ICOE 2024
Hybrid Conference
International Conference on Education 2024

PROCEEDINGS 2024
The 2nd International Conference on Education
E-ISSN: 3025-6828
Volume 02, Tahun 2024

Contextualization of Mathematics Learning Through Decision-Making Schemes in Disaster Mitigation

Salma Zahrotun Nihayah Al Hasani[1]; Qothrun Nada Salsabela[2]; Nur Fadilatul Ilmiyah[3]
[1]State Islamic Institute of Kediri, Kediri; [2]State Islamic Institute of Kediri, Kediri;
[3]State Islamic Institute of Kediri, Kediri
Correspondence e-mail: nur.fadilatul.ilmiyah@iainkediri.ac.id

Abstract:
The internalization of abstract mathematical concepts often poses a significant challenge for students, even though mathematics is fundamental to numerous disciplines, such as complex decision-making. This study aims to show the critical role of the matrix in the Multi-Attribute Utility Theory (MAUT) method in determining the location of suitable shelters for victims of natural disasters, especially the eruption of Mount Kelud in the Kediri area. This study employs a qualitative descriptive approach to examine the application of the matrix in evaluating various criteria, including the number of public facilities, capacity, availability of bathrooms and ventilation. The study results show that the MAUT method, with the help of a matrix, can provide recommendations for the five most suitable sub-districts as shelter locations. This research is expected to contribute to developing decision support systems for disaster mitigation and improve students' understanding of mathematics applications in real contexts.

Keywords: *Disaster Evacuation; MAUT; Shelter*

Article History:
Received : 10 August 2024
Revised : 06 October 2024
Accepted : 25 October 2024
**editors will fill up the article history*

Introduction

Mathematics learning in higher education presents challenges, especially in connecting abstract concepts with real applications. Many students have difficulty understanding the material presented due to the lack of relevance between mathematical theory and the context of daily life or the field of study students learn. This makes learning less meaningful and difficult for some students to understand. Therefore, contextualising mathematics learning at the university level is crucial to increase conceptual understanding and student involvement (Showalter *et al*., 2014). By linking mathematical concepts with real problems that are relevant to student's experiences and interests, the learning process can become more interactive, applicative, and meaningful, thus optimising learning outcomes and encouraging the development of critical and analytical thinking skills needed in the world of work (Darminto, 2012).

Contextualization in mathematics learning is an approach that connects mathematical theory to real-life situations. This approach has been identified as one of the promising strategies to overcome the various obstacles that have long been faced in mathematics teaching and learning (Wang *et al*., 2022). In addition to helping students understand concepts more deeply, contextualization also strengthens students' ability to apply this knowledge to practical situations. Research shows that context-based learning increases student motivation and learning outcomes and prepares students to face challenges in the professional world (Darminto, 2012).

Mathematics learning must be designed in college to meet students' diverse needs. An interactive and contextual approach to learning can create a more effective and meaningful learning environment (Reyes *et al*., 2019) so that students not only memorize formulas but also understand the right way and time to apply them in real situations (Kadir & Masi, 2014).

One form of effective contextualization of mathematics learning in higher education is providing insight to students about applying mathematical concepts, such as matrices, in decision-making schemes. For example, using matrices in disaster mitigation methods can be an example of relevant and interesting applications for students. Through this approach, students will understand that matrices, often seen as mere numerical calculations, have a significant role in complex and crucial decision-making processes.

According to World Risk Index data in 2020, out of 181 countries prone to disasters, Indonesia occupies the 40th position. In 2022, the Badan Nasional Penanggulangan Bencana (National Disaster Management Agency) reported that there were 3,522 natural disasters in Indonesia, namely 1,520 flood disasters, 1,057 extreme weather disasters, 634 landslide disasters, 252 forest and land fire disasters, 28 earthquake disasters, 26 tidal / abrasion disasters, four drought disasters, and a volcanic eruption disaster (Badan Nasional Penanggulangan Bencana, 2022). Disaster mitigation is carried out to reduce the impact of disasters, as explained in Law Number 24 of 2007.

The volcano eruption forced residents to evacuate from the threat of volcanic gases, ash, and hot clouds. Local governments usually provide evacuation shelters in surrounding villages that are considered safe. However, in reality, many residents face difficulties in obtaining proper shelter. Darmi (2022) noted that some evacuation places are overcapacity, while others do not meet standards. This problem is further exacerbated by uneven distribution, as many residents have not yet gained access to Temporary Evacuation Sites (TES) or shelters. A good shelter should accommodate disaster victims on an individual and family scale and have adequate facilities (Badan Nasional Penanggulangan Bencana, 2012).

