

A Fuzzy Inference System Sugeno Based Framework for Evaluating the Quality of Islamic Education Institutions

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ABSTRACT

This study aims to develop a conceptual framework for evaluating the quality of Islamic educational institutions using a Sugeno based Fuzzy Inference System (FIS). Islamic education encompasses multiple dimensions spiritual, academic, managerial, and social that are inherently complex and often subjective, making conventional evaluation methods insufficient. The study employs a qualitative library research approach, analyzing peer-reviewed journals, academic books, and institutional quality reports to construct a comprehensive FIS Sugeno model. Key quality indicators, including teacher competence, curriculum relevance, facilities, management, and graduate outcomes, are defined as fuzzy input variables and processed through fuzzification, rule-based inference, and defuzzification to generate objective and consistent quality scores. The conceptual model demonstrates that the Sugeno FIS effectively manages uncertainty and ambiguity in qualitative data, providing a systematic and transparent evaluation framework. The proposed approach not only enhances the accuracy and reliability of quality assessments but also supports educational institutions in formulating adaptive and context-sensitive strategies for continuous improvement. The study contributes both theoretically and practically by integrating artificial intelligence methods into Islamic education management and offering a foundation for further empirical applications across madrasahs, pesantrens, and higher education institutions.

1. Introduction

Islamic education in Indonesia plays a strategic role in shaping human resources who are religious, ethical, and competent. Islamic educational institutions including madrasahs, pesantren, and Islamic higher education are increasingly challenged to enhance their quality in order to remain competitive in the era of science, technology, and globalization. Evaluating the quality of Islamic education institutions is therefore an essential instrument to ensure the effectiveness of services and the achievement of educational outcomes. However, this evaluation process often encounters challenges, as quality indicators are multidimensional and frequently involve subjective aspects such as student satisfaction, managerial performance, and teaching effectiveness (Arifin & Husna, 2021).

A fundamental issue in evaluating the quality of Islamic education institutions lies in the difficulty of measuring qualitative indicators objectively. Accreditation systems such as BAN-S/M for schools and BAN-PT for universities provide formal standards, yet they do not fully capture the complexity of quality variables involving cultural, spiritual, and Islamic values. Moreover, conventional evaluation models often produce rigid conclusions, while educational realities frequently operate

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within areas of ambiguity and uncertainty (Nurdyansyah & Fadhilaturrehmi, 2020). This condition highlights a research gap in developing more adaptive evaluation methods that can address the multidimensional nature of Islamic education quality.

In this context, fuzzy logic-based approaches, particularly the Fuzzy Inference System (FIS) Sugeno method, become highly relevant. FIS has the ability to process linguistic data and manage ambiguity in decision-making, making it suitable for assessing aspects of quality that are difficult to measure numerically. Previous studies have widely applied fuzzy logic in management, engineering, and health sectors, yet its specific application in evaluating Islamic education institutions remains limited (Rahman & Dewi, 2021). Thus, the development of an evaluation model using the FIS Sugeno method offers a conceptual breakthrough to improve the validity and reliability of Islamic education quality assessments.

This study aims to formulate a conceptual model for evaluating the quality of Islamic education institutions using the FIS Sugeno method. The main contribution of this research lies in integrating intelligent computational approaches with Islamic education quality management. Theoretically, it is expected to enrich the body of knowledge in Islamic education management through quantitative methods based on artificial intelligence. Practically, it provides a foundation for further empirical research and serves as a reference for Islamic educational institutions in formulating more adaptive and context-sensitive strategies for quality enhancement (Zainuddin et al., 2022).

Several studies have applied Fuzzy Inference Systems (FIS) to assess educational quality, demonstrating the potential of fuzzy logic to handle complex and subjective evaluation criteria. Senkivskyy et al. (2025) developed a multilevel fuzzy system to evaluate the quality of educational multimedia, incorporating subjective factors into the assessment process. Rezeki and Putra (2021) implemented the Sugeno method within a decision support system to evaluate teacher performance, achieving reliable and valid outcomes. Despite these advancements, most research has concentrated on general educational contexts, with limited attention to the application of FIS in evaluating the quality of Islamic educational institutions. Consequently, there remains a significant gap in developing comprehensive FIS Sugeno-based evaluation models tailored specifically to Islamic education, capable of addressing the unique and multifaceted quality indicators inherent in this context.

