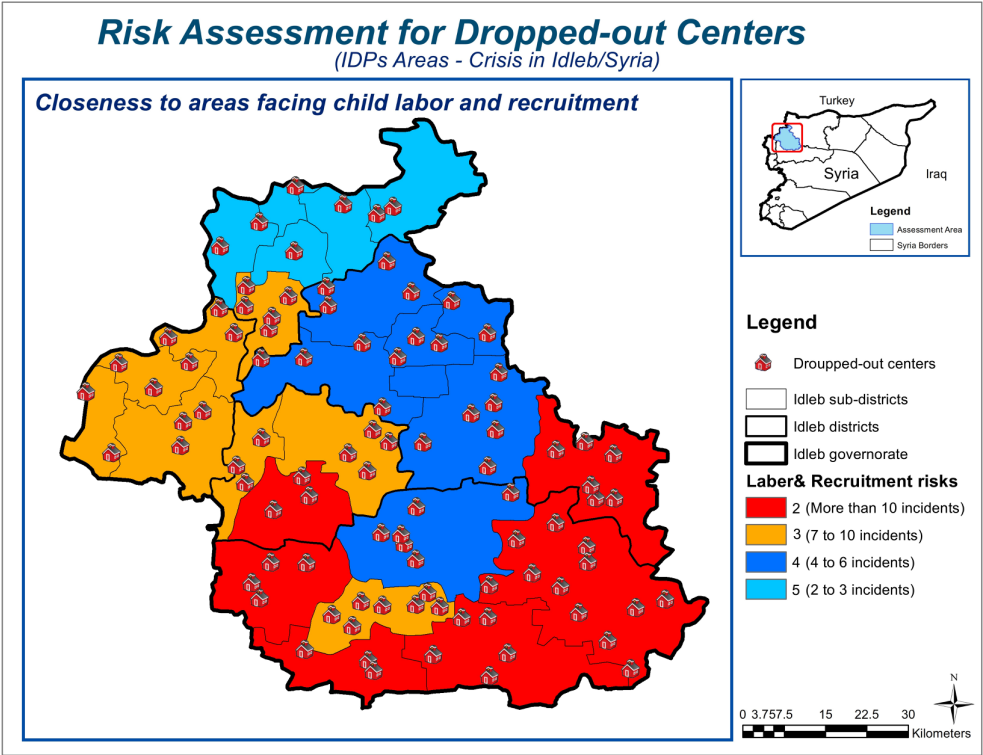


Figure 5. Proximity to areas that reported child labour incidents

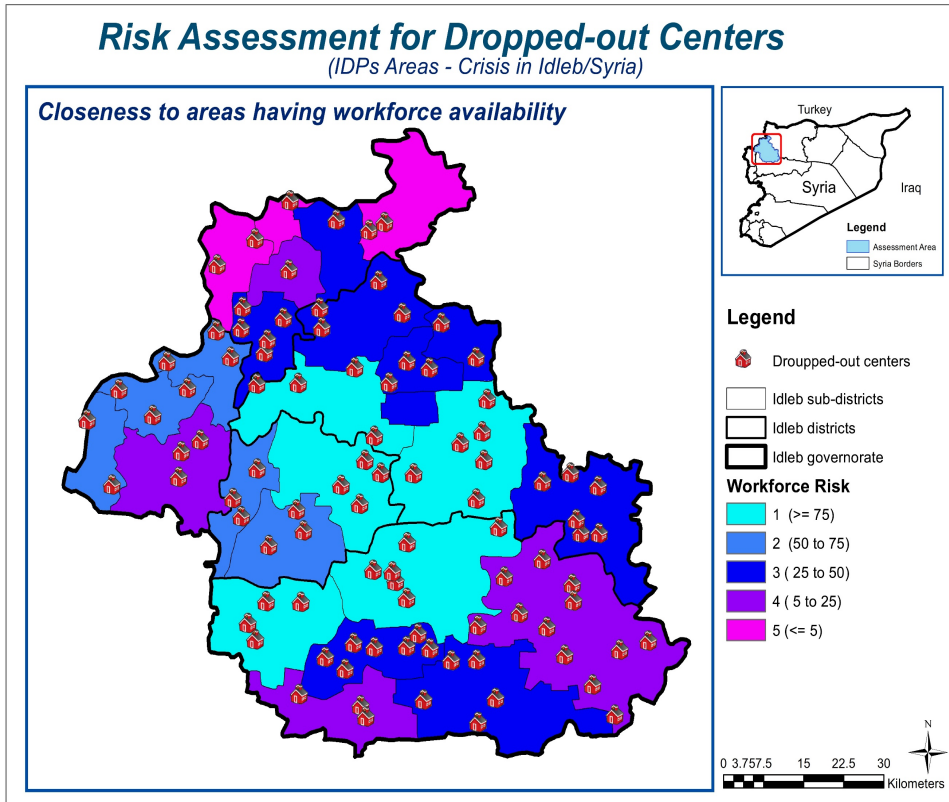


Figure 6. Proximity to areas that have educational workforce

Figure 6 depicts the proximity to areas having a larger education workforce. The workforce risks are classified into five groups, each shown in a different colour shade. The larger the workforce an area has, the lower its risk value. It is notable that some regions have fewer than 5 dedicated educational staff, whereas others have more than 75. In our model, we aim to select facilities in areas that have a higher number of educational staff so that they can improve the efficiency of the educational process.

