Istifkar
Media Transformasi Pendidikan

ISSN 1979-2794
e-ISSN: 2655-6634

OPTIMIZING BUDGET ALLOCATION FOR SUPPORTING EDUCATIONAL FACILITIES IN ISLAMIC BOARDING SCHOOLS

Muhammad Ali Gunawan[1]
guns12380@gmail.com

Sabilal Rosyad[2]
sabilfahnisan@yahoo.com

Hawa Husna Ab Ghani[3]
husnaghani@unisza.edu.my

[1]Sekolah Tinggi Aagama Islam Ki Ageng Pekalongan, Pekalongan
[2]Sekolah Tinggi Aagama Islam Ki Ageng Pekalongan, Pekalongan
[3]Universiti Sultan Zainal Abidin, Terengganu, Malaysia

Abstrak

Mengoptimalkan alokasi anggaran untuk fasilitas pendidikan di pesantren merupakan langkah penting dalam memastikan kualitas pendidikan yang berkelanjutan. Penelitian ini bertujuan untuk mengoptimalkan alokasi anggaran guna mendukung fasilitas pendidikan di Pesantren Al-Qutub, Wonopringgo, Kabupaten Pekalongan, dengan pendekatan Bayesian Decision Making menggunakan metode Markov Chain Monte Carlo (MCMC). Data dikumpulkan melalui angket, observasi, dan wawancara untuk memperoleh informasi tentang kondisi fasilitas, alokasi anggaran saat ini, serta kebutuhan tambahan fasilitas. Analisis data menggunakan metode MCMC, memungkinkan pengambilan keputusan berdasarkan distribusi probabilistik dari data yang terkumpul. Hasil penelitian menunjukkan bahwa alokasi anggaran yang dioptimalkan melalui model Bayesian menghasilkan distribusi yang lebih efektif, dengan fokus pada prioritas fasilitas yang mendesak dan secara langsung meningkatkan kualitas pendidikan. Studi ini berkontribusi pada model analisis anggaran yang dapat diterapkan di lembaga pendidikan Islam di Indonesia. Secara teoretis, penelitian ini memperkaya literatur tentang manajemen anggaran pendidikan di pesantren dengan pendekatan statistik Bayesian. Secara praktis, penelitian ini membantu pengelola pesantren dalam mengalokasikan anggaran secara lebih efisien dan akurat sesuai dengan kebutuhan pendidikan.

Kata kunci: Optimasi Alokasi Anggaran, Pesantren, Pengambilan Keputusan Bayesian, *Markov Chain Monte Carlo* (MCMC), Fasilitas Pendidikan.

Abstract

Optimizing budget allocation for educational facilities in Islamic boarding schools is essential to ensure sustainable education quality. This study aims to optimize budget allocation to support educational facilities at Al-Qutub Islamic Boarding School, Wonopringgo, Pekalongan Regency, using a Bayesian Decision Making approach with the Markov Chain Monte Carlo (MCMC) method. Data were collected through questionnaires, observations, and interviews to gather insights on facility conditions, current budget allocation, and additional facility needs. Data analysis employed the MCMC method, enabling decision-making based on the probabilistic distribution of the collected data. The findings indicate that budget allocation optimized through the Bayesian model results in a more effective distribution, addressing urgent facility priorities that directly enhance educational quality. This study contributes a budget analysis model applicable to Islamic educational institutions in Indonesia. Theoretically, it enriches the literature on educational budget management in Islamic boarding schools using Bayesian statistical approaches, while practically, it assists school administrators in allocating budgets more efficiently and accurately in line with educational needs.

***Keywords**: Budget Allocation Optimization, Islamic Boarding Schools, Bayesian Decision Making, Markov Chain Monte Carlo (MCMC), Educational Facilities*.

A. INTRODUCTION

The effective allocation of financial resources is crucial for Islamic boarding schools, known as Pondok Pesantren, to sustain and improve their educational facilities. These institutions often face financial constraints due to their reliance on public support and limited internal revenue. Strategic budgeting is therefore essential to ensure educational goals are met without compromising quality.[1] Although Islamic boarding school make significant contributions to both religious and general education, they often lack the necessary infrastructure to support a modern educational environment.[2] Budget

[1] Amos, O., Ephrahem, G., & Bhoke-Africanus, A. (2021). Effectiveness of School Heads' Financial Management Skills in Provision of Quality Education in Secondary School. *Journal of Education, Society and Behavioural Science*, 20–28. https://doi.org/10.9734/jesbs/2021/v34i230302

[2] El Syam, R. S., & Haryanto, S. (2023). Innovation of Islamic Education System in Pondok Boarding. *BIRCI-Journal*. https://doi.org/10.33258/birci.v5i2.4995

allocation in Islamic boarding school is essential not only for facility improvement but also for enhancing teaching quality and student outcomes.[3]

Previous research has explored various methods of budget allocation in educational settings. A particularly promising approach is Bayesian Decision Theory, which enables probabilistic assessments and dynamic adjustments based on continuously updated data.[4] Studies indicate that Bayesian models, such as those implemented through Markov Chain Monte Carlo (MCMC) methods, offer a more robust decision-making framework, especially in contexts with complex, multi-faceted needs like Islamic boarding school.[5] These statistical methods are valued for their ability to incorporate prior information and refine decisions over time, making them suitable for environments with financial limitations and diverse facility requirements.