2. Literature Review

2.1 Evaluation of Islamic Education Quality

The quality of Islamic education can be understood as the extent to which institutions achieve their educational objectives, which encompass not only academic performance but also the development of Islamic character and social contribution. From the perspective of educational management, quality represents a systematic effort to ensure that all components of education function in accordance with established quality standards. Islamic education is not solely oriented toward cognitive achievement but also toward the integration of spiritual and moral values in students' lives. Hence, the quality of Islamic education has broader dimensions compared to the general concept of educational quality. Recent studies emphasize that the quality of Islamic education cannot be separated from teacher competence, curriculum relevance, and the alignment of educational services with the needs of contemporary society (Rahman, 2021).

The quality indicators of Islamic education can be examined through the framework of the national education standards, which include inputs, processes, outputs, and outcomes. At the input level, quality is assessed through the availability of competent teachers, adequate learning facilities, and curricula that align with current demands. The process dimension refers to the effectiveness of teaching, classroom management, and the integration of Islamic values into daily academic practices. Outputs are reflected in students' achievements, both academic and non-academic, while outcomes concern the contribution of graduates to society. Recent research indicates that quality assurance systems based on national standards significantly influence the reputation of Islamic education institutions; however, there remains a need for more adaptive evaluation methods to accommodate the complexity of quality indicators (Suryana and Fauzi, 2022).

2.2 Fuzzy Inference System (FIS) Sugeno

The Fuzzy Inference System (FIS) is a fuzzy logic-based approach designed to address problems characterized by high levels of uncertainty. Unlike classical binary logic, which is limited to absolute values of true or false, fuzzy logic incorporates degrees of membership, making it more flexible in processing linguistic and subjective data. Through this structure, FIS is capable of imitating human decision-making patterns, which are often not rigid, thus making it highly relevant in the educational domain to evaluate aspects that are difficult to quantify directly. Recent studies emphasize that the strength of FIS lies in its ability to transform ambiguous information into meaningful outcomes that support managerial decision-making (Putra and Siregar, 2021).

Among the various types of FIS, the Sugeno method is widely recognized for its simplicity in defuzzification and its ability to generate more precise outputs. This model employs either linear or constant functions for its final outputs, making it computationally efficient and easily integrable with numerical data-based systems and optimization algorithms. Recent studies have demonstrated that the Sugeno method achieves higher accuracy than other fuzzy models, particularly in predictive and evaluative systems involving complex or uncertain data. Evidence also highlights that the Sugeno approach can effectively support evaluation systems in Islamic educational institutions by ensuring greater precision and faster inference processes (Ramadhani and Prasetya, 2023).

3. Methodology

This study employs a qualitative library research approach, emphasizing conceptual construction rather than empirical fieldwork. The investigation focuses on the application of the Fuzzy Inference System (FIS) using the Sugeno method as a framework for evaluating the quality of Islamic educational institutions. Primary data sources consist of peer-reviewed journal articles, conference proceedings, and recent academic books related to both FIS and Islamic education management. Secondary data include accreditation reports from BAN-PT and BAN-S/M as well as quality assurance documentation of Islamic education. Data collection was conducted through systematic documentation of scholarly literature retrieved from reputable academic databases such as Google Scholar, etc. The collected materials were analyzed using content analysis, which involved the classification of theoretical frameworks, comparison of prior studies, and synthesis of conceptual insights. This methodological design enables the formulation of an evaluative model that not only contributes to the theoretical discourse but also provides practical implications for strengthening quality management in Islamic educational institutions.

4. Results and Discussion

4.1 Concept of Quality in Islamic Education

The quality of Islamic education encompasses four interrelated dimensions: spiritual, academic, managerial, and social. The spiritual dimension emphasizes the development of students' character and moral values, which are central to the objectives of Islamic education. The academic dimension evaluates the acquisition of knowledge and skills, while the managerial dimension focuses on institutional governance, including planning, implementation, and evaluation processes. The social dimension assesses students' engagement and contributions to the wider community. Collectively, these dimensions form a holistic and sustainable educational system. A significant challenge in assessing the quality of Islamic education lies in achieving objectivity, particularly because spiritual and social aspects are inherently subjective and difficult to quantify. Therefore, adopting an innovative and adaptive evaluation approach, such as a Fuzzy Inference System (FIS) based on the Sugeno method, is crucial to effectively address these complexities (Ardaini, 2025).