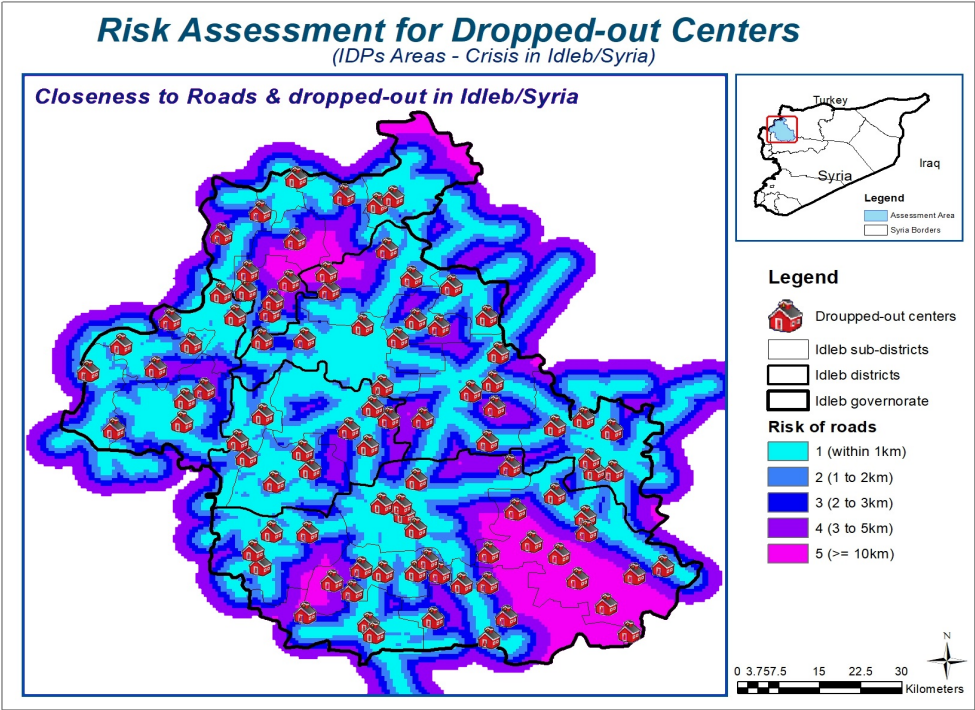


Figure 7. Proximity to main roads

In Figure 7, we present the closeness to main roads for better accessibility. Some centres are located within 1 km from the main roads, while others are located 10 km away from the main roads. The further the centre is from a main road, the greater its risk value. In our model, we try to select facilities in areas that are closer to the main roads in order to increase and facilitate the access of children and supplies.

Figure 8 depicts the distance from clash lines/frontlines between the combatant groups in the area. Frontline risks are represented with five different categories. Some centres are located within 1 km of the frontlines, while others are located 10 km away from the frontlines. The closer the centre is from a clash line, the greater its risk value. In our model, we aim to select facilities in areas that are far away from frontlines in order to save the lives of both children and educational staff, and to protect the facility itself.

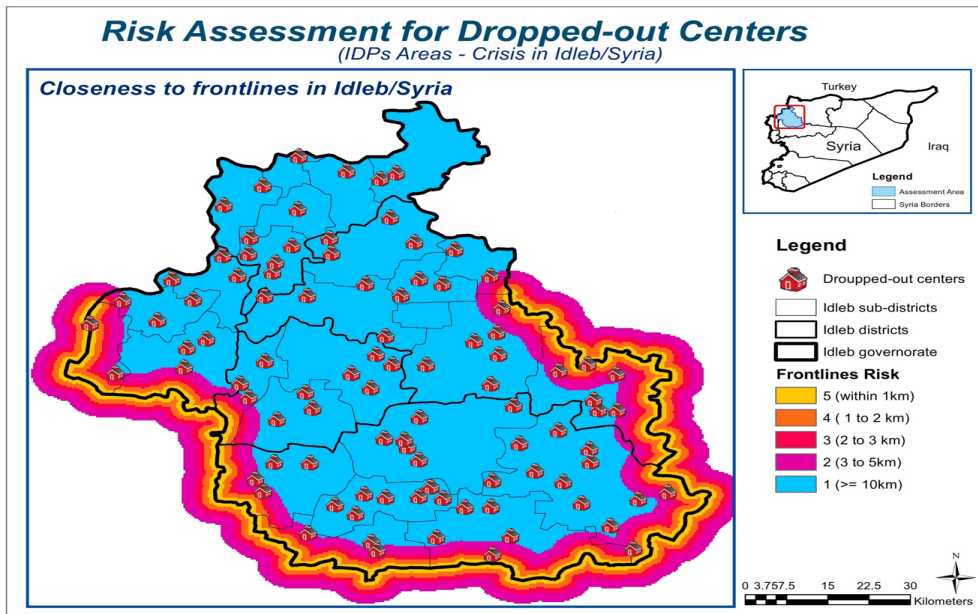


Figure 8. Distance from clash lines/frontlines between the conflicting groups

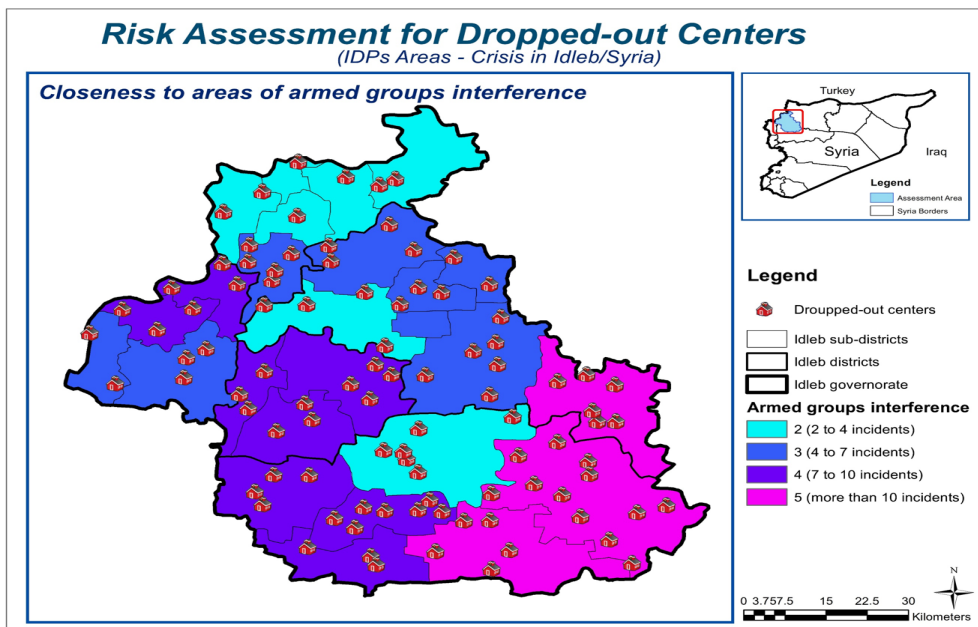


Figure 9. Distance from areas that encountered interference of armed groups in the education process

Figure 9 shows the proximity to areas which have witnessed the interference of armed groups in the educational process, clustered into groups according to the number of incidents which have been reported in each area. The higher the amount of incident reports an area has, the higher its risk value. In our model, we aim to select facilities in areas that have a lower number of incident reports so that the educational staff can improve the outcomes without any negative interference.

