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Fuzzy AHP for Determining the Optimal Location of Schools: The Case of Pastoral Communities

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ABSTRACT

Selecting optimal facility location is a challenging decision, as it is expensive to relocate the facilities once they are located. The aim of this paper is to find optimal location of schools in pastoral communities in Mille Woreda, Afar region, Ethiopia. In this study, Fuzzy AHP approach is used to prioritize the candidate locations with respect to environmental (vegetation & proximity to water source), social (distance between facility and demand points & exposure conflict), and geological (history of natural disaster & suitability of location) factors. For obtaining the comparison matrix of the criteria's and alternatives, questionnaire was designed and filled by the decision makers (academicians and officials from education bureau). From the candidate locations Alidewarto & Wekki were found to be optimal locations for locating new schools. This will help to ensure the education for all program of the government by providing a framework for locating schools in pastoral communities.

1. Introduction

Education is the foundation of a society which brings economic wealth, social prosperity and political stability. Therefore, it is the milestone of the nation's development. In Ethiopia, the education structure is composed of 3 years of pre-primary education, 8 years of primary education (1st cycle: grades 1-4, 2nd cycle: grade 5-8), 2 years of general secondary education (grade 9-10), 2 years of preparatory secondary education, and higher education (college or university) [7]. The government has continued to expand access to achieve universal primary education in line with the education for all goals. As a result of concerted efforts since 1996, the number of primary schools has risen from 11,000 to 32,048 and student's enrolment at this level has grown from less than 3 million to over 18 million. However, the fact that a large majority of the Ethiopian population lives in rural areas and in dispersed communities (pastoralist societies like Afar) poses specific problem for the education sector: spreading education and ensuring equitable access to education presents specific challenges in such a geographic context [9]. And, from

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observation it is found that there are schools which are built in rural areas to give service for pastoral communities who lives around the site. However, due improper site selection, these schools are not used totally or covered few demand points. Therefore, it is necessary to determine the optimal location of schools by taking into account different factors that affect the decision making process. This paper discusses school location problem in pastoral communities in Mille Woreda (Afar region, Ethiopia).

The mathematical science of facility location has attracted much research in discrete and continuous optimization over nearly four decades. Investigators have focused on both algorithms and formulation in the private sector (eg., industrial plants, banks, retail facilities, etc.) and the public sectors (eg., ambulances, clinics, etc.) [11]. Facility location problem locate a set of facilities (resources) to minimize the cost of satisfying some set of demands (of the customers) with respect to some set of constraints. High costs associated with property acquisition and facility construction make facility location or relocation projects long-term investment [4]. As pastoralist move from one place to another based on environmental factors, efficient location of schools need to be determined to maximize the usage of the facility by the community. This paper uses fuzzy AHP approach for selecting optimal school location by considering different factors.

2. Literature Review

The facility location problem (FLP) has been studied for one hundred years, but formally it is accepted by all scientists that Alfred Weber's book of 1909 is the essential origin of this theory [5]. Many authors studied FLP extensively in different context. Dasci and Laporte [3] presented an analysis of facility location and capacity acquisition problem under demand uncertainty. Zanjirani et al. [13] investigated the problem of locating a facility in continuous space when the weight of each existing facility is a known linear function of time and they also proposed an exact algorithm to solve the problem in a polynomial time. Kim et al. [8] developed integer programming and heuristic algorithm based on lagrangian relaxation for solving a public healthcare facility location problem. Gabor and Van Ommeren [6] proposed an approximation algorithm for a facility location problem with stochastic demands and inventories. Wichapa and Khokhajaikiat [12] proposed a new multi objective facility location problem model which combines fuzzy analytical hierarchy process (FAHP) and goal programming (GP) called FAHP-GP model to select new suitable locations for infectious waste disposal by considering both total cost and final priority weight objectives. Das et al. [2] proposed heuristic two heuristic approaches for solving solid transportation-p-facility location problem (ST-p-FLP). They concluded that Loc Alloc heuristic approach is appropriate to solve the ST-p-FLP program with small size. The approximate heuristic is more suitable for the ST-p-FLP of larger size, since it can generate optimal solution in less computational burden. Corberán et al. [1] introduced and analyzed the problem of locating capacitated facilities that may transfer commodity between them. In this setting, the capacities of the facilities are no longer exogenous but become part of the decision making process. Two mixed integer programming models were proposed for the problem, both when the transfer cost satisfy the triangular inequality and when this is not the case. Ortega, J. et al. adapted an integrated analytical hierarchy process and triangular fuzzy sets for analyzing the park-and-ride facility location problem. The hierarchical structure of the problem was established to evaluate a real-life problem Cuenca city, Ecuador. The outcomes highlighted "accessibility of public transport" as the most significant issue in the park-and-ride facility location problem [10].