There are several sub-districts in each district. When a disaster occurs, residents from the affected sub-districts will usually evacuate to safer sub-districts (Ragil *et a*l., 2020). However, not all safe sub-districts can be used as evacuation places. The selection of evacuation sites must be carried out carefully by considering various factors, such as the availability of public facilities, sanitation, and ventilation. A decision support system is needed to ensure that the process of selecting evacuation sites runs objectively and meets the needs of all parties. This system will help local governments, village heads, and refugees to determine the most suitable evacuation sites.

Nowadays, assistance programs in the decision support system have grown rapidly. There are several methods to help support the decision to choose several alternatives. Kusumadewi and Guswaludin (2005) stated that the decision must consider alternatives as a supporting factor for decision-making success. Several previous studies have related to the selection of shelters as temporary housing for prospective disaster refugees using methods in the decision support system. Some of these methods are the Spatial Multi-Criteria Evaluation (SMCE) method (Muzaky et al., 2022), the Simple Additive Weighting (SAW) method (Antika dan Pratama, 2021) and the Analytical Hierarchy Process method (AHP) (Wigati et al., 2023).

Another method for supporting the selection of shelter locations is the Multi-Attribute Utility Theory (MAUT). In this context, the matrix is one of the important elements in the MAUT method, which is an approach to analyzing and integrating various attributes or factors in decision-making (Taufik *et al*., 2021). MAUT allows for a comprehensive evaluation of the number of decision alternatives based on different criteria, such as prioritization of disaster mitigation actions based on the level of risk, cost, or potential impact. In this case, matrices are used to compile data related to various factors to make decisions more systematically and rationally.

This study aims to provide information on how the matrix concept is implemented in the MAUT method to support the selection of the best shelter location. Students gain a deeper understanding of mathematical theory by understanding the application of matrices in the MAUT method. They are equipped with relevant and applicable skills for the world of work, especially in fields involving data-driven decision-making and risk analysis. This contextual learning approach is expected to increase students' motivation to learn, strengthen conceptual understanding, and prepare them to face challenges in the professional world.

Methods

This qualitative descriptive research aims to examine the application of the matrix concept in the MAUT method to support the selection of the best shelter location. This research focuses on the Disaster Risk Assessment (KRB) 1 and 2 areas around Mount Kelud, involving 5 sub-districts as candidates for shelter locations. Each village area will be given a unique code from *KGK01* to *KGK05* to facilitate the analysis. The procedure in this study consists of a series of stages: making criteria with their measurement scales, determining the weight of importance for each criterion in each decision-making, implementing the MAUT method, and sorting the recommended shelter locations.

This study focuses on several important criteria in selecting shelter locations around Mount Kelud. These criteria include (1) the number of public facilities, (2) capacity, (3) the availability of bathrooms, (4) kitchens, (5) final disposal sites, (6) final waste bins, (7) ventilation, and (8) the emergency places. These criteria will be assessed based on a specific measurement scale to determine which village is most suitable as a shelter location. The following is the measurement scale for each criterion:

a) The number of public facilities (K1).
Public facilities are often found in every village, such as mosques, churches, other places of worship, fields, village head offices, and many more. These places are used as a shelter for prospective refugees. However, not all villages have many facilities; some only have mosques and village head offices. The assessment scale for these criteria includes:
Value 1, if the village has less than three public facilities.
Value 2, if the village has three to five public facilities.
Value 3, if the village has more than five public facilities.
b) The village capacity of prospective shelter locations (K2).
The author stated this capacity in the calculation per Family Card. The assessment scale for these criteria includes:
Value 1, if the village can accommodate less than three Family Cards.
Value 2, if the village can accommodate three to five Family Cards.
Value 3, if the village can accommodate more than five Family Cards.
c) The availability of bathrooms (K3).
The assessment scale for these criteria includes:
Value 1, if the village does not have a bathroom.
Value 2, if the village has a bathroom, but it is not feasible.
Value 3, if the village has a bathroom and is decent.
d) The availability of kitchens (K4).
The assessment scale for these criteria includes:
Value 1, if the village does not provide a kitchen for refugees.
Value 2, if the village provides a kitchen for refugees.
e) The availability of a final disposal site, which is the completeness of the MCK (K5).
The assessment scale for these criteria includes:
Value 1, if the village does not have a final disposal site for prospective refugees.
Value 2, if the village has a final disposal site for prospective refugees, but it is not feasible.
Value 3, if the sub-district has a final disposal site for prospective refugees and is feasible.
f) The availability of final bins (K6)
The existence of refugees living in a sub-district requires the places to prepare a location that can accommodate waste from refugees without causing environmental pollution.
The assessment scale for these criteria includes:
Value 1, if the sub-district no longer has a final garbage can.
Value 2, if the sub-district has a final trash can for refugees, but it is not feasible.
Value 3, if the sub-district has a final and decent garbage can.
g) Ventilation availability (K7)
The assessment scale for these criteria includes:
Value 1, if the shelter does not have ventilation.
Value 2, if the shelter has ventilation, but is not feasible.
Value 3, if the shelter is ventilated and feasible.
h) The availability of an emergency place (K8).
Emergency places in the sub-district of the prospective shelter location are places of worship, storage places for food and medicines, and so on. The assessment scale for these criteria includes:
Value 1, if the sub-district does not have an emergency place.