Despite these advancements, a research gap remains in exploring how Bayesian models can optimize budget allocation specifically for Islamic boarding school. While traditional schools may benefit from such methods, Islamic boarding school face unique challenges tied to their dual role in providing both religious and general education.[6] Existing research rarely considers these distinctions, impacting the applicability of conventional budgetary models to Islamic boarding school. Additionally, most studies have yet to adequately examine how Bayesian frameworks can directly support budget allocation decision-making in religiously affiliated institutions.

---

[3] Mukti, A., Budianti, Y., & Hamdani, H. (2020). The Financial Aspects of Islamic Education (An Idea to Improve the Quality of Islamic Education in Islamic Boarding Schools). *International Journal for Educational and Vocational Studies*, *2*(12). https://doi.org/10.29103/ijevs.v2i12.3042

[4] Francesco, D. Di. (2021). *Bayesian Data Analysis of Imperfect Information for Decision-Theoretic Approaches to Structural Integrity Management*.

[5] Hanada, M., & Matsuura, S. (2022). MCMC from Scratch: A Practical Introduction to Markov Chain Monte Carlo. In *MCMC from Scratch: A Practical Introduction to Markov Chain Monte Carlo*. Springer Nature. https://doi.org/10.1007/978-981-19-2715-7

[6] Lundeto, A., Talibo, I., & Nento, S. (2021). Challenges and Learning Strategies of Islamic Education in Islamic Boarding Schools in the Industrial Revolution Era 4.0. *AL-ISHLAH: Jurnal Pendidikan*, *13*(3), 2231–2240. https://doi.org/10.35445/alishlah.v13i3.1153

Addressing this gap is urgent given the role of Islamic boarding school in Indonesia's socio-educational landscape. With increasing demands for educational quality and facility management, Islamic boarding school administrators require reliable tools to effectively optimize their limited resources.[7] By focusing on budget allocation for educational facilities, this study responds to the pressing need for a systematic and evidence-based approach, specifically tailored to Islamic educational settings. An optimized budget framework suited to the unique structure and needs of Islamic boarding school is not only necessary but timely, considering evolving educational standards.

This study contributes to the field by proposing a practical model for budget allocation that leverages Bayesian Decision-Making through MCMC, tailored to the needs of Islamic boarding school. Addressing the challenges of facility management and financial resource allocation in Islamic boarding school, this study aims to provide a replicable model that can benefit similar institutions across Indonesia and beyond. The model is designed to support decision-makers in Islamic boarding school by providing a structured approach to budget distribution based on probabilistic data, thus reducing uncertainty and maximizing the utility of limited funds.

The primary objective of this study is to evaluate and implement a Bayesian approach to optimize budget allocation for educational facilities at Al-Qutub Islamic Boarding School in Wonopringgo, Pekalongan. This includes a practical application of MCMC to address various budgetary needs and facility requirements. By combining Bayesian Decision Theory with real-world data from Islamic boarding school, this study aims to establish a robust decision-making framework that meets both current and future facility needs, supporting long-term educational improvements in Islamic boarding schools.

[7] Sulastri, S. E., Sari, T. L., Marlina, Y., Wijaya, E. R., & Hidayah, N. (2022). Operational Financial Management of Jami'atul Qura'wal Hufadz Islamic Boarding School Palembang. *Journal Corner of Education, Linguistics, and Literature*, *2*(2), 181–190. https://doi.org/10.54012/jcell.v2i2.94

B. METHOD

This study utilized a mixed-methods approach, combining quantitative and qualitative data collection to assess the budgetary needs for educational facilities at Al-Qutub Islamic Boarding School, Wonopringgo, Pekalongan. Quantitative data was obtained through structured questionnaires administered to administrators, teachers, and facility management staff, providing insights into current budget allocations and perceptions of facility needs. This structured data served as a foundation to assess financial prioritization. In addition, qualitative data from in-depth interviews and observations provided nuanced perspectives on operational challenges, facility requirements, and perceived impacts on education quality, aligning with literature that emphasizes multi-source data for complex educational assessments.[8] This mixed-method approach allowed the study to capture both measurable data and contextual insights, essential for implementing the Bayesian Decision-Making framework.

Data analysis employed the Bayesian Decision-Making framework through the Markov Chain Monte Carlo (MCMC) method, executed in R for precise modelling. R was selected for its statistical libraries that support Bayesian analysis, such as "rjags" and "Stan", enabling MCMC simulations to estimate optimal posterior distributions. Recent studies have highlighted Bayesian methods' effectiveness in refining budget allocations under uncertainty, especially in resource-limited educational settings.[9] Using these tools, the model iteratively simulated budget allocation scenarios, allowing a probabilistic assessment of outcomes to address varying facility needs. The MCMC method allowed the model to generate dynamic budget distributions that reflect the institution's unique

[8] de Villiers, C., Farooq, M. B., & Molinari, M. (2022). Qualitative research interviews using online video technology – challenges and opportunities. *Meditari Accountancy Research*, *30*(6), 1764–1782. https://doi.org/10.1108/MEDAR-03-2021-1252

[9] Rens van de Schoot et al., "Bayesian Statistics and Modelling," *Nature Reviews Methods Primers* 1, no. 1 (2021), https://doi.org/10.1038/s43586-020-00001-2.

priorities, aligning with research that supports Bayesian methods for flexible, data-informed decisions in educational institutions.[10]

The analysis process in R also involved comprehensive pre-processing of data, ensuring reliability for Bayesian analysis by handling missing values, standardizing responses, and merging datasets. Visualization tools, particularly **"ggplot2"** and **"bayesplot"**, facilitated interpretable representations of budget priorities, with recent studies recommending visual aids for decision-making in educational contexts to ensure accessible interpretations of complex data.[11] R's adaptability thus supported a structured,[12] reproducible approach to model validation,[13] convergence checks,[14] and output visualization,[15] reinforcing the study's objectives of evidence-based, actionable recommendations for budget allocation. This method provides a scalable model applicable to similar educational settings facing financial constraints.