3. Fuzzy Analytical Hierarchy Process

The definition of "fuzzy" emerged as a result of the complexity in decision making problems encountered in real life. This fuzziness is scientifically defined as uncertainty, and in situations where uncertainty is the case, the decision maker's preference is to make more general judgments rather than definite one. Therefore, in order to express the uncertainties in the methods used for decision making, "fuzzy logic" which is very similar to human thinking, is added to the methods. In classical approaches, there is a binary logic, which means something is either right or wrong. In fuzzy logic, on the other hand, there are many situations between wright and wrong. Many decision making and problem solving methods are very complex. The decision making models and the success of decision makers depend on uncertainty. Decision makers prefer to express their comparisons as a range rather than fixed values, due to the fuzzy nature of the process. Since the AHP method does not sufficiently consider humanitarian factors, an alternative method to this multi criteria decision making method was developed. In order to solve hierarchical fuzzy problems, the fuzzy AHP was designed.

In this paper, Triangular Fuzzy Numbers (TFNs) are used to evaluate priority weights with fuzzy arithmetic operations, which are shown in equations (1-5). Let $\tilde{A} = \{\tilde{a}_{ij}\}$ be the TFN judgment matrix containing all pairwise comparisons between each criterion i and each alternative j. $\tilde{A}$ can be defined by equation (1).

$$\tilde{A} = \begin{bmatrix} \tilde{a}_{11} & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & \tilde{a}_{22} & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{a}_{nn} \end{bmatrix}, i \in \{1,2,\cdots,n\}, j \in \{1,2,\cdots,n\} \quad (1)$$

Where $\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$ is TFN and l_{ij}, m_{ij}, and u_{ij} are the least possible value, modal value and highest value respectively. The fuzzy arithmetic operations on TFN can be expressed as follow:

Addition: $F_1 + F_2 = (l_1 + l_2, m_1 + m_2, u_1 + u_2)$ (2)

Multiplication: $F_1 \otimes F_2 = (l_1 \times l_2, m_1 \times m_2, u_1 \times u_2)$ (3)

Division: $F_1/F_2 = (l_1/u_2, m_1/m_2, u_1/l_2)$ (4)

Reciprocal: $F_1^{-1} = (1/u_1, 1/m_1, 1/l_1)$ (5)

In this paper, TFN is used to compare a priority scale between each criterion i and each alternative *j* as shown in Table 1.

Table 1: Fuzzy numbers for criteria comparison

Definition	Importance level
Equal importance	(1,1,1)
Moderate importance	(2,3,4)
Strong importance	(4,5,6)
Very strong importance	(6,7,8)
Extreme importance	(8,9,9)
Intermediate values between the two neighboring scales	2,4,6,8

The fuzzy AHP approach steps are presented as follow:

Step 1: Construct the hierarchy

To define relevant factors, the n decision factors can be defined by asking experts or decision makers, about which criterion is more important with regard to the goal. The problem will be decomposed into a multi-level hierarchy. In figure 1, the hierarchical structure is based upon the traditional AHP methodology. At level “0”, the goal is to select new suitable locations. At level “1”, the main criteria are C_1, C_2,…, C_n, and at level “2”, the alternatives are location 1 (A_1), location 2 (A_2) and location n (A_n).

