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Assessing Waste Management and Green Technology Adoption in Enhancing Sustainable Tourism at Jabal Arafah Mosque Batam Indonesia

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ABSTRACT: The rapid growth of religious tourism contributed to increased economic and social activities but also created environmental pressures, particularly related to increased waste volume and resource use in spiritually based tourist destinations. Jabal Arafah Mosque (MJA) in Batam City, as an icon of religious tourism, faced challenges in maintaining environmental sustainability due to the high intensity of visits. In contrast, empirical studies integrating waste management and the adoption of green technology within religious tourism were still limited. This study aimed to analyse the partial and simultaneous effects of waste management implementation and green technology adoption on sustainable tourism performance at MJA. The study used a quantitative, causal-associative design involving 50 respondents, including managers, operational officers, stakeholders, traders, and visitors. Data collection was carried out using a structured questionnaire, and the data were analysed using multiple linear regression in SPSS. The analysis results showed that the implementation of waste management ($\beta = 0.562$; $p < 0.001$) and the adoption of green technology ($\beta = 0.368$; $p = 0.005$) had positive and significant effects on sustainable tourism performance, with waste management as the dominant variable. The model explained 75.8% of the variation in sustainable tourism performance ($R^2 = 0.758$). These findings confirmed that strengthening a structured waste management system, supported by the implementation of green technology, was a key strategy for improving environmental sustainability and the quality of management of religious tourism destinations.

KEYWORDS: Waste management; green technology; sustainable tourism; religious tourism; Jabal Arafah Mosque

1. Introduction

Religious tourism was a promising tourism segment, given the high public interest in religious-themed destinations [1]. In Batam City, the Jabal Arafah Mosque (MJA) in the Nagoya area became an icon of religious tourism and a centre of worship, attracting many tourists and worshippers. The development of visits to MJA reflected a global trend in which religious

tourism continued to grow as a driver of the local economy and a tool for preserving cultural values. However, according to the principles of the Sustainable Development Goals (SDGs), tourism practices needed to be aligned with sustainable development, namely balancing economic, social, and environmental benefits [2]. SDG Target 8.9, for example, emphasised the importance of sustainable tourism policies and support for local culture [3]. Therefore, destinations such as MJA needed to be managed in ways that maintained cleanliness and aesthetic quality, improved the welfare of surrounding communities, and avoided environmental degradation.

The increase in tourist and pilgrim visits to MJA posed significant challenges for waste management. Studies in Bali, for example, showed that increasing visitor numbers at holy sites were positively correlated with increased waste volume [4]. Poorly managed organic and solid waste degraded the environmental quality of a destination. Piles of mishandled waste polluted soil and water and damaged the aesthetics of tourist sites [5]. As a result, destination attractiveness declined, tourist experiences were disrupted, and sustainable tourism performance weakened. Solid waste management played a crucial role in the sustainability of tourist destinations; without effective management, achieving sustainable tourism goals was difficult [6]. Conditions in Bali also demonstrated weak coordination among stakeholders in tourism waste management [7], thereby necessitating stronger policies, multi-stakeholder participation, and community-level hygiene education.

Beyond serving as an icon of religious tourism, the Jabal Arafah Mosque (MJA) functioned as a frequently visited public space that demanded well-planned environmental management. In sustainable tourism, the success of destination management was measured not only by visitor numbers but also by the extent to which ecological impacts were minimised and long-term benefits were provided to local communities [8]. Poorly managed tourism generated significant waste, accelerated environmental degradation, and diminished the aesthetic appeal of tourist destinations [9]. Therefore, comprehensive and measurable waste management involving various stakeholders was a crucial prerequisite for realising sustainable tourism in religious areas such as MJA.

Various previous studies showed that religious tourism destinations tended to face higher environmental pressures during specific periods, particularly during religious holidays or peak seasons. Research [10] confirmed that religious tourism exhibited fluctuating but dense visitor patterns, necessitating a sustainability management approach different from that of general tourism destinations. This was reinforced by research findings [11], which stated that increasing tourist interest in spiritually valuable destinations needed to be balanced with sustainability-oriented management strategies to avoid excessive environmental burdens. At MJA, increased visits during weekends, national holidays, and major religious events resulted in a significant increase in waste volume. If not managed effectively, this accumulation of waste created negative impressions among visitors and disrupted the comfort of worship and recreational activities.

The principles of the SDGs, notably Target 8.9, which highlighted the importance of supporting sustainable tourism development, underscored the need for tourist destinations to strengthen their environmental management capacity [12]. One strategic step receiving global attention was the implementation of green technology, defined as environmentally friendly technologies designed to reduce emissions, minimise waste, increase energy efficiency, and support sustainable resource management [13]. Green technology included waste-processing

sensors, organic shredding machines, automated sorting systems, and energy-efficient devices that helped reduce the ecological footprint of tourist destinations [14]. In one study [15], the adoption of waste-processing technology in a temple area in Bali significantly reduced carbon emissions. This demonstrated that combining waste management with technological innovation strengthened the performance of culturally and religiously based tourist destinations.

In addition to technology, the implementation of structured waste management formed the foundation of successful sustainability efforts in tourist destinations [16]. The concept of integrated sustainable waste management proposed by [17] emphasised the need for synergy among government agencies, destination managers, local communities, and the private sector to build effective waste management systems. This approach included waste segregation at source, efficient collection, appropriate processing, and material reuse in accordance with the 3R principle (Reduce, Reuse, Recycle). Research [18] confirmed that suboptimal waste management practices often resulted from limited facilities, inadequate environmental literacy, and weak coordination among stakeholders. This situation could also occur in large religious tourism destinations such as MJA if clear coordination mechanisms among mosque management, cleaning staff, local vendors, and visitors were absent.