C. RESULTS AND DISCUSSION

Before proceeding with further analysis, the descriptive statistics from the collected data provide essential insights into the fundamental characteristics of the study variables. Table 1 presents a summary of the mean, standard deviation (SD), naive standard error (Naive SE), and time-series standard error (Time-series SE) for the primary

[10] Tolba, Ahlam. (2022). Bayesian and Non-Bayesian Estimation Methods for Simulating the Parameter of the Akshaya Distribution. *Computational Journal of Mathematical and Statistical Sciences*, *1*(1), 13–25. https://doi.org/10.21608/cjmss.2022.270897

[11] Tomaszewski, L. E., Zarestky, J., & Gonzalez, E. (2020). Planning Qualitative Research: Design and Decision Making for New Researchers. *International Journal of Qualitative Methods*, *19*. https://doi.org/10.1177/1609406920967174

[12] Barry J. Grant, Lars Skjærven, and Xin Qiu Yao, "The Bio3D Packages for Structural Bioinformatics," *Protein Science* 30, no. 1 (2021): 20–30, https://doi.org/10.1002/pro.3923.

[13] Nalini Schaduangrat et al., "Towards Reproducible Computational Drug Discovery," *Journal of Cheminformatics* 12, no. 1 (2020): 1–30, https://doi.org/10.1186/s13321-020-0408-x.

[14] Gordon W. Cheung et al., *Reporting Reliability, Convergent and Discriminant Validity with Structural Equation Modeling: A Review and Best-Practice Recommendations, Asia Pacific Journal of Management*, vol. 41 (Springer US, 2024), https://doi.org/10.1007/s10490-023-09871-y.

[15] David Barnett, Ilja Arts, and John Penders, "MicroViz: An R Package for Microbiome Data Visualization and Statistics," *Journal of Open Source Software* 6, no. 63 (2021): 3201, https://doi.org/10.21105/joss.03201.

model parameters: mu (mean perception) and sigma (perception variation). Additionally, Table 1 shows the quantiles for each variable, including the median (50%) and quantile range (2.5% to 97.5%), which helps to understand the probability distribution of the data.

Table 1. Descriptive Statistic and Quantiles for each variable

Descriptive Statistic

	Mean	**SD**	**Naive SE**	**Time-series SE**
mu	2,720	0,148	0,001	0,001
sigma	1,470	0,107	0,001	0,001

Quantiles for each variable

	2,50%	**25%**	**50%**	**75%**	**97,50%**
mu	2,431	2,621	2,721	2,82	3,003
sigma	1,277	1,395	1,462	1,538	1,693

Table 1 above, shows a mean (mu) value of 2.720, indicating that respondents' perceptions are generally slightly above the midpoint on the scale used, suggesting a neutral to moderately positive tendency regarding the observed variable. The standard deviation (sigma) of 1.470 reflects moderate variation in respondents' perceptions, highlighting differences in their assessments or experiences related to facility budget allocation. The naive standard error (Naive SE) for mu is 0.001, suggesting that the sample mean provides a fairly accurate estimate of the population mean. The time-series standard error (Time-series SE) is similarly close, reinforcing the consistency of the sample mean from the collected data.

The quantile distribution for mu and sigma also demonstrates consistency and data spread. The median (50%) of mu is 2.721, aligning with the mean, while the 25% to 75% quantile range lies between 2.621 and 2.82, indicating that most respondents fall within a similar perception range. For sigma, the median value is 1.462, with the 25% to 75% quantile range between 1.395 and 1.538, showing a somewhat centralized distribution with acceptable variability. The 2.5% to 97.5% quantile range further highlights the extreme data values without showing significant outliers, supporting the stability of results within the Bayesian model applied.

To verify the convergence and posterior distribution of the primary parameters analyzed, namely mu (mean perception) and sigma (perception variability), the following plots display the trace and density plots from the MCMC analysis for these parameters. The trace plot examines whether the MCMC process has achieved convergence, while the density plot shows the shape of each parameter's posterior distribution, indicating the most likely range of values. These visualizations help confirm that the Bayesian model estimates are stable and reliable, supporting decision-making in facility budget allocation.