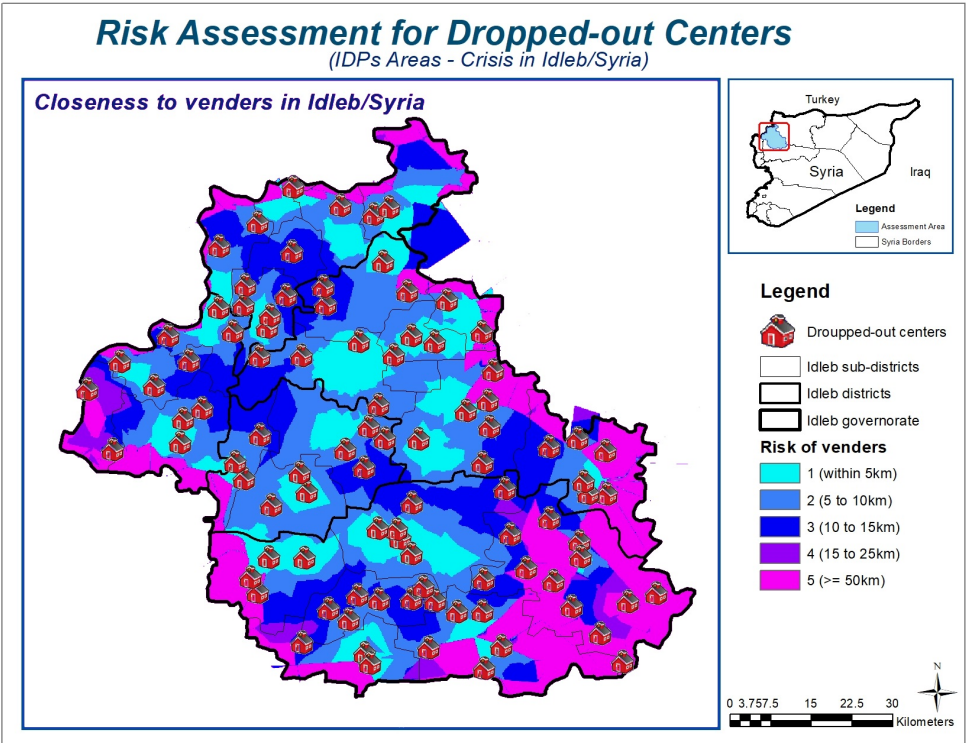


Figure 10. Proximity to materials suppliers/providers

Figure 10 presents the proximity to materials suppliers/providers, depicted as five groups according to the distance between candidate facilities and vendors. The further the centre is from vendors, the higher the risk. In our model, we strive to select facilities in areas that are closer to the vendors and materials, in order to provide the facilities with all the materials and supplies that they need to improve the educational process.

4.2 Findings and discussion

We applied the proposed methodology, starting from the first stage to find the risk value of each candidate facility by considering the risk weight in each criterion utilizing the F-AHP and risk maps according to each criterion. Then we utilized equation (1) to obtain the final risk value/map in each region. In the final map, all the risk maps are merged and

overlapped into a final risk map, as shown in Figure 11. In this map we can visualized the following results:

- Each region is coloured according to its total risk value from 1.47 (lowest risk regions) to 3.91 (highest risk regions)
- As the candidate educational centres are in the final risk map, we extracted the shelter coordinates on the final map to acquire the risk value for each shelter: these vary from 1.47 (lowest risk value) to 3.54 (highest risk value).
- The more criteria we include the more varied values we obtain. This results in higher variance between the risk values of candidate facilities, which facilitates the selection process for the decision makers.
- The high-risk areas congregate in the southern regions, because the highest risk weights are located there, which are "R4; proximity to areas of frontlines" and "R1; presenting in areas where armed groups interfere in the educational process". The central regions are less dangerous since they have a lower value of R1 and R4 relatively.

After calculating the risk value for each facility, we embedded this value into the goal programming based mathematical model, as described in the second stage, and solved the model using the software package, where all the five goals are included in this model to find out the optimum solution for the whole problem.

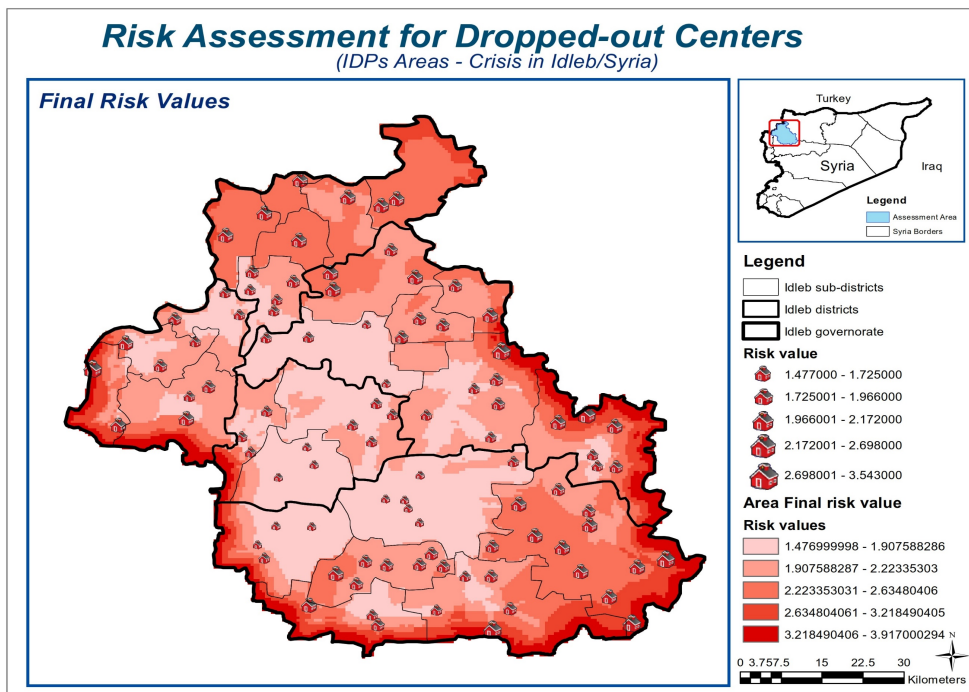


Figure 11. Final risk map after merging all risk maps

The results obtained from solving the whole model showed the optimum achieved value in each goal. We show the goals in Table 4 to compare each of them in terms of target values (target values are identified by three dedicated experts taking into account previous similar projects in the target area). Figure 12 shows the achieved outputs for each objective as a percentage compared to the horizontal 100% target line.