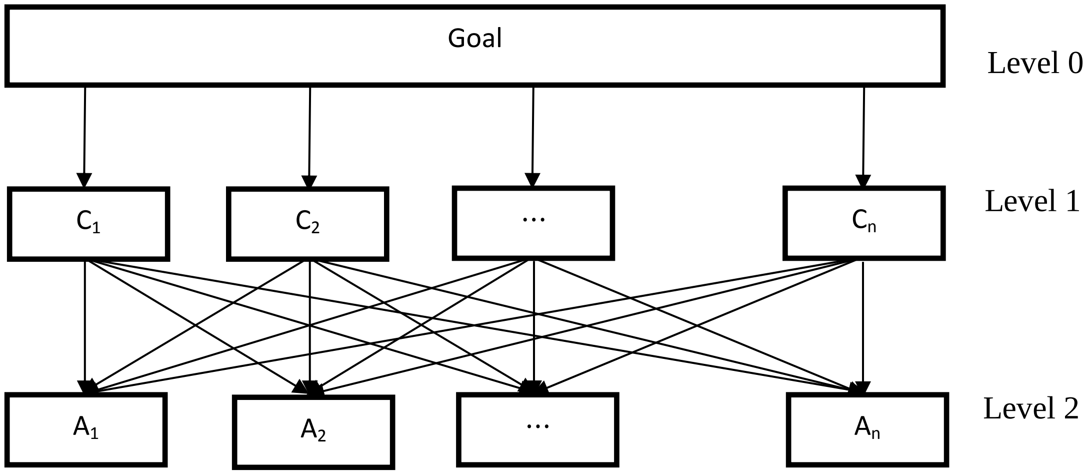

Figure 1: Multi-level Analytical Hierarchy Process

Step 2: Construct the comparison matrices of each decision maker

The answers for each decision maker k can be constructed using pairwise comparison matrices as follow:

$$\tilde{A}_k = \begin{bmatrix} \tilde{a}_{11k} & \tilde{a}_{12k} & \cdots & \tilde{a}_{1nk} \\ \tilde{a}_{21k} & \tilde{a}_{22k} & \cdots & \tilde{a}_{2nk} \\ \vdots & \vdots & \vdots & \vdots \\ \tilde{a}_{n1k} & \tilde{a}_{n2k} & \cdots & \tilde{a}_{nnk} \end{bmatrix}, \text{k} = 1, 2, \ldots, \text{K} \tag{6}$$

Where $\tilde{A}_k$ are fuzzy pairwise comparison matrices for each decision maker k, and K is the number of decision makers.

Step 3: Combine the comparison matrices of each decision maker

The pairwise comparison matrices can be aggregated with the fuzzy geometric mean method and can be defined by equation (7)

$$\tilde{G} = \left(\prod_{i=1}^{k} \tilde{a}_{ijk}\right)^{1/k} = \begin{bmatrix} \tilde{g}_{11} & \tilde{g}_{12} & \cdots & \tilde{g}_{1n} \\ \tilde{g}_{21} & \tilde{g}_{22} & \cdots & \tilde{g}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \tilde{g}_{n1} & \tilde{g}_{n2} & \cdots & \tilde{g}_{nn} \end{bmatrix} \tag{7}$$

Where $\tilde{G}$ is aggregated comparison matrix.