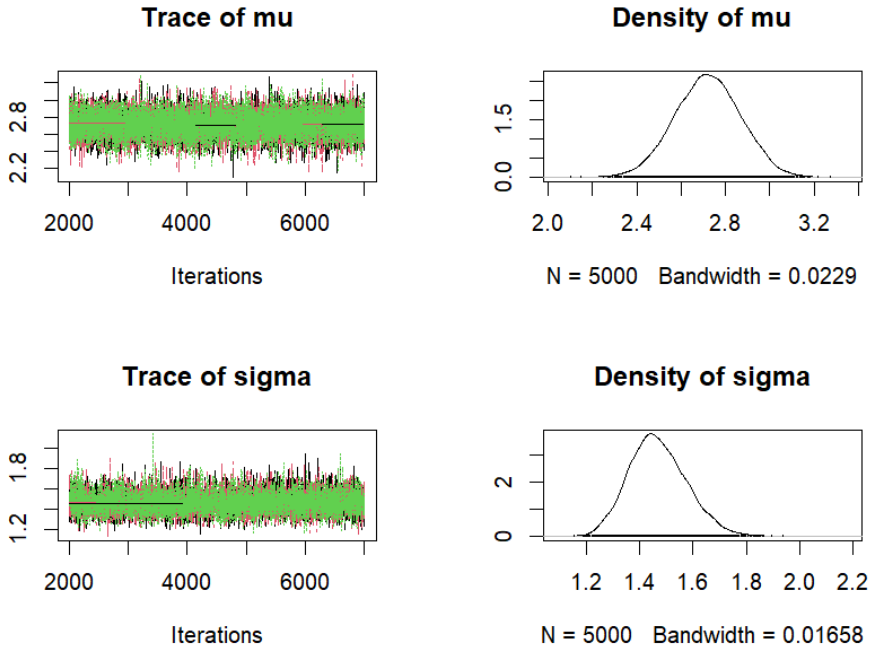

Figure 1. **Trace Plot and Density Plot**

Figure 1 shows the MCMC analysis results for the parameters mu and sigma. The trace plots on the left indicate convergence for both parameters, mu and sigma, which appear stable and do not exhibit any patterns or trends, suggesting that the MCMC process has achieved good convergence. The posterior distribution for mu (top) peaks around 2.7, while the distribution for sigma (bottom) peaks around 1.4. The density plots on the right display bell-shaped (normal) posterior distributions for both parameters, showing that the

parameter estimates are within a stable and centered range without extreme dispersion. This indicates that the data has a distribution centered around specific values with moderate variation, making it reliable for further decision-making within the Bayesian model.

As a follow-up, the following posterior distribution plots display the estimated parameters mu and sigma to validate the analysis results.

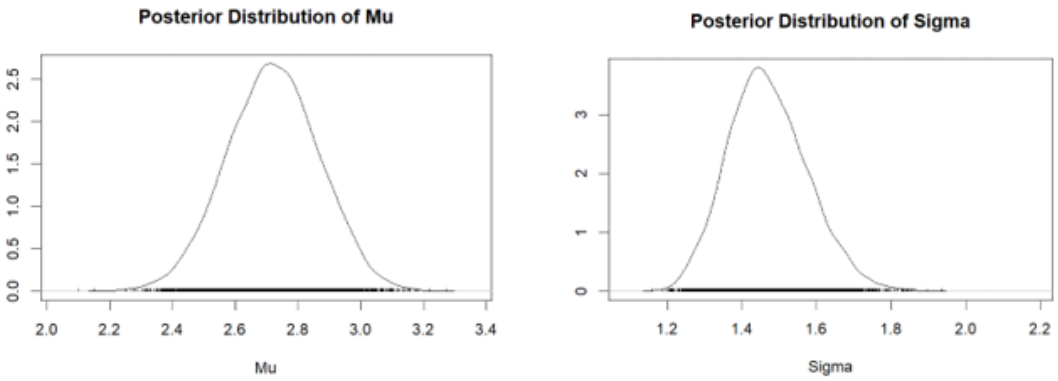

Figure 2. Posterior Distribution of Mu and Sigma

The above plots show the posterior distributions for the parameters mu (on the left) and sigma (on the right) obtained from Bayesian analysis. The distribution of mu peaks around 2.7, indicating that the most likely mean value for this parameter is approximately at this point, with a range from about 2.4 to 3.0. The distribution of sigma peaks around 1.4, reflecting moderate variability in the data, with a range from approximately 1.2 to 1.8. The symmetric bell-shaped form in both plots suggests a nearly normal distribution, indicating stable and consistent estimates for the mean and variability parameters. This implies that the Bayesian model has successfully provided reliable parameter estimates for further interpretation in the context of budget allocation and educational facility prioritization.

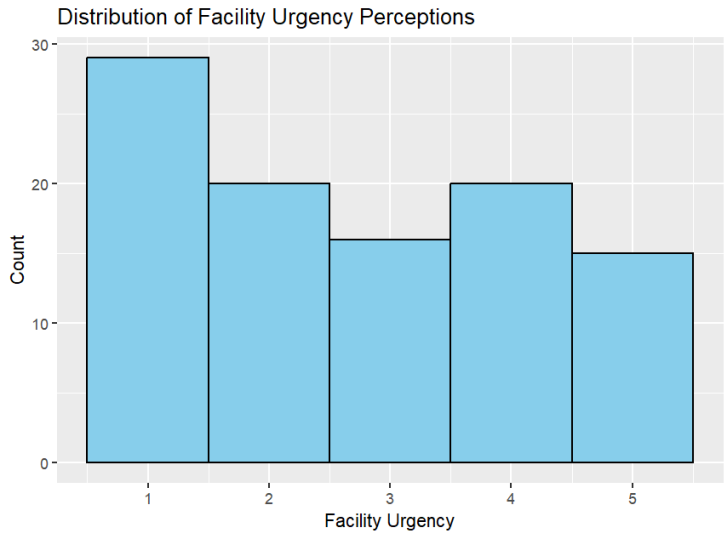

Figure 3. Distribution of Facility Urgency Perceptions

Figure 3 above shows the distribution of facility urgency perceptions in an educational institution, measured on a Likert scale from 1 to 5. In this chart, we can see those perceptions of facility urgency vary among respondents, with the majority tending to rate urgency at a low level (1), with the highest frequency around 30 respondents. A rating of 4 also shows a significant frequency, while the middle value (3) and high value (5) have relatively fewer respondents. This distribution pattern indicates that most respondents consider facility improvements or upgrades as a low priority, or they may have limited urgent needs related to facilities. However, the spread across the scale suggests that a small portion of respondents still view facility enhancements as an important, immediate priority.