Value 2, if the sub-district has 1-3 emergency places.
Value 3, if the sub-district has more than 3 emergency places.

All of the criteria outlined previously were obtained from the interview with the head of the Badan Penanggulangan Bencana Daerah (Regional Disaster Management Agency) of Kediri Regency on February 29, 2024. The five sub-districts are shelters occupied by refugees previously based on the results of questions and answers conducted by the Kediri Regency BPBD management to residents. From the data, the following is obtained:

Table 1. Interview Results Data

District/Alternative Codes	Criteria							
	$K1$	$K2$	$K3$	$K4$	$K5$	$K6$	$K7$	$K8$
$KGK01$	3	2	2	2	3	3	3	3
$KGK02$	2	2	3	2	2	2	2	1
$KGK03$	3	3	3	2	3	3	3	3
$KGK04$	3	2	3	2	2	2	3	2
$KGK05$	2	2	3	1	2	2	3	1

Source: Author's Documentation

Table 2. Maximum and Minimum Values of each Criterion

Value Type	Criteria							
	$K1$	$K2$	$K3$	$K4$	$K5$	$K6$	$K7$	$K8$
Maximum	3	3	3	2	3	3	3	3
Minimum	2	2	2	1	2	2	2	1

Source: Author's Documentation

This study also assumes that decision-makers have different preference weights for each criterion. Decision makers can be considered as villagers or prospective refugees, village heads from existing shelters, heads of the Regional Disaster Management Agency (BPBD), and so on. Then, the preference weights of the decision makers are outlined in Table 3, as follows:

Table 3. Decision Maker Preferences Weights

Decision-Maker	Criteria							
	$K1$	$K2$	$K3$	$K4$	$K5$	$K6$	$K7$	$K8$
	0,200	0,200	0,100	0,050	0,100	0,200	0,100	0,050

Source: Author's Documentation

From Table 3, the preference weight matrix for each decision maker can be compiled as follows:

$$DM = \begin{bmatrix} 0{,}200 \\ 0{,}200 \\ 0{,}100 \\ 0{,}050 \\ 0{,}100 \\ 0{,}200 \\ 0{,}100 \\ 0{,}050 \end{bmatrix}$$

According to Hadinata (2018), the Multi-Attribute Utility Theory (MAUT) method can be implemented through the following steps:

a) Construct a P decision matrix with the following definitions:

$$P = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1j} \\ p_{21} & p_{22} & \cdots & p_{2j} \\ \vdots & \vdots & \ddots & \vdots \\ p_{i1} & p_{i2} & \cdots & p_{ij} \end{bmatrix}$$

p_{ij} = Weight or average score of the results of the i alternative interview in the j criterion

b) Normalizing the mathematical value of the P decision by calculating the utility value of each alternative in each criterion by utilizing the following formula:

$$u(p_{ij}) = \frac{p_{ij} - p_i}{p_i - p_i} \quad (1)$$

$u(p_{ij})$ = the utility value of the i alternative weight in the j criterion
p_i = Minimum value of each criterion
p_i = Maximum value of each criterion

c) Construct a U normalization matrix with the following definitions:

$$U = \begin{bmatrix} u(p_{11}) & u(p_{12}) & \cdots & u(p_{1j}) \\ u(p_{21}) & u(p_{22}) & \cdots & u(p_{2j}) \\ \vdots & \vdots & \ddots & \vdots \\ u(p_{i1}) & u(p_{i2}) & \cdots & u(p_{ij}) \end{bmatrix}$$

d) Multiply the normalization matrix U by the preference weight matrix DM_i.