Step 4: Estimate priority weights of each level

After aggregation of pairwise comparison matrices, the aggregated matrix will be normalized with equation 8.

$$Nor\left(\tilde{G}\right)=\begin{bmatrix}\frac{\tilde{g}_{11}}{\sum_{i=1}^{n}\tilde{g}_{i1}} & \frac{\tilde{g}_{12}}{\sum_{i=1}^{n}\tilde{g}_{i2}} & \cdots & \frac{\tilde{g}_{1n}}{\sum_{i=1}^{n}\tilde{g}_{in}}\\ \frac{\tilde{g}_{21}}{\sum_{i=1}^{n}\tilde{g}_{i1}} & \frac{\tilde{g}_{22}}{\sum_{i=1}^{n}\tilde{g}_{i2}} & \cdots & \frac{\tilde{g}_{2n}}{\sum_{i=1}^{n}\tilde{g}_{in}}\\ \vdots & \vdots & \vdots & \vdots\\ \frac{\tilde{g}_{n1}}{\sum_{i=1}^{n}\tilde{g}_{i1}} & \frac{\tilde{g}_{n2}}{\sum_{i=1}^{n}\tilde{g}_{i2}} & \cdots & \frac{\tilde{g}_{nn}}{\sum_{i=1}^{n}\tilde{g}_{in}}\end{bmatrix} \tag{8}$$

After that, the priority weights of each level can be defined by calculating the mean of each row i of the normalized matrix, as shown in equation (9). The fuzzy priority weights are TFN, which can be converted to crisp priority weights using equation (10).

$$\tilde{W}_i=\begin{bmatrix}\tilde{w}_1\\ \tilde{w}_2\\ \vdots\\ \tilde{w}_n\end{bmatrix}=\begin{bmatrix}\left[\frac{\tilde{g}_{11}}{\sum_{i=1}^{n}\tilde{g}_{i1}}+\frac{\tilde{g}_{12}}{\sum_{i=1}^{n}\tilde{g}_{i2}}+\cdots+\frac{\tilde{g}_{1n}}{\sum_{i=1}^{n}\tilde{g}_{in}}\right]\Big/n\\ \left[\frac{\tilde{g}_{21}}{\sum_{i=1}^{n}\tilde{g}_{i1}}+\frac{\tilde{g}_{22}}{\sum_{i=1}^{n}\tilde{g}_{i2}}+\cdots+\frac{\tilde{g}_{2n}}{\sum_{i=1}^{n}\tilde{g}_{in}}\right]\Big/n\\ \vdots\\ \left[\frac{\tilde{g}_{n1}}{\sum_{i=1}^{n}\tilde{g}_{i1}}+\frac{\tilde{g}_{n2}}{\sum_{i=1}^{n}\tilde{g}_{i2}}+\cdots+\frac{\tilde{g}_{nn}}{\sum_{i=1}^{n}\tilde{g}_{in}}\right]\Big/n\end{bmatrix} \tag{9}$$

$$df\,\tilde{a}_{ij}=\left[\left(u_{ij}-l_{ij}\right)+\left(m_{ij}-l_{ij}\right)\right]/3+l_{ij}\quad\forall i,\forall j \tag{10}$$

Step 5: Check for consistency ratio (CR) value

$\tilde{\tilde{W}}_i$ is defined by equation (11). After that, using equation (10), the crisp numbers of $\tilde{\tilde{W}}_i$ can be defined by equation (12).

$$\tilde{\tilde{W}}_i=\begin{bmatrix}\tilde{\tilde{w}}_1\\ \tilde{\tilde{w}}_2\\ \vdots\\ \tilde{\tilde{w}}_n\end{bmatrix}=\begin{bmatrix}\left(w_1\times\tilde{g}_{11}+w_2\times\tilde{g}_{12}+\cdots+w_n\times\tilde{g}_{1n}\right)/w_1\\ \left(w_1\times\tilde{g}_{21}+w_2\times\tilde{g}_{22}+\cdots+w_n\times\tilde{g}_{2n}\right)/w_2\\ \vdots\\ \left(w_1\times\tilde{g}_{n1}+w_2\times\tilde{g}_{n2}+\cdots+w_n\times\tilde{g}_{nn}\right)/w_n\end{bmatrix} \tag{11}$$

$$\overline{w}=df\begin{bmatrix}\tilde{\tilde{w}}_1\\ \tilde{\tilde{w}}_2\\ \vdots\\ \tilde{\tilde{w}}_n\end{bmatrix}=\begin{bmatrix}\overline{w}_1\\ \overline{w}_2\\ \vdots\\ \overline{w}_n\end{bmatrix} \tag{12}$$