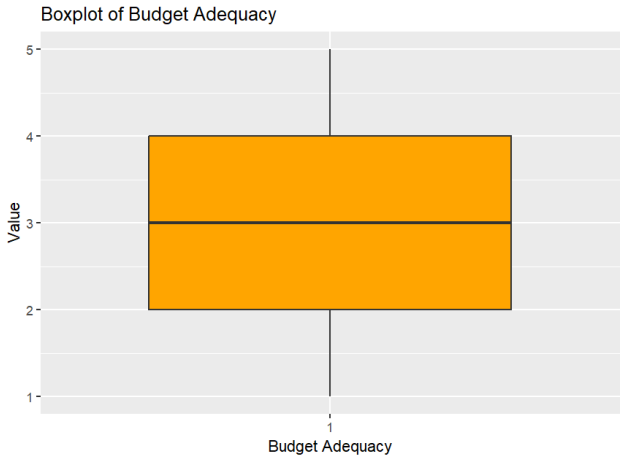

Figure 4. Boxplot of Budget Adequacy

The boxplot above illustrates respondents' perceptions of budget adequacy in an institution, using a Likert scale from 1 to 5. The median perception value is 3, indicating that most respondents have a neutral view on budget adequacy, neither too low nor too high. The interquartile range (IQR) from the first quartile (2) to the third quartile (4) encompasses most respondents' perceptions, suggesting moderate variation in budget adequacy assessments. The range from 1 to 5 shows that some respondents find the budget highly inadequate (value 1), while others perceive it as very adequate (value 5). This distribution indicates that, while the majority of respondents have a neutral or moderately positive view on budget adequacy, there is significant variation in perceptions, which may influence future budget allocation planning decisions.

The following histogram illustrates respondents' perceptions of facility urgency, providing an initial overview of budget allocation priorities.

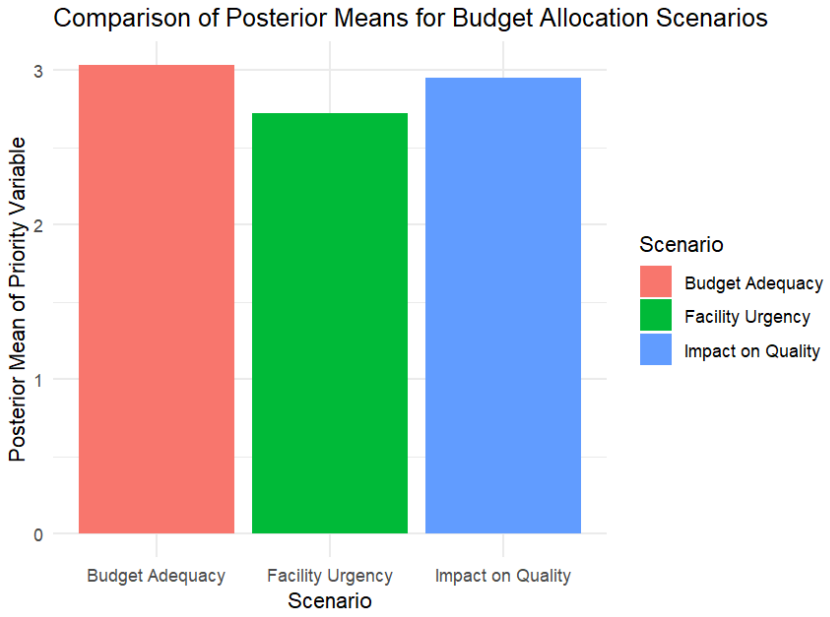

Figure 5. Comparison of Posterior Means for Budget Allocation Scenarios

The chart above shows a comparison of posterior means for three budget allocation priority scenarios: budget adequacy, facility urgency, and impact on quality. The results indicate that the highest posterior mean is in the budget adequacy scenario, followed by impact on quality, with facility urgency being the lowest. This suggests that, based on the Bayesian analysis results, the Budget Adequacy scenario is considered most important by the model, indicating that sufficient budget allocation is viewed as the top priority. The impact on quality scenario also has a high posterior mean, underscoring the importance of the budget's effect on educational quality. Meanwhile, Facility Urgency has a lower priority within this budget distribution. This interpretation can support decision-making in budget allocation, with a primary focus on budget adequacy and its direct impact on educational quality.

D. DISCUSSION

The analysis results indicate that perceptions of budget adequacy hold a high priority in budget allocation. This suggests that the majority of respondents consider

adequate budget allocation to meet educational facility needs to be essential. This study aligns with findings from,[16] which show that effective budget allocation significantly impacts educational quality in resource-constrained environments. When budget adequacy becomes a priority, it implies that basic needs must be fulfilled before moving towards further quality improvements. In the context of Islamic boarding school, which generally have limited funding, it is crucial to ensure that available resources cover essential needs.

The posterior distribution results reveal that impact on quality, or the effect of the budget on educational quality, is also a high priority after budget adequacy. These findings highlight the importance of allocating the budget not only to meet basic needs but also to directly enhance quality. Research by shows that budget management focused on quality improvement yields significant impacts on student satisfaction and academic outcomes.[17] Improved educational quality through proper budget allocation not only enhances the learning environment but also boosts student motivation and teacher satisfaction, contributing to better overall results.