For instance, we aimed to reach 150 overall in the sum of risk values and we achieved 149.14 (99.43%); this was a satisfactory result, since we were striving to minimize this goal. We aimed to keep the budget for this project within \$500,000 as the total cost goal, but we exceeded this amount by approximately 29%, with a final total cost of \$649,650. Our target for distance to educational centre was 15 km maximum, and after running the model we achieved approximately the same value: 15.14 km. We aimed to have 50 facilities with basements and 55 with a water source; in the results, we had 41 and 51, respectively.

As a result, we can conclude that we approximately achieved values that were around the desired values identified by experts, except in the total cost objective. When we investigated this discrepancy further, we discovered that the experts predicted a relatively low target value for the total cost in this model. This has been shown to us by solving the model with a single objective function which is the total cost without putting any of the other objective functions. The results that we obtained in this case, a total cost of \$596,914 and when we compare this value with the value that we already achieved when placing all the goals together, which is \$ 649,650, we recognize that we have exceed the optimal value by only 8.8%.

Table 4. Planned and obtained results according to each goal

	Main goals				
	Total Sum of Risk values	Total Cost	Max Distance to centres	# Centres with Basement	# Centres with Water source
Goal Type	MIN	MIN	MIN	MAX	MAX
Planned value	150.00	500,000	15.00	50.00	55.00
Obtained Results	149.15	649,650	15.14	41.00	54.00
As Percentage (%)	99.43%	129.93%	100.95%	82.00%	98.18%

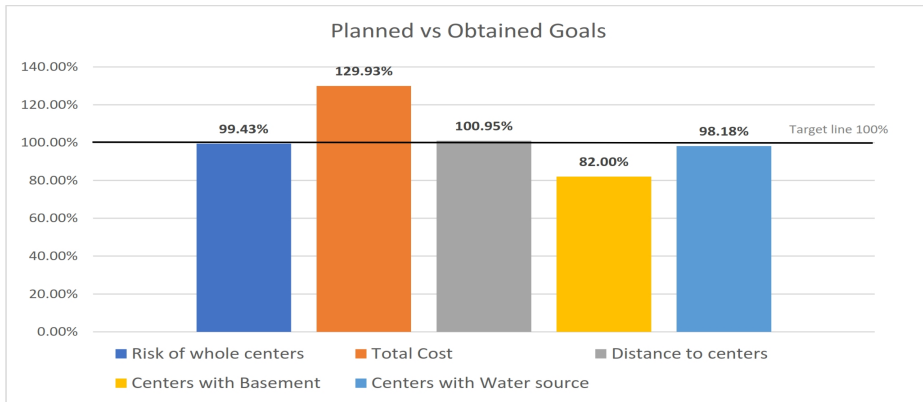


Figure 12. Obtained goals as a percentage of the planned goals

Figure 13 depicts the chosen educational centres as a result of applying the suggested methodology, where 71 centres were chosen out of 95. The maximum distance between demand nodes and facility allocated to is 15.14 km and all demand nodes are allocated once to a chosen educational centre.

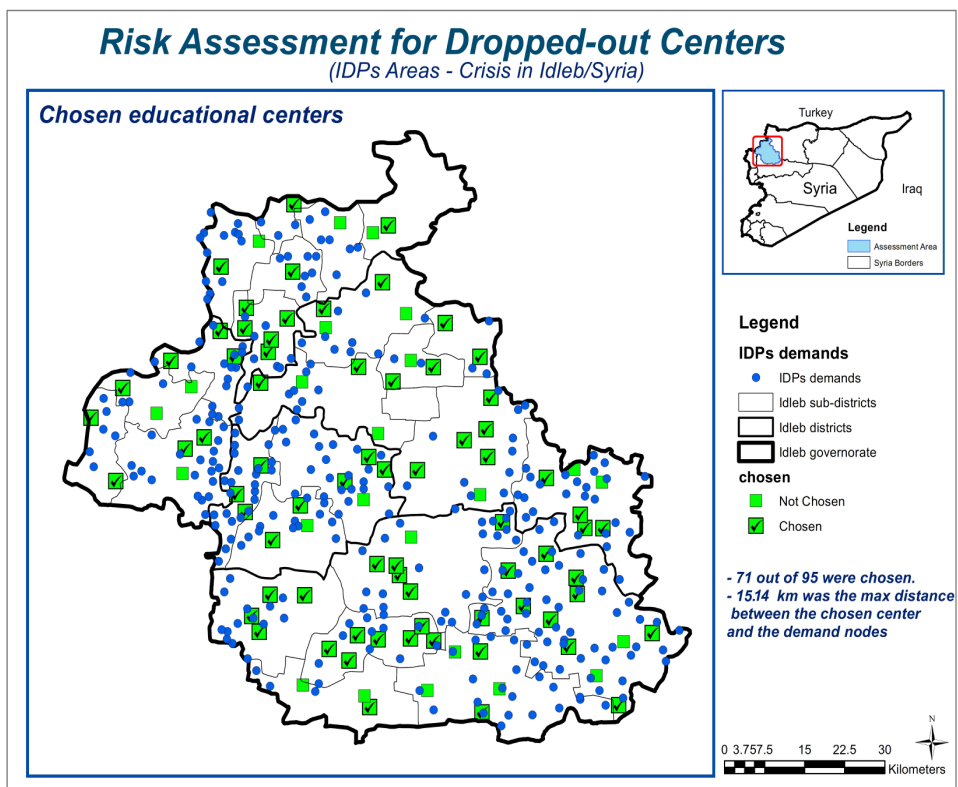


Figure 13. Chosen centres according to the applied methodology

In Appendix 1, we present the chosen educational centres, types and numbers of vehicles selected, and capacities compared with the amount of demand nodes. We can verify from this appendix that all demand nodes are allocated to a chosen facility and that the selected vehicle capacity is equal to or higher than the number of children located in each node, as shown in Figure 14. In terms of selecting the vehicle type and number, Figure 15 presents how the model reacts to deal with increased demand. When the demand is low, the model select the smaller vehicle, which is enough to cover the demand and have a lower cost. As much as the demand increased the model select a bigger vehicle to cover the demand. In the higher demand, starting from node 95, we find that the model relies on large vehicles, which is reasonable since it leads to lower total cost, while using either a medium or small vehicle to compensate for the deficiency to meet the real demand for each node. that's mean the proposed methodology is validated and verified since it addresses the changes of inputs to find optimum solution in each case.