Results and Discussion

In this section, the author will explain the role of matrices in the MAUT method to provide recommendations on the best shelter locations.

a) Compile a decision matrix P.

Each entry in the P decision matrix represents the data in Table 1. The large number of rows represents the number of alternatives used, while the large number of columns represents the number of criteria used.

$$P = \begin{bmatrix} 3 & 2 & 2 & 2 & 3 & 3 & 3 & 3 \\ 2 & 2 & 3 & 2 & 2 & 2 & 2 & 1 \\ 3 & 3 & 3 & 2 & 3 & 3 & 3 & 3 \\ 3 & 2 & 3 & 2 & 2 & 2 & 3 & 2 \\ 2 & 2 & 3 & 1 & 2 & 3 & 3 & 1 \end{bmatrix}$$

b) Normalize the decision matrix P.

The normalization of the P decision matrix is carried out by calculating the utility value of each entry in the matrix using equation (1). The author states the results of the calculation in the following Table 4:

Table 4. The Results of Normalization of Decision Matrix P

District/Alternative Codes	Criteria							
	$K1$	$K2$	$K3$	$K4$	$K5$	$K6$	$K7$	$K8$
$KGK01$	1	0	0	1	1	1	1	1
$KGK02$	0	0	1	1	0	0	0	0
$KGK03$	1	1	1	1	1	1	1	1
$KGK04$	1	0	1	1	0	0	1	0,5
$KGK05$	0	0	1	0	0	0	1	0

Source: Author's Documentation

c) Compose the U normalization matrix.

Each entry in the U normalization matrix represents the data in Table 4. The large number of rows represents the number of alternatives used, while the large number of columns represents the number of criteria used.

$$U = \begin{bmatrix} 1 & 0 & 0 & 1 & 1 & 1 & 1 & 1 \\ 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 & 0 & 0 & 1 & 0{,}5 \\ 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 \end{bmatrix}$$

d) Multiply the normalization matrix U by the DM preference weight matrix.

In this step, the normalization matrix U is multiplied by the DM preference weight matrix. From these activities, a new matrix with a size of 5×1 is produced as follows:

$$UDM = \begin{bmatrix} 0{,}7000 \\ 0{,}1500 \\ 1 \\ 0{,}4750 \\ 0{,}2000 \end{bmatrix}$$

After implementing the Multi-Attribute Utility Theory (MAUT) method, the next stage is to compile recommendations. The matrix formed from the multiplication between the normalization matrix U and the DM preference weight matrix shows the order of recommendations. This means that the concept of matrices in the MAUT method implementation provides the realization of abstract mathematics lessons in solving contextual problems. Based on the results of the calculations in step (d), *KGK03* is considered the sub-district that best meets the expectations of the decision-makers. However, the calculation ratings are not invariably fixed. This means that the weight of preferences given by the decision-maker will affect the ranking of recommendations from each alternative. Therefore, the calculation result in this study may change if the weight of the preferences of each decision maker also changes.

Conclusion

Based on the research results, it can be concluded that the matrix concept implemented in the MAUT method can help students realize abstract forms of mathematics to solve real-world problems, such as supporting the selection of the best shelter location. The MAUT Method application can provide sub-district recommendations for shelter locations that meet the expectations of prospective refugees, village heads from existing shelters, heads of the Regional Disaster Management Agency (BPBD), and so on. Using the preference weight illustrations in Table 3, *KGK03* is the sub-district that best meets the decision-maker expectations. The results of the calculations in this study may change if the weight of the preferences of each decision maker also changes.

This study provides a preliminary overview of the potential use of matrices in the MAUT method to select the best shelter location. However, many aspects still need to be further developed. One limitation of this study is the limited number of criteria considered. Further research can expand the scope of the criteria, for example, by adding factors such as accessibility, distance from clean water sources, and potential secondary hazards to support the decision-making process related to the selection of shelter locations.

References

Ahmad, H. H. dan Widiyansah, D. 2021. Sosialisasi Konstruksi Bangunan Sederhana Tahan Gempa. Jurnal Pengabdian Masyarakat IPTEKS 7(1): 107– 111.

Antika, E., dan Pratama, R. Y. 2021. Penentuan Lokasi Pengungsian Erupsi Gunung Kelud Menggunakan Metode Simple Additive Weighting (Studi Kasus: Gunung Kelud). Prosiding Seminar Nasional Terapan Riset Inovatif. Politeknik Negeri Jember: 613-620.

Badan Nasional Penanggulangan Bencana (BNPB). 2022. Data Angka Kejadian Bencana di Indonesia Sepanjang Tahun 2022. Retrieved October 10, 2024 from https://bnpb.go.id.