On the other hand, facility urgency ranks lower in priority within the Bayesian model. Although perceptions of facility urgency are important, the data shows that respondents consider facility needs as something that can be delayed compared to budget adequacy and impact on educational quality. This perception arises from the belief that facilities can be gradually improved or upgraded without directly affecting the educational process. This finding is supported by research from which indicates that prioritizing facilities often depends on specific situations and may not always be a primary factor in Islamic education environments.[18]

---

[16] O. Vasylevska, H., Pozdieieva, K., Ivashchenko, O., Shapoval, O., & Kurtsev, "Budgetary Fund Management in Resource-Constrained Environments: Financing Strategies.," *Multidisciplinary Science Journal* 6 (2024), https://doi.org/https://doi.org/10.31893/multiscience.2024ss0727.

[17] Wan Hoong Wong and Elaine Chapman, "Student Satisfaction and Interaction in Higher Education," *Higher Education* 85, no. 5 (2023): 957–78, https://doi.org/10.1007/s10734-022-00874-0.

[18] Muhammad Annas Budiarto and Unik Hanifah Salsabila, "Optimizing Islamic Education Towards the Golden Era of Indonesia," *Tafkir: Interdisciplinary Journal of Islamic Education* 3, no. 1 (2022): 1–19, https://doi.org/10.31538/tijie.v3i1.105.

According to an interview with the management of Al-Qutub Islamic boarding school, one respondent stated, "Facilities are important, but as long as basic needs, such as teacher salaries and class operations, are met, facility improvements can wait. We always try to ensure that teaching and teacher welfare are the top priorities in budget allocation." This statement aligns with the analysis results, indicating that as long as basic needs are met, the primary focus can be directed toward quality and operational aspects of education rather than facility upgrades.

The histogram results for facility urgency perceptions show that most respondents rate the urgency of facilities as low. This distribution confirms that the majority of respondents do not feel an urgent need for facility improvements at the moment. This is consistent with research suggesting that in Islamic boarding school settings, there is often a greater focus on the substance of teaching than on physical infrastructure.[19] Physical facilities that are perceived as less urgent can be a reasonable choice in a resource-constrained environment where administrators prioritize direct teaching aspects.

In an interview with the management of Al-Qutub Islamic boarding school, one administrator stated, "We understand the importance of adequate facilities, but for us, the primary priority is ensuring that teaching and learning activities run smoothly. Facility improvements will be carried out gradually as budget allows." This statement reflects a common view among Islamic boarding school administrators, who prioritize the smoothness of the learning process and teaching quality over physical facility enhancements. This shows that, as long as educational goals are met, facility improvements can be postponed or carried out gradually according to budget constraints.

The boxplot analysis for budget adequacy shows that respondents hold neutral to moderately positive views on existing budget adequacy. This indicates that most basic operational needs are met, though there is room for improvement. These findings suggest

[19] Adri Lundeto, Ishak Talibo, and Shinta Nento, "Challenges and Learning Strategies of Islamic Education in Islamic Boarding Schools in the Industrial Revolution Era 4.0," *AL-ISHLAH: Jurnal Pendidikan* 13, no. 3 (2021): 2231–40, https://doi.org/10.35445/alishlah.v13i3.1153.

that Islamic boarding school have enough funds to cover basic operations but may lack sufficient funds for expansion or further facility upgrades. Research by confirms that Islamic boarding school often need to prioritize their budgets very carefully to ensure that basic operational needs remain the main focus.[20]

In the context of the Bayesian model, the emphasis on budget adequacy and impact on educational quality demonstrates an approach consistent with literature on decision-making in resource-constrained educational environments. Bayesian Decision Theory allows Islamic boarding school administrators to assess needs and priorities probabilistically, helping to address uncertainty in budget allocation With this model, Islamic boarding school can allocate funds optimally by considering the probability of more beneficial outcomes, making the allocation more efficient and relevant to fundamental needs.[21]

The scenario comparison in this analysis also highlights the flexibility of Bayesian Decision-Making in adjusting budget allocation priorities according to different contextual needs. In this scenario, budget adequacy and impact on quality receive primary attention, while facility urgency ranks lower. This flexibility allows Islamic boarding school to make adaptive decisions aligned with changing conditions and short-term or long-term needs. This is crucial because conditions in Islamic boarding school can vary widely depending on economic factors, student numbers, and community support, as explained by in the context of Islamic educational settings.[22]

---

[20] Abd Mukti, Yusnaili Budianti, and Hamdani Hamdani, "The Financial Aspects of Islamic Education (An Idea to Improve the Quality of Islamic Education in Islamic Boarding Schools)," *International Journal for Educational and Vocational Studies* 2, no. 12 (2020): 987–94, https://doi.org/10.29103/ijevs.v2i12.3042.

[21] Eduarda Asfora Frej et al., "Collaborative Decision Model for Allocating Intensive Care Units Beds with Scarce Resources in Health Systems: A Portfolio Based Approach under Expected Utility Theory and Bayesian Decision Analysis," *Mathematics* 11, no. 3 (2023), https://doi.org/10.3390/math11030659.

[22] Zalik Nuryana et al., "Mapping the Landscape of Inclusive Education in Islamic Educational Contexts," *Al-Misbah (Jurnal Islamic Studies)* 12, no. 1 (2024): 1–17, https://doi.org/10.26555/almisbah.v12i1.7988.

Theoretically, this study enriches the literature on educational budget management in Islamic boarding schools by demonstrating the application of Bayesian Decision Making through the MCMC method, highlighting its potential in handling budget allocation under resource constraints and uncertainty. Practically, the findings provide a replicable budgeting model that administrators of Islamic boarding schools can adopt to prioritize essential educational needs effectively, ensuring that limited funds are allocated to areas with the most significant impact on educational quality. This approach not only supports better financial decision-making but also aligns with the institutional goals of sustaining both religious and academic education within a constrained budget environment.