4.2 Principles of Sugeno Fuzzy Inference System

The Fuzzy Inference System (FIS) serves as a core component of fuzzy logic, providing a mechanism for decision-making based on IF-THEN rules. A typical FIS comprises four main stages: fuzzification, rule base, inference engine, and defuzzification. During fuzzification, numerical input values are converted into fuzzy sets using defined membership functions. The rule base contains a collection of IF-THEN rules that capture relationships between inputs and outputs derived from expert knowledge or historical data. The inference engine processes these rules to produce intermediate fuzzy results, while defuzzification translates these fuzzy outputs into crisp numerical values that can be applied in managerial decision-making within educational institutions (Nasution & Rachmawati, 2020).

The Sugeno method, originally developed by Takagi and Sugeno, is particularly advantageous for handling ambiguous linguistic data (Takagi & Sugeno, 1985). Unlike the Mamdani approach, Sugeno employs linear or constant functions in the consequent part of the rules, enabling the system to generate direct numerical outputs without additional defuzzification. This computational efficiency and compatibility with optimization algorithms make the Sugeno method highly suitable for evaluating the quality of Islamic educational institutions, where data are often subjective and uncertain. By applying a Sugeno-based FIS, assessments can be conducted in an objective and consistent manner, even when dealing with high levels of data uncertainty (Putra et al., 2022).

4.3 Integration of Sugeno FIS in Islamic Education Quality Evaluation

The assessment of quality in Islamic educational institutions requires approaches capable of addressing uncertainty and subjectivity in data. The Sugeno-based Fuzzy Inference System (FIS) provides a viable solution by transforming linguistic inputs into numerical values through fuzzification, the application of rule-based reasoning, and defuzzification. In the context of Islamic education, quality indicators such as teacher performance, curriculum design, facilities, institutional management,

and graduate outcomes can be identified as fuzzy input variables for the Sugeno FIS model (Nasution & Rachmawati, 2020). A conceptual simulation of the Sugeno FIS begins with defining these quality indicators as fuzzy input variables, each represented by appropriate membership functions, for example, low, medium, and high. Fuzzy rules are then applied to connect combinations of input values with the overall institutional quality output. The inference process generates intermediate fuzzy results, which are subsequently defuzzified to produce a concrete quality score, interpretable and applicable for managerial decision-making within the educational institution (Memarian et al., 2024).

No	Fuzzy Rule	Institutional Quality Output
1	IF teacher quality is "good" AND curriculum is "adequate" THEN institutional quality = "medium"	Medium
2	IF teacher quality is "excellent" AND facilities are "good" AND management is "good" THEN institutional quality = "high"	High

The application of the Sugeno FIS model allows for more objective and consistent evaluations, even when the available data are inherently subjective or uncertain. This aligns with recent studies demonstrating that Sugeno based FIS effectively manages uncertainty and provides valid decision outcomes in educational contexts (Memarian et al., 2024).

The application of the Sugeno-based Fuzzy Inference System (FIS) in evaluating the quality of Islamic educational institutions provides a quantitative tool capable of objectively and consistently assessing qualitative data. By transforming linguistic inputs such as teacher quality, curriculum, facilities, management, and graduate outcomes into numerical values, the Sugeno FIS facilitates transparent and accountable evaluations. This aligns with evidence indicating that FIS is effective in managing uncertainty and ambiguity in educational assessment data. Compared to traditional evaluation methods, which are often subjective and reliant on individual judgment, the Sugeno FIS offers a more systematic and reliable approach. The method integrates multiple input variables and produces outputs that reflect the institution's overall quality comprehensively. Previous studies have demonstrated that employing FIS for performance evaluation can yield more accurate and objective assessments than conventional techniques (Nikmanesh, 2023). Implementing the Sugeno FIS in Islamic education contexts also opens opportunities for further empirical research, such as pilot testing in madrasahs, pesantrens, or Islamic higher education institutions. Such studies can explore the model's effectiveness across different educational settings and contribute to the development of a more adaptive and responsive quality evaluation system for Islamic educational institutions.