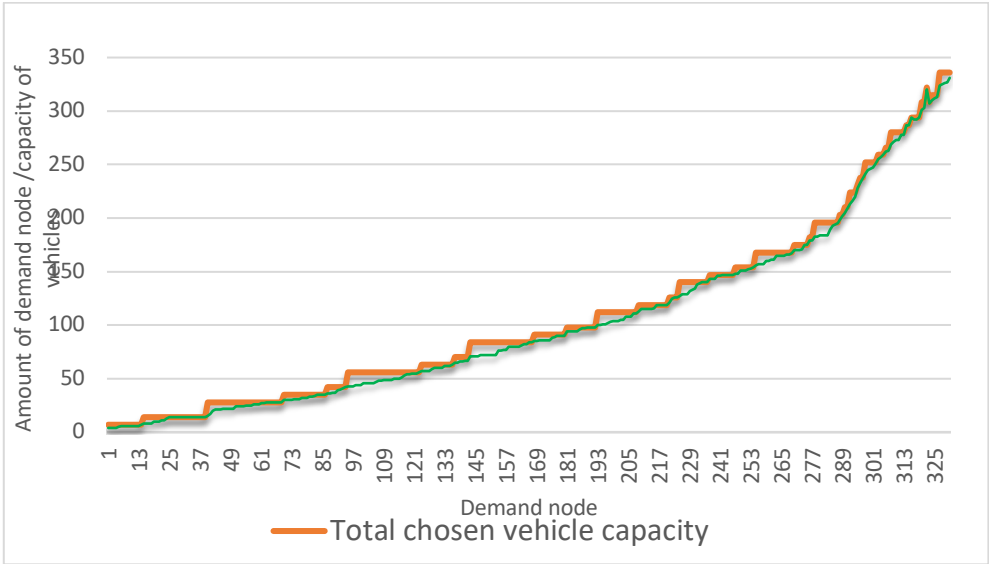


Figure 14. Comparison between capacity of chosen vehicle and actual demand

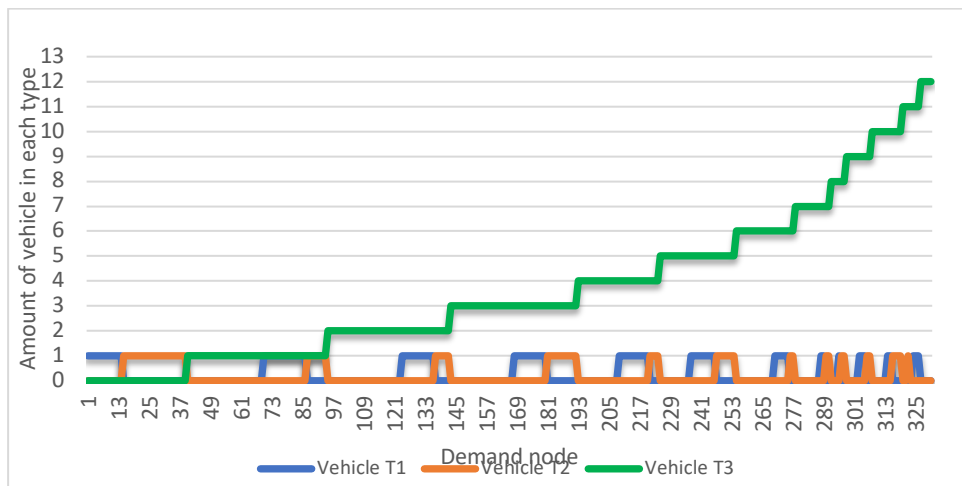


Figure 15. Amount of each vehicle type according to increasing of demand

5. Conclusions

In this paper, we have presented a methodology consisting of two stages: a risk assessment approach using GIS and F-AHP to determine the risk value of each candidate educational centre in the conflict area to be considered in finding the most appropriate educational centre, where the lower the risk, the higher the possibility it has to be selected; and a location-allocation approach with vehicle selection utilizing a mathematical model to allocate all demands to the most appropriate, safest and closest centres.

The main contribution of this study is threefold. First, we suggest a practical framework approach to be utilized by decision makers in humanitarian contexts. It allows them to analyse the multi-criteria optimization by integrating GIS, F-AHP and a mathematical model in a two-stage approach, consisting of a risk assessment approach and mathematical modelling approach, using real data and a case study in a humanitarian context for the allocation of dropped-out children communities. Secondly, the model shows the feasibility of the application and integration of geographic information systems with decision support systems to resolve problems in conflict zones. Thirdly, the model can be generalized to be applied in other conflict areas around the world by customizing and changing some inputs relevant to other contexts.

The novelty of this paper comes from the practical framework approach, in which we integrated GIS and F-AHP for the risk assessment approach and a mathematical model for the location-allocation problem giving priority to the humanitarian goals of alleviating the suffering that children face in the conflict areas, improving the educational process there, and utilizing donations effectively without wasting them, by making decisions based on personal experiences and expert opinions. This study can produce effective and efficient solutions to facilitate decision-making in conflict areas and maximize the benefits for the affected beneficiaries.

This study has limitations in that the study area was limited to Idleb governorate/Syria, and the risk assessment didn't evaluate other risks, such as the needs of disabled drop-out children, or the availability of electricity and heating sources. Moreover, the mathematical

model was not dynamic location-allocation multi-objective model. To address these shortcomings, future studies could proceed according to the following suggestions:

- ✓ Other regions of Syria could be added to expand the study and make it more comprehensive.
- ✓ Expanding the transportation model by including the synchronizing of routing, to be identified by updating the risk map continuously and simultaneously.
- ✓ In addition to the considered factors, other criteria (e.g., electricity, heating sources, internet, etc.) could be included to take into account additional elements and aspects of the educational process.
- ✓ A more comprehensive study can be conducted to include selection of other types of facilities, such as shelter facilities and health facilities, and thus to maximize the benefits for all affected people.
- ✓ A more dynamic model could be developed to take into account the uncertainty and constantly evolving situation in areas affected by conflict and crisis.