E. CONCLUSION

The analysis results indicate that budget adequacy and its direct impact on educational quality are the top priorities, while facility urgency ranks lower. These findings confirm that the Bayesian model helps *Islamic boarding school* allocate their budgets more efficiently and effectively, thereby supporting the sustainability and overall improvement of educational quality. A limitation of this study lies in its focus on a single *Islamic boarding school*, so the results may not fully represent all *Islamic boarding school*. Future research is recommended to expand the sample and include additional variables, such as stakeholder participation, to gain a more comprehensive view of budget allocation needs within *Islamic boarding school* environments.

Daftar Pustaka

Amos, O., Ephrahem, G., & Bhoke-Africanus, A. (2021). Effectiveness of School Heads' Financial Management Skills in Provision of Quality Education in Secondary School. *Journal of Education, Society and Behavioural Science*, 20–28. https://doi.org/10.9734/jesbs/2021/v34i230302

Barnett, D., Arts, I., & Penders, J. (2021). microViz: an R package for microbiome data visualization and statistics. *Journal of Open Source Software*, *6*(63), 3201. https://doi.org/10.21105/joss.03201

Biondi, L., & Russo, S. (2022). Integrating strategic planning and performance management in universities: a multiple case-study analysis. *Journal of Management and Governance*, *26*(2), 417–448. https://doi.org/10.1007/s10997-022-09628-7

Budiarto, M. A., & Salsabila, U. H. (2022). Optimizing Islamic Education Towards the Golden Era of Indonesia. *Tafkir: Interdisciplinary Journal of Islamic Education*, *3*(1), 1–19. https://doi.org/10.31538/tijie.v3i1.105

Cheung, G. W., Cooper-Thomas, H. D., Lau, R. S., & Wang, L. C. (2024). Reporting reliability, convergent and discriminant validity with structural equation modeling: A review and best-practice recommendations. *Asia Pacific Journal of Management*, *41*(2), 745–783. https://doi.org/10.1007/s10490-023-09871-y

de Villiers, C., Farooq, M. B., & Molinari, M. (2022). Qualitative research interviews using online video technology – challenges and opportunities. *Meditari Accountancy Research*, *30*(6), 1764–1782. https://doi.org/10.1108/MEDAR-03-2021-1252

El Syam, R. S., & Haryanto, S. (2023). Innovation of Islamic Education System in Pondok Boarding. *BIRCI-Journal*. https://doi.org/10.33258/birci.v5i2.4995

Falqueto, J. M. Z., Hoffmann, V. E., Gomes, R. C., & Onoyama Mori, S. S. (2020). Strategic planning in higher education institutions: what are the stakeholders' roles in the process? *Higher Education*, *79*(6), 1039–1056. https://doi.org/10.1007/s10734-019-00455-8

Francesco, D. Di. (2021). *Bayesian Data Analysis of Imperfect Information for Decision-Theoretic Approaches to Structural Integrity Management*.

Frej, E. A., Roselli, L. R. P., Alberti, A. R., Britto, M. A., de Barros Campelo Júnior, E., Ferreira, R. J. P., & de Almeida, A. T. (2023). Collaborative Decision Model for Allocating Intensive Care Units Beds with Scarce Resources in Health Systems: A

Portfolio Based Approach under Expected Utility Theory and Bayesian Decision Analysis. *Mathematics*, *11*(3). https://doi.org/10.3390/math11030659

Grant, B. J., Skjærven, L., & Yao, X. Q. (2021). The Bio3D packages for structural bioinformatics. *Protein Science*, *30*(1), 20–30. https://doi.org/10.1002/pro.3923

Hanada, M., & Matsuura, S. (2022). MCMC from Scratch: A Practical Introduction to Markov Chain Monte Carlo. In *MCMC from Scratch: A Practical Introduction to Markov Chain Monte Carlo*. Springer Nature. https://doi.org/10.1007/978-981-19-2715-7

Lim, W. M. (2024). What Is Qualitative Research? An Overview and Guidelines. *Australasian Marketing Journal*. https://doi.org/10.1177/14413582241264619

Lundeto, A., Talibo, I., & Nento, S. (2021). Challenges and Learning Strategies of Islamic Education in Islamic Boarding Schools in the Industrial Revolution Era 4.0. *AL-ISHLAH: Jurnal Pendidikan*, *13*(3), 2231–2240. https://doi.org/10.35445/alishlah.v13i3.1153

Mezmir, E. A. (2020). Qualitative Data Analysis: An Overview of Data Reduction, Data Display and Interpretation. *Research on Humanities and Social Sciences*. https://doi.org/10.7176/rhss/10-21-02

Mukti, A., Budianti, Y., & Hamdani, H. (2020). The Financial Aspects of Islamic Education (An Idea to Improve the Quality of Islamic Education in Islamic Boarding Schools). *International Journal for Educational and Vocational Studies*, *2*(12). https://doi.org/10.29103/ijevs.v2i12.3042

Nuryana, Z., Wijayati, R. D., Sa'ari, C. Z., Ead, H. A., & Malik, S. (2024). Mapping the Landscape of Inclusive Education in Islamic Educational Contexts. *Al-Misbah (Jurnal Islamic Studies)*, *12*(1), 1–17. https://doi.org/10.26555/almisbah.v12i1.7988