λ_{max} is computed using equation (13).

$$\lambda_{max}=\sum_{i=1}^{n}\overline{w}_i/n \tag{13}$$

CI is computed using equation (14).

$$CI=(\lambda_{max}-n)/(n-1) \tag{14}$$

CR is computed using equation (15), and RI is defined using table 2.

Table 2: Randomness indicators (RI)

1	2	3	4	5	6	7	8	9	10
0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

$$CR = CI/RI \quad (15)$$

A consistency ratio (CR) of 0.10 or less is accepted as a fine consistency measure. If the value exceeds 0.10, it should be revised.

Step 6: Compute the final priority weights for each alternative

The final priority weights are calculated by adding the weights per candidate and multiplying by the weights of the corresponding criteria. A final score is obtained for each candidate location. The best alternative is the maximum value of the final priority weight, and a high value for a priority weight means that it is better than a low priority weight.

4. Result and Discussion

In this study, fuzzy AHP approach is used to identify suitable school location in pastoral communities in Mille Woreda (Afar, Ethiopia). Candidate location include Alidewarto (A1), Waytaleyta (A2), and Wekki (A3). The weights of the criteria's and alternatives are obtained from 2 academicians and 2 officials from Mille Woreda education bureau by using questionnaire. The following are the three criteria are considered in the decision making process:

- **Environmental:** more vegetation, proximity to water source,
- **Social:** distance between the facilities (schools) and the community, conflict occurrence frequency
- **Geological:** history of natural disaster, the suitability of location