Conflict of Interest

The authors do not have any conflicts of interest.

References

- [1] Aburas, R., Najeeb, A., Baageel, L., Mackey, T. K. The Syrian conflict: a case study of the challenges and acute need for medical humanitarian operations for women and children internally displaced persons. *BMC Medicine*, **16**(1): 65, 2018.
- [2] Al Garni, H. Z., Awasthi, A. Solar PV power plant site selection using a GIS-AHP based approach with application in Saudi Arabia. *Applied Energy*, **206**, 2017, 1225-1240.
- [3] Al-Sabbagh, T. A. GIS location-allocation models in improving accessibility to primary schools in Mansura city-Egypt. *GeoJournal*, 2020, 1-18.
- [4] Alkaradaghi, K., Ali, S. S., Al-Ansari, N., Laue, J., Chabuk, A. Landfill site selection using MCDM methods and GIS in the Sulaimaniyah governorate, Iraq. *Sustainability*, **11**(17): 4530, 2019.
- [5] Asakereh, A., Omid, M., Alimardani, R., Sarmadian, F. Developing a GIS-based fuzzy AHP model for selecting solar energy sites in Shodirwan region in Iran. *International Journal of Advanced Science and Technology*, **68**, 2014, 37-48.
- [6] Aydi, A., Zairi, M., Dhia H.B. Minimization of environmental risk of landfill site using fuzzy logic, analytical hierarchy process, and weighted linear combination methodology in a geographic information system environment. *Environmental Earth Sciences*, **68**(5): 2013,1375–1389
- [7] Baykasoglu, A., Durmusoglu, Z. D. A hybrid MCDM for private primary school assessment using DEMATEL based on ANP and fuzzy cognitive map. *International Journal of Computational Intelligence Systems*, **7**(4): 2014, 615-635.
- [8] Buckley, J. J. Ranking alternatives using fuzzy numbers. *Fuzzy Sets and Systems* **15**(1): 1985, 21-31.

-
- [9] Denekos, S. N., Koutsoukis, N. S., Fakiolas, E. T., Konstantopoulos, I., & Rachaniotis, N. P. Siting refugee camps in mainland Greece using geographic information systems-based multi-criteria decision-making. *Journal of Humanitarian Logistics and Supply Chain Management*, 2021.
- [10] Erdin, C., Akbaş, H. E. A comparative analysis of fuzzy topsis and geographic information systems (GIS) for the location selection of shopping malls: A case study from Turkey. *Sustainability* **11**(14): 2019, 3837.
- [11] Gul, M., Guneri, A. F. Hospital Location Selection: A Systematic Literature Review on Methodologies and Applications. *Mathematical Problems in Engineering*, 2021.
- [12] Ibrahim, E. H., Mohamed, S. E., Atwan, A. A. Combining fuzzy analytic hierarchy process and GIS to select the best location for a wastewater lift station in El-Mahalla El-Kubra, North Egypt. *International Journal of Engineering & Technology* **11**(5): 2011, 44-50.
- [13] Junian, J., Azizifar, V. The evaluation of temporary shelter areas locations using geographic information system and analytic hierarchy process. *Civil Engineering Journal*, **4**(7), 2018,1678-1688.
- [14] Kabak, M., Erbaş, M., Çetinkaya, C., Özceylan, E. A GIS-based MCDM approach for the evaluation of bike-share stations. *Journal of Cleaner Production* **201**, 2018, 49-60.
- [15] Lin, M., Huang, C., Xu, Z. MULTIMOORA based MCDM model for site selection of car sharing station under picture fuzzy environment. *Sustainable Cities and Society* **53**, 2020, 101873.
- [16] Messaoudi, D., Setrou, N., Negrou, B., Setrou, B. GIS based multi-criteria decision making for solar hydrogen production sites selection in Algeria. *International Journal of Hydrogen Energy*, **44**(60), 2019, 31808-31831.
- [17] Pourahmad, A., Hosseini, A., Banaitis, A., Nasiri, H., Banaitienė, N., Tzeng, G. H. Combination of fuzzy-AHP and DEMATEL-ANP with GIS in a new hybrid MCDM model used for the selection of the best space for leisure in a blighted urban site. *Technological and Economic Development of Economy*, **21**(5): 2015,773-796.
- [18] Rahman, M., Chen, N., Islam, M. M., Dewan, A., Pourghasemi, H. R., Washakh, R. M. A., Ahmed, N. Location-allocation modeling for emergency evacuation planning with GIS and remote sensing: A case study of Northeast Bangladesh. *Geoscience Frontiers*, **12**(3), 2021, 101095.
- [19] Rezaur Rahman, N. S. M., Chowdhury, M. A. A., Firoze, A., Rahman, R. M. Fusion of BWM and AHP MCDM Methods to Choose the Most Suitable Secondary School for an Individual in the Context of Bangladesh. *Vietnam Journal of Computer Science*, 2019, 1-18.
- [20] Roh, S. Y., Jang, H. M., Han, C. H. Warehouse location decision factors in humanitarian relief logistics. *The Asian Journal of Shipping and Logistics*, **29**(1), 2013,103-120.
- [21] Saaty, L. T. 1990. How to make decision. The analytic hierarchy process. *European Journal of Operational Research* **48**,1990, 9-26.

- [22] Timperio, G., Panchal, G. B., Samvedi, A., Goh, M., De Souza, R. Decision support framework for location selection and disaster relief network design. *Journal of Humanitarian Logistics and Supply Chain Management*, 2017.
- [23] Tsaor, S. H., Chiu, Y. C., & Huang, C. H. Determinants of guest loyalty to international tourist hotels- a neural network approach. *Tourism Management*, **23**(4): 2002, 397-405.
- [24] Uslu, A., Kiziloglu, K., Isleyen, S. K., Kahya, E. Geographic Information System-Based AHP-TOPSIS Approach for School Site Selection: A Case Study for Ankara, *Politeknik Dergisi*, **20**(4): 2017, 933-943.
- [25] The United Nations (UN) Report. 2019. Humanitarian needs overview.

Received 28.12.2020, Accepted 09.09.2021

Appendix 1 Location Allocation Between Demand Nodes, Vehicle and Facility

VT1: Vehicle Type1.

VT2: Vehicle Type2.

VT3: Vehicle Type3.