Darmi, Y. dan Muntahanah. 2022. Implementasi Algoritma Dijkstra Untuk Menentukan Jalur Evakuasi Pada Simulasi Gempa Dan Tsunami di Kota Bengkulu Berbasis Gis. Jurnal Media Computer Science 1(2): 117-130.

Darminto, B. P. 2012. Penerapan Model Pembelajaran Matematika "CAS" Di Perguruan Tinggi. Universitas Muhammadiyah Purworejo, 1(1), 46–61.

Hadinata, N. 2018. Implementasi Metode Multi Attribute Utility Theory (MAUT) pada Sistem Pendukung Keputusan dalam Menentukan Penerima Kredit. Jurnal Sisfokom: Sistem Informasi dan Komputer 7(2): 87-92.

Ilmiyah, N. F., Salsabela, Q. N., Rohmah, N., dan Nisa, A. 2023. Implementation of Multi-Attribute Utility Theory and Borda Count Method for Selecting Tahfidzul Qur'an Islamic Boarding Schools. Prosiding International Conference on Education. Institut Agama Islam Negeri Kediri: 143-152.

Kadir, K., & Masi, L. 2014. Penggunaan Konteks dan Pengetahuan Awal Matematika dalam Pembelajaran Keterampilan Berpikir Kreatif Siswa. Jurnal Pendidikan Matematika, 5(1), 52–66.

Kusumadewi, S., dan Guswaludin, I. 2005. Fuzzy Multi-Criteria Decision Making. Media Informatika 3(1): 25-38.

Muzaky, M. H., Cahyono, A. B., dan Nurwatik. 2022. Penentuan Lokasi Flood Shelter Menggunakan Analisis Spatial Multi Criteria Evaluation (SMCE) (Studi Kasus: Kota Batu, Provinsi Jawa Timur). Jurnal Teknik Institut Teknologi Sepuluh Nopember 11(3): 136-141.

Pratiwi, S.P., Rozakiyah, D.S., Apriadi, D.W., dan Anzari, P.P. 2021. Upaya Peningkatan Kesadaran terhadap Bencana Letusan Gunung Kelud di Desa Batuaji, Kabupaten Kediri. E-DIMAS: Jurnal Pengabdian kepada Masyarakat 12(2): 285-290.

Ragil, C., Pramana, A. Y.E., dan Efendi, H. 2020. Kearifan Lokal dalam Mitigasi Bencana di Wilayah Lereng Gunung Merapi Studi Kasus Kecamatan Cangkringan, Kabupaten Sleman. Reka Ruang 2(1): 10-18.

Reyes, J. D., Insorio, A. O., Ingreso, M. L. V, Hilario, F. F., & Gutierrez, C. R. 2019. Conception and Application of Contextualization in Mathematics Education. International Journal of Education Studies in Mathematics, 6(1), 1–18.

Showalter, D. A., Wollet, C., & Reynolds, S. 2014. Teaching a High-Level Contextualized Mathematics Curriculum to Adult Basic Learners. Journal of Research and Practice for Adult Literacy, Secondary, and Basic Education, 3(2), 21–34.

Subagyo, W.H., Imaduddina, A.H., dan Hidayati, A.N. 2022. Perancangan Webgis Jalur Evakuasi Bencana Di Gunung Kelud Kabupaten Blitar. Jurnal Plano Buana 3(1): 34-43.

Taufik, I., Alam, C. N., Mustofa, Z., Rusdiana, A., & Uriawan, W. 2021. Implementation of Multi-Attribute Utility Theory (MAUT) method for selecting diplomats. IOP Conference Series: Materials Science and Engineering, 1098(3), 032055. https://doi.org/10.1088/1757-899x/1098/3/032055

Undang-Undang Republik Indonesia Nomor 24 Tahun 2007 Penanggulangan Bencana Pasal 1. Jakarta.

Wang, X., Lee, Y., Zhu, X., & Okur Ozdemir, A. 2022. Exploring the Relationship Between Community College Students' Exposure to Math Contextualization and Educational Outcomes. Research in Higher Education, 63(2), 309–336. https://doi.org/10.1007/s11162-021-09644-w

Wigati, S. S. 2023. Pemilihan Lokasi Temporary Shelter pada Evakuasi Bertahap Erupsi Gunung Api. Disertasi. Program Doktor Universitas Gadjah Mada. Yogyakarta.

World Risk Index. 2020. Forced Displacement and Migration. Retrieved October 10, 2024.