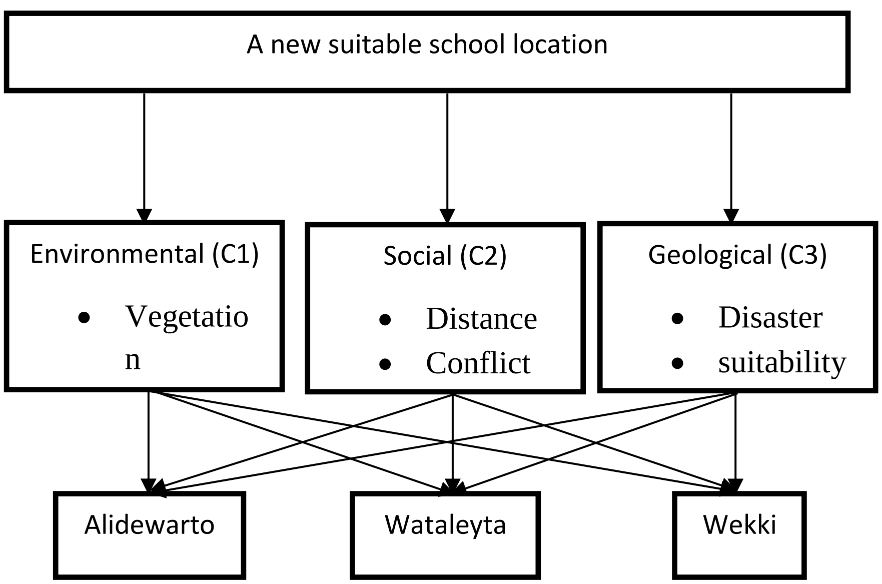

Figure 2: Decision hierarchy for selecting suitable school location

Table 3: Comparison criteria with respect to goal from the four decision makers

Goal	C1	C2	C3
C1	(1.00,1.00,1.00), (1.00,1.00,1.00), (1.00,1.00,1.00), (1.00,1.00,1.00)	(1.00,1.00,1.00),(0.25,0.33,0.5), (0.25,0.33,0.5),(0.16,0.2,0.25)	(0.13,0.14,0.16), (6.00,7.00,8.00), (0.13,0.14,0.16), (0.11,0.11,0.13)
C2	(1.00,1.00,1.00),(2.00,3.00,4.00), (2.00,3.00,4.00), (4.00,5.00,6.00)	(1.00,1.00,1.00),(1.00,1.00,1.00), (1.00,1.00,1.00), (1.00,1.00,1.00)	(0.13,0.14,0.16), (0.13,0.14,0.16), (0.16,0.20,0.25), (0.13,0.14,0.16)
C3	(6.00,7.00,8.00),(0.13,0.14,0.16), (6.00,7.00,8.00), (8.00,9.00,9.00)	(6.00,7.00,8.00), (6.00,7.00,8.00), (4.00,5.00,6.00), (6.00,7.00,8.00)	(1.00,1.00,1.00), (1.00,1.00,1.00), (1.00,1.00,1.00), (1.00,1.00,1.00)

Table 4: Combined comparison matrix of criteria with respect to goal

Goal	C1			C2			C3			Wc(i)	CR
C1	1.00	1.00	1.00	0.32	0.38	0.06	0.32	0.35	0.03	0.01	0.03
C2	2.00	2.60	3.13	1.00	1.00	1.00	0.14	0.15	0.17	0.20	
C3	2.47	2.80	3.10	5.42	6.44	7.44	1.00	1.00	1.00	0.70	

Table 5: Pairwise comparison of alternatives with respect to the criteria

C_1	A1	A2	A3
A1	(1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00)	(0.25,0.33,0.5), (0.25,0.33,0.5), (0.16,0.2,0.25), (0.25,0.33,0.5)	(0.11,0.11,0.13), (0.13,0.14,0.16), (0.11,0.11,0.13), (0.13,0.14,0.16)
A2	(2.00,3.00,4.00), (2.00,3.00,4.00), (4.00,5.00,6.00), (2.00,3.00,4.00)	(1.00,1.00,1.00,1.00),(1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00)	(0.16,0.2,0.25), (0.16,0.2,0.25), (0.13,0.14,0.16), (0.16,0.2,0.25)
A3	(8.00,9.00,9.00), (6.00,7.00,8.00), (8.00,9.00,9.00), (6.00,7.00,8.00)	(4.00,5.00,6.00), (4.00,5.00,6.00), (6.00,7.00,8.00), (4.00,5.00,6.00)	(1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00)
C_2	A1	A2	A3
A1	(1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00)	(2.00,3.00,4.00), (2.00,3.00,4.00), (2.00,3.00,4.00), (6.00,7.00,8.00)	(2.00,3.00,4.00), (6.00,7.00,8.00), (8.00,9.00,9.00), (6.00,7.00,8.00)
A2	(0.25,0.33,0.5), (0.25,0.33,0.5), (0.25,0.33,0.5), (0.16,0.2,0.25)	(1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00)	(1.00,1.00,1.00,1.00), (0.16,0.2,0.25), (0.13,0.14,0.16), (1.00,1.00,1.00,1.00)
A3	(0.25,0.33,0.5), (0.13,0.14,0.16), (0.11,0.11,0.13), (0.13,0.14,0.16)	(1.00,1.00,1.00,1.00), (4.00,5.00,6.00), (6.00,7.00,8.00), (1.00,1.00,1.00,1.00)	(1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00)
C_3	A1	A2	A3
A1	(1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00)	(0.25,0.33,0.5), (0.25,0.33,0.5), (0.16,0.2,0.25), (0.16,0.2,0.25),	(0.16,0.2,0.25), (0.25,0.33,0.5), (0.25,0.33,0.5), (0.25,0.33,0.5)
A2	(2.00,3.00,4.00), (2.00,3.00,4.00), (1.00,1.00,1.00), (4.00,5.00,6.00),	(1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00)	(1.00,1.00,1.00), (0.16,0.2,0.25), (0.16,0.2,0.25), (4.00,5.00,6.00)
A3	(2.00,3.00,4.00), (6.00,7.00,8.00), (4.00,5.00,6.00), (1.00,1.00,1.00),	(1.00,1.00,1.00), (4.00,5.00,6.00), (4.00,5.00,6.00), (0.16,0.2,0.25)	(1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00), (1.00,1.00,1.00,1.00)