TVC: Total chosen vehicle capacity.

TAD: Total actual demand.

DAT: Demand Allocated to.

Ca: Vehicle Capacity.

Co: vehicle Cost.

	VT1	VT2	VT3	TVC	TAD	DAT		VT1	VT2	VT#	TVC	TAD	DAT
Ca	7	14	28				Ca	7	14	28			
Co	4	6	8				Co	4	6	8			
d1	1			7	4	Ed83	d167			3	84	84	Ed45
d2	1			7	4	Ed89	d168	1		3	91	85	Ed64
d3	1			7	4	Ed76	d169	1		3	91	85	Ed34
d4	1			7	4	Ed75	d170	1		3	91	86	Ed86
d5	1			7	5	Ed47	d171	1		3	91	86	Ed4
d6	1			7	6	Ed77	d172	1		3	91	86	Ed67
d7	1			7	6	Ed34	d173	1		3	91	86	Ed34
d8	1			7	6	Ed33	d174	1		3	91	86	Ed67
d9	1			7	6	Ed40	d175	1		3	91	88	Ed89
d10	1			7	6	Ed53	d176	1		3	91	89	Ed2
d11	1			7	6	Ed17	d177	1		3	91	90	Ed12
d12	1			7	6	Ed17	d178	1		3	91	90	Ed48
d13	1			7	6	Ed40	d179	1		3	91	90	Ed85
d14	1			7	7	Ed62	d180	1		3	91	90	Ed28
d15		1		14	8	Ed75	d181		1	3	98	94	Ed8
d16		1		14	8	Ed16	d182		1	3	98	94	Ed26
d17		1		14	8	Ed5	d183		1	3	98	94	Ed89
d18		1		14	8	Ed34	d184		1	3	98	94	Ed37
d19		1		14	10	Ed54	d185		1	3	98	94	Ed84
d20		1		14	10	Ed39	d186		1	3	98	96	Ed72
d21		1		14	10	Ed49	d187		1	3	98	97	Ed95
d22		1		14	11	Ed91	d188		1	3	98	97	Ed84
d23		1		14	11	Ed43	d189		1	3	98	98	Ed76

d24		1		14	13	Ed40	d190		1	3	98	98	Ed54
d25		1		14	14	Ed84	d191		1	3	98	98	Ed16
d26		1		14	14	Ed2	d192		1	3	98	98	Ed89
d27		1		14	14	Ed39	d193			4	112	100	Ed11
d28		1		14	14	Ed39	d194			4	112	100	Ed35
d29		1		14	14	Ed39	d195			4	112	101	Ed6
d30		1		14	14	Ed41	d196			4	112	101	Ed18
d31		1		14	14	Ed74	d197			4	112	102	Ed53
d32		1		14	14	Ed39	d198			4	112	103	Ed54
d33		1		14	14	Ed56	d199			4	112	104	Ed84
d34		1		14	14	Ed28	d200			4	112	104	Ed77
d35		1		14	14	Ed79	d201			4	112	104	Ed62
d36		1		14	14	Ed5	d202			4	112	105	Ed10
d37		1		14	14	Ed28	d203			4	112	105	Ed66
d38		1		14	14	Ed40	d204			4	112	108	Ed21
d39		1		14	14	Ed85	d205			4	112	108	Ed12
d40			1	28	15	Ed28	d206			4	112	108	Ed85
d41			1	28	17	Ed53	d207			4	112	111	Ed10
d42			1	28	20	Ed39	d208			4	112	111	Ed28
d43			1	28	21	Ed95	d209	1		4	119	113	Ed57
d44			1	28	21	Ed17	d210	1		4	119	115	Ed22
d45			1	28	21	Ed17	d211	1		4	119	115	Ed66
d46			1	28	22	Ed4	d212	1		4	119	115	Ed64
d47			1	28	22	Ed35	d213	1		4	119	115	Ed89
d48			1	28	22	Ed84	d214	1		4	119	115	Ed79
d49			1	28	22	Ed28	d215	1		4	119	116	Ed33
d50			1	28	22	Ed33	d216	1		4	119	119	Ed6
d51			1	28	24	Ed69	d217	1		4	119	119	Ed83
d52			1	28	24	Ed23	d218	1		4	119	119	Ed59
d53			1	28	24	Ed3	d219	1		4	119	119	Ed69
d54			1	28	24	Ed84	d220	1		4	119	119	Ed36
d55			1	28	25	Ed19	d221		1	4	126	121	Ed1
d56			1	28	25	Ed48	d222		1	4	126	125	Ed34
d57			1	28	25	Ed83	d223		1	4	126	126	Ed47
d58			1	28	26	Ed2	d224		1	4	126	126	Ed83
d59			1	28	26	Ed28	d225			5	140	127	Ed49

d60			1	28	26	Ed78	d226			5	140	129	Ed34
d61			1	28	27	Ed2	d227			5	140	129	Ed29
d62			1	28	27	Ed80	d228			5	140	129	Ed60
d63			1	28	28	Ed4	d229			5	140	132	Ed55
d64			1	28	28	Ed11	d230			5	140	133	Ed83
d65			1	28	28	Ed69	d231			5	140	134	Ed16
d66			1	28	28	Ed88	d232			5	140	138	Ed48
d67			1	28	28	Ed46	d233			5	140	139	Ed5
d68			1	28	28	Ed2	d234			5	140	140	Ed8
d69			1	28	28	Ed33	d235			5	140	140	Ed19
d70	1		1	35	30	Ed4	d236			5	140	140	Ed28
d71	1		1	35	30	Ed88	d237	1		5	147	143	Ed43
d72	1		1	35	30	Ed6	d238	1		5	147	143	Ed19
d73	1		1	35	30	Ed39	d239	1		5	147	143	Ed80
d74	1		1	35	31	Ed78	d240	1		5	147	146	Ed77
d75	1		1	35	31	Ed49	d241	1		5	147	146	Ed75
d76	1		1	35	31	Ed95	d242	1		5	147	147	Ed75
d77	1		1	35	32	Ed72	d243	1		5	147	147	Ed19
d78	1		1	35	32	Ed35	d244	1		5	147	147	Ed41
d79	1		1	35	32	Ed47	d245	1		5	147	147	Ed39
d80	1		1	35	33	Ed19	d246	1		5	147	147	Ed16
d81	1		1	35	33	Ed95	d247		1	5	154	148	Ed74
d82	1		1	35	34	Ed4	d248		1	5	154	148	Ed17
d83	1		1	35	35	Ed42	d249		1	5	154	151	Ed36
d84	1		1	35	35	Ed39	d250		1	5	154	151	Ed78
d85	1		1	35	35	Ed95	d251		1	5	154	151	Ed23
d86	1		1	35	35	Ed85	d252		1	5	154	152	Ed88
d87		1	1	42	36	Ed54	d253		1	5	154	153	Ed56
d88		1	1	42	36	Ed2	d254		1	5	154	154	Ed54
d89		1	1	42	37	Ed11	d255			6	168	156	Ed49
d90		1	1	42	37	Ed17	d256			6	168	157	Ed72
d91		1	1	42	39	Ed30	d257			6	168	157	Ed42
d92		1	1	42	40	Ed41	d258			6	168	157	Ed29
d93		1	1	42	41	Ed49	d259			6	168	160	Ed74
d94		1	1	42	42	Ed60	d260			6	168	160	Ed36
d95			2	56	43	Ed86	d261			6	168	161	Ed12