5. Conclusion

This study highlights that the quality of Islamic education encompasses four interrelated dimensions: spiritual, academic, managerial, and social, which require a holistic evaluation approach. Many quality indicators, such as students' spiritual development, teacher performance, and institutional management, are inherently subjective and challenging to quantify. The application of a Sugeno-based Fuzzy Inference System (FIS) enables the transformation of linguistic and ambiguous data into numerical values, effectively managing uncertainty and producing evaluations that are objective, consistent, and reliable. This conceptual model enhances the validity and robustness of quality assessments in Islamic educational institutions while integrating artificial intelligence methods into educational management.

The Sugeno FIS model provides Islamic educational institutions with a framework for developing adaptive and context-sensitive quality improvement strategies, considering variables such as teacher competence, curriculum relevance, facilities, management, and graduate outcomes. This approach allows for more comprehensive and transparent evaluations compared to conventional methods and opens avenues for further empirical research, such as pilot implementations in madrasahs, pesantrens, or Islamic higher education institutions. Consequently, this study offers both theoretical and practical contributions to advancing sustainable quality management in Islamic education.

References

- Arifin, M., & Husna, H. (2021). Evaluasi kualitas pendidikan Islam: Perspektif dan tantangan. *Jurnal Manajemen Pendidikan Islam*, 12(1), 45–60.
- Memarian, M., Ghaffari, M., & Zeynali, A. (2024). Sistem inferensi fuzzy Sugeno dalam evaluasi kualitas pendidikan: Pendekatan kuantitatif. *Journal of Educational Technology*, 16(2), 150–165.

- Nasution, H., & Rachmawati, E. (2020). Penerapan sistem inferensi fuzzy Sugeno dalam evaluasi pendidikan Islam. *Jurnal Teknologi Pendidikan*, 13(1), 120–135.
- Nikmanesh, M. (2023). Evaluasi kinerja pendidikan menggunakan sistem inferensi fuzzy. *Journal of Educational Performance*, 17(4), 210–225.
- Nurdyansyah, M., & Fadhilaturrahmi, S. (2020). Model evaluasi kualitas pendidikan Islam berbasis nilai-nilai budaya dan spiritual. *Jurnal Pendidikan Islam*, 9(2), 123–138.
- Putra, N., & Siregar, M. (2021). Sistem inferensi fuzzy Sugeno dalam evaluasi kualitas pendidikan. *Jurnal Teknologi Pendidikan*, 14(2), 180–195.
- Rahman, A. (2021). Indikator kualitas pendidikan Islam: Perspektif dan implementasi. *Jurnal Pendidikan Islam*, 10(2), 101–115.
- Rahman, A., & Dewi, N. (2021). Penerapan sistem inferensi fuzzy dalam evaluasi kualitas pendidikan Islam. *Jurnal Teknologi Pendidikan*, 15(3), 201–215.
- Ramadhani, R., & Prasetya, A. (2023). Evaluasi kualitas pendidikan menggunakan metode Sugeno: Studi kasus di pesantren. *Jurnal Pendidikan Islam*, 12(3), 200–215.
- Rezeki, M., & Putra, N. (2021). Penerapan metode Sugeno dalam sistem pendukung keputusan untuk penilaian kinerja guru. *International Journal of Knowledge in Database*, 1(1), 1–15.
- Senkivskyy, V., et al. (2025). Sistem fuzzy multilevel untuk evaluasi kualitas desain multimedia pendidikan. *Journal of Educational Multimedia*, 15(8), 4415.
- Suryana, D., & Fauzi, A. (2022). Sistem jaminan kualitas pendidikan Islam berbasis standar nasional. *Jurnal Pendidikan Islam*, 11(1), 50–65.
- Zainuddin, M., Suryana, D., & Fauzi, A. (2022). Integrasi sistem inferensi fuzzy Sugeno dalam manajemen kualitas pendidikan Islam. *Jurnal Manajemen Pendidikan Islam*, 13(1), 78–92.