Table 5: Combined comparison matrix of alternatives with respect to criteria's

C1	A1			A2			A3			W(i,1)	CR
A1	1.00	1.00	1.00	0.22	0.30	0.42	0.12	0.12	0.14	0.01	0.05
A2	2.38	3.40	4.43	1.00	1.00	1.00	0.15	0.18	0.22	0.16	
A3	6.93	7.94	8.50	4.43	5.44	6.45	1.00	1.00	1.00	0.74	
C2	A1			A2			A3			W(i,2)	
A1	1.00	1.00	1.00	2.63	3.70	3.76	4.90	6.03	6.93	0.69	0.03
A2	0.22	0.30	0.42	1.00	1.00	1.00	0.38	0.12	0.45	0.11	
A3	0.15	0.16	0.20	2.21	2.43	2.63	1.00	1.00	1.00	0.19	
C3	A1			A2			A3			W(i,3)	
A1	1.00	1.00	1.00	0.20	0.26	0.35	0.22	0.3	0.42	0.14	0.06
A2	2.38	2.59	3.13	1.00	1.00	1.00	0.56	0.67	0.78	0.38	

A3	2.63	3.20	3.72	1.26	1.50	1.73	1.00	1.00	1.00	0.48

Table 6: All priority weights for each level

Wc(i)	CR	Wl (i,j)	CR	W(i)	Decision
Wc(1) = 0.01	0.03	Wl(1,1) = 0.01 Wl(2,1) = 0.16 Wl(3,1) = 0.74	0.05	$((0.01 \times 0.01)) + (0.16 \times 0.20) + (0.74 \times 0.7) = 0.55$	**Selected**
Wc(2) = 0.20		Wl(1,2) = 0.69 Wl(2,2) = 0.11 Wl(3,2) = 0.19	0.03	$((0.69 \times 0.01)) + (0.11 \times 0.20) + (0.19 \times 0.7) = 0.16$	Not Selected
Wc(3) = 0.70		Wl(1,3) = 0.14 Wl(2,3) = 0.38 Wl(3,3) = 0.48	0.06	$((0.14 \times 0.01)) + (0.38 \times 0.20) + (0.48 \times 0.7) = 0.41$	**Selected**

This paper uses fuzzy AHP approach for selecting optimal school location in pastoral community by taking into account environmental, social, and geological factors. The pairwise comparison matrix for the criteria's and alternatives were constructed using preferences obtained by asking experts (two academicians and two education bureau workers) as shown in table 3 & 5. Then, the pairwise comparison matrices were aggregated and fuzzy weights for each criteria's and alternatives obtained through equation (7-9). The goodness of judgments is evaluated by calculating the inconsistency ratio (CR) through equation (10-15). And finally, it is found that from the candidate locations, Alidewarto and Wekki are found to be optimal locations for locating new schools as shown in table 7.

5. Conclusion

The aim of this paper is to find optimal location for schools in pastoral communities in Mille Woreda, Afar region, Ethiopia. In this study, fuzzy AHP was used for prioritizing three candidate location such as Alidewarto, Wataleyta, and Wekki. The factors considered include environmental (vegetation, proximity to water source), social (the distance between the facility and community location), and geological (history of natural disaster, suitability of location). And finally, the paper concludes that from the candidate locations Alidewarto & Wekki were found to be best location for locating new schools.

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