d96			2	56	43	Ed2	d262			6	168	161	Ed20
d97			2	56	43	Ed16	d263			6	168	165	Ed40
d98			2	56	44	Ed2	d264			6	168	165	Ed66
d99			2	56	44	Ed78	d265			6	168	165	Ed11
d100			2	56	44	Ed1	d266			6	168	165	Ed17
d101			2	56	46	Ed86	d267			6	168	166	Ed6
d102			2	56	46	Ed72	d268			6	168	166	Ed11
d103			2	56	46	Ed2	d269			6	168	167	Ed31
d104			2	56	46	Ed53	d270	1		6	175	170	Ed78
d105			2	56	46	Ed86	d271	1		6	175	170	Ed29
d106			2	56	47	Ed2	d272	1		6	175	170	Ed52
d107			2	56	48	Ed49	d273	1		6	175	171	Ed63
d108			2	56	48	Ed45	d274	1		6	175	175	Ed76
d109			2	56	49	Ed2	d275	1		6	175	175	Ed74
d110			2	56	49	Ed3	d276		1	6	182	179	Ed48
d111			2	56	49	Ed28	d277		1	6	182	179	Ed8
d112			2	56	49	Ed33	d278			7	196	183	Ed18
d113			2	56	50	Ed2	d279			7	196	183	Ed87
d114			2	56	50	Ed79	d280			7	196	184	Ed39
d115			2	56	50	Ed45	d281			7	196	184	Ed75
d116			2	56	51	Ed46	d282			7	196	184	Ed52
d117			2	56	53	Ed57	d283			7	196	184	Ed22
d118			2	56	54	Ed79	d284			7	196	189	Ed86
d119			2	56	54	Ed12	d285			7	196	193	Ed18
d120			2	56	55	Ed34	d286			7	196	194	Ed30
d121			2	56	55	Ed40	d287			7	196	195	Ed22
d122			2	56	55	Ed3	d288	1		7	203	198	Ed24
d123			2	56	56	Ed4	d289	1		7	203	202	Ed33
d124	1		2	63	57	Ed86	d290		1	7	210	205	Ed24
d125	1		2	63	57	Ed59	d291		1	7	210	209	Ed76
d126	1		2	63	57	Ed4	d292			8	224	213	Ed69
d127	1		2	63	57	Ed35	d293			8	224	216	Ed10
d128	1		2	63	59	Ed4	d294			8	224	220	Ed93
d129	1		2	63	60	Ed10	d295	1		8	231	228	Ed21
d130	1		2	63	60	Ed52	d296		1	8	238	233	Ed40
d131	1		2	63	60	Ed17	d297		1	8	238	237	Ed77

d132	1		2	63	60	Ed33	d298			9	252	241	Ed62
d133	1		2	63	62	Ed4	d299			9	252	245	Ed85
d134	1		2	63	62	Ed5	d300			9	252	246	Ed59
d135	1		2	63	62	Ed62	d301			9	252	247	Ed60
d136	1		2	63	63	Ed16	d302			9	252	251	Ed30
d137		1	2	70	65	Ed4	d303	1		9	259	255	Ed47
d138		1	2	70	65	Ed48	d304	1		9	259	257	Ed93
d139		1	2	70	66	Ed12	d305	1		9	259	259	Ed79
d140		1	2	70	66	Ed84	d306		1	9	266	262	Ed5
d141		1	2	70	67	Ed78	d307		1	9	266	263	Ed37
d142		1	2	70	67	Ed36	d308			10	280	269	Ed80
d143			3	84	71	Ed37	d309			10	280	271	Ed88
d144			3	84	71	Ed37	d310			10	280	273	Ed91
d145			3	84	71	Ed8	d311			10	280	273	Ed95
d146			3	84	71	Ed83	d312			10	280	278	Ed3
d147			3	84	72	Ed84	d313			10	280	278	Ed87
d148			3	84	72	Ed24	d314	1		10	287	287	Ed35
d149			3	84	72	Ed26	d315	1		10	287	287	Ed41
d150			3	84	72	Ed49	d316		1	10	294	294	Ed23
d151			3	84	72	Ed91	d317		1	10	294	292	Ed64
d152			3	84	72	Ed21	d318		1	10	294	292	Ed42
d153			3	84	72	Ed59	d319		1	10	294	294	Ed56
d154			3	84	76	Ed66	d320			11	308	301	Ed20
d155			3	84	76	Ed54	d321			11	308	303	Ed45
d156			3	84	77	Ed3	d322		1	11	322	320	Ed67
d157			3	84	77	Ed21	d323			11	308	307	Ed57
d158			3	84	80	Ed52	d324	1		11	315	310	Ed43
d159			3	84	80	Ed60	d325	1		11	315	312	Ed31
d160			3	84	80	Ed72	d326	1		11	315	313	Ed63
d161			3	84	80	Ed47	d327			12	336	324	Ed53
d162			3	84	80	Ed89	d328			12	336	325	Ed55
d163			3	84	81	Ed6	d329			12	336	326	Ed1
d164			3	84	82	Ed62	d330			12	336	327	Ed26
d165			3	84	82	Ed72	d331			12	336	331	Ed46
d166			3	84	84	Ed46	Total	96	76	1,210	35,616	34,155	