Osborne, N., & Grant-Smith, D. (2021). *In-depth Interviewing*. https://doi.org/https://doi.org/10.1007/978-981-16-1677-8_7

Pratolo, S., Sofyani, H., & Anwar, M. (2020). Performance-based budgeting implementation in higher education institutions: Determinants and impact on quality. *Cogent Business and Management*, *7*(1). https://doi.org/10.1080/23311975.2020.1786315

Riinawati. (2022). Strategy of Financing Management to Improve the Quality of Islamic Education Institution. *Al-Ishlah: Jurnal Pendidikan*, 2757–2768. https://doi.org/10.35445/alishlah.v14i1.1519

Rodríguez-Abitia, G., Martínez-Pérez, S., Ramirez-Montoya, M. S., & Lopez-Caudana, E. (2020). Digital gap in universities and challenges for quality education: A diagnostic study in Mexico and Spain. *Sustainability (Switzerland)*, *12*(21), 1–14. https://doi.org/10.3390/su12219069

Sahid, U., Wasliman, I., Muchtar, H. S., & Insan, H. S. (2021). Management of Student Characteristics Through Extracurricular Activities in The School Environment Based on Islamic Boarding Schools. *Munaddhomah: Jurnal Manajemen Pendidikan Islam*, *2*(2), 116–125. https://doi.org/10.31538/munaddhomah.v2i2.97

Saleh, M., & Satriawan, L. A. (2020). The Model of Islamic Boarding School Economic Development In Hidayatullah Islamic Boarding School Mataram City and Darussalam West Lombok. *IQTISHODUNA: Jurnal Ekonomi Islam*, *9*(1), 105. https://doi.org/10.36835/iqtishoduna.v9i1.474

Schaduangrat, N., Lampa, S., Simeon, S., Gleeson, M. P., Spjuth, O., & Nantasenamat, C. (2020). Towards reproducible computational drug discovery. In *Journal of Cheminformatics* (Vol. 12, Issue 1). BioMed Central Ltd. https://doi.org/10.1186/s13321-020-0408-x

Shaturaev, J. (2021). FINANCING AND MANAGEMENT OF ISLAMIC (MADRASAH) EDUCATION IN INDONESIA. *Zeszyty Naukowe Politechniki Częstochowskiej Zarządzanie*, *42*(1), 57–65. https://doi.org/10.17512/znpcz.2021.2.05

Simchowitz, M., Tosh, C., Krishnamurthy, A., Hsu, D., Lykouris, T., Dudík, M., & Schapire, R. (2021). Bayesian decision-making under misspecified priors with applications to meta-learning. *35th Conference on Neural Information Processing Systems (NeurIPS 2021)*.

South, L. F., Riabiz, M., Teymur, O., & Oates, C. J. (2024). *Annual Review of Statistics and Its Application Postprocessing of MCMC*. https://doi.org/10.1146/annurev-statistics-040220

Sulastri, S. E., Sari, T. L., Marlina, Y., Wijaya, E. R., & Hidayah, N. (2022). Operational Financial Management of Jami'atul Qura'wal Hufadz Islamic Boarding School Palembang. *Journal Corner of Education, Linguistics, and Literature*, *2*(2), 181–190. https://doi.org/10.54012/jcell.v2i2.94

Tolba, Ahlam. (2022). Bayesian and Non-Bayesian Estimation Methods for Simulating the Parameter of the Akshaya Distribution. *Computational Journal of Mathematical and Statistical Sciences*, *1*(1), 13–25. https://doi.org/10.21608/cjmss.2022.270897

Tomaszewski, L. E., Zarestky, J., & Gonzalez, E. (2020). Planning Qualitative Research: Design and Decision Making for New Researchers. *International Journal of Qualitative Methods*, *19*. https://doi.org/10.1177/1609406920967174

Urefe, O., Odonkor, T. N., Chiekezie, N. R., & Agu, E. E. (2024). Corresponding author: Oghenekome Urefe Enhancing small business success through financial literacy and education. *Magna Scientia Advanced Research and Reviews*, *2024*(02), 297–315. https://doi.org/10.30574/msarr.2024.11.2.0123

Uwamusi, C. B., & Ajisebiyawo, A. (2023). Participant Observation as Research Methodology: Assessing the Defects of Qualitative Observational Data as Research Tools. *Asian Journal of Social Science and Management Technology*, *5*(3), 2313–7410. www.ajssmt.com

van de Schoot, R., Depaoli, S., Gelman, A., King, R., Kramer, B., Kaspar, M., Tadesse, M. G., Vannucci, M., Veen, D., Willemsen, J., & Yau, C. (2021). Bayesian statistics and modelling. *Nature Reviews Methods Primers*, *1*(1). https://doi.org/10.1038/s43586-020-00003-0

Vasylevska, H., Pozdieieva, K., Ivashchenko, O., Shapoval, O., & Kurtsev, O. (2024). Budgetary fund management in resource-constrained environments: Financing strategies. In *Multidisciplinary Science Journal* (Vol. 6). Malque Publishing. https://doi.org/10.31893/multiscience.2024ss0727

Wong, W. H., & Chapman, E. (2023). Student satisfaction and interaction in higher education. *Higher Education*, *85*(5), 957–978. https://doi.org/10.1007/s10734-022-00874-0

Yusuf, F. A. (2022). An Investigation on the Learning Barriers of Boarding School Students in terms of Different Dimensions of the Curriculum Implementation. *Pegem Egitim ve Ogretim Dergisi*, *13*(1), 301–308. https://doi.org/10.47750/pegegog.13.01.33