Strong waste management implementation at MJA was increasingly vital given its strategic location in the heart of Batam. This highly mobile urban area required preventive measures to avoid waste accumulation that could pollute the surrounding environment, including the commercial areas around Nagoya. Furthermore, MJA visitors came from diverse age groups and social backgrounds, resulting in varied waste-disposal behaviours. Public education-based approaches and adequate facilities were therefore needed to foster sustained environmental awareness. The use of information boards, segregated waste bins, and the “MJA Green Tourism” campaign were potential strategies to support behavioural change.

From a sustainability perspective, good tourism performance was assessed not only from an ecological perspective but also from social and economic dimensions [19]. Effective waste management implementation increased visitor satisfaction, strengthened destination image, and created new economic opportunities through segregated waste management practices, such as plastic recycling and organic waste composting [20]. Thus, waste management implementation and green technology adoption contributed not only to destination cleanliness and comfort but also generated a multiplicative effect that strengthened overall sustainable tourism performance [21]. Given the increasing urgency of sustainability in the tourism sector, research examining the effects of waste management implementation and green technology adoption on sustainable tourism performance at MJA was essential. The results of this study were expected to provide empirical contributions and practical recommendations for religious destination managers, particularly in formulating integrated and data-driven environmental policies and strategies.

2. Materials and Methods

2.1. Research design and location.

This research used a quantitative design with a causal-associative approach. This design was chosen for its effectiveness in objectively examining relationships among variables through structured data collection and statistical analysis. As Creswell explained, quantitative research

was highly effective for objectively testing theories and relationships among variables using numerical data [22]. The study focused on the Jabal Arafah Mosque (MJA) in Batam, a religious tourism icon with high visitor numbers, making it a relevant location for observing waste management and green technology issues.

2.2. Population and sampling procedure.

The research population included all stakeholders involved in the religious tourism ecosystem at MJA. Sampling was conducted using purposive sampling [22]. Respondent criteria were specifically defined (inclusion criteria) to ensure data quality: (i) Internal respondents included management, cleaners, mosque staff, and security personnel who had a technical understanding of daily cleaning and operational procedures; (ii) External respondents included traders or shop tenants in the MJA area, related stakeholders, and visitors engaged in religious tourism activities. The total sample size of 50 respondents was considered sufficient for a medium-scale quantitative research design employing regression analysis [23].

2.3. Data collection and instrumentation.

Primary data were collected using a structured questionnaire with a five-point Likert scale to measure respondents' perceptions of the variables Waste Management Implementation (X1), Green Technology Adoption (X2), and Sustainable Tourism Performance (Y) [22]. The data collection process was strengthened by direct field observations of waste-sorting facilities, environmentally friendly equipment, and visitor behaviour, which provided empirical context for the questionnaire data [23]. In addition, secondary data were obtained from MJA operational documents and relevant scientific literature.

2.4. Data quality testing.

The research instrument underwent validity testing using a corrected item–total correlation (r-count) threshold greater than 0.300 and a significance level below 0.05 [22]. Reliability testing was conducted to assess the level of internal consistency among items within each variable. A summary of the testing results is presented in Table 1.

Table 1. Summary of instrument validity and reliability tests.

Variable	Number of Items	Range of r-count	Cronbach's Alpha	Description
X1 – waste management implementation	6	0.588 - 0.702	0.874	Very Reliable
X2 – green technology adoption	5	0.589 – 0.705	0.861	Very Reliable
Y – sustainable tourism performance	6	0.612 – 0.744	0.892	Very Reliable

Table 1 presented a summary of the validity and reliability testing results of the research instruments used to measure waste management implementation (X1), green technology adoption (X2), and sustainable tourism performance (Y). The validity test results indicated that all statement items for each variable had corrected item–total correlation values above the minimum required threshold; therefore, all items were declared valid for measuring the intended constructs. In addition, the reliability test results showed that all variables had Cronbach's Alpha values above 0.80. This value indicated an excellent level of internal consistency, suggesting that the research instruments were highly reliable and suitable for

further analysis. Thus, all data obtained from the questionnaire were considered highly reliable in representing respondents' perceptions of the research variables.

2.5. Data analysis technique.

All data were analysed using multiple linear regression to determine the partial and simultaneous effects of X1 and X2 on Y. All statistical analyses were conducted using IBM SPSS Statistics (version 26). The hypothesised relationships among Waste Management Implementation (X1), Green Technology Adoption (X2), and Sustainable Tourism Performance (Y) were tested using multiple linear regression with the ordinary least squares (OLS) method, as this approach allowed the estimation of both partial and simultaneous effects of multiple predictors on a single outcome variable within a quantitative causal-associative design.

Following standard OLS modelling requirements, classical assumption tests were performed to ensure that the model produced valid and unbiased estimates (i.e., BLUE). The normality of residuals was assessed using the Shapiro–Wilk test (Sig. > 0.05). Multicollinearity was evaluated using Tolerance values greater than 0.10 and Variance Inflation Factor (VIF) values below 10. Heteroscedasticity was examined using the Glejser test (Sig. > 0.05). Model adequacy was evaluated using the F-test to assess overall model significance at $\alpha = 0.05$ and the coefficient of determination (R^2) to determine the proportion of variance in Y explained by X1 and X2.

The t-test ($\alpha = 0.05$) was used to assess the significance of each predictor, while standardised beta coefficients were employed to identify the dominant predictor. This analytical strategy was consistent with established quantitative research procedures for hypothesis testing using regression-based inference [22,23]. The analysis began with a series of classical assumption tests, including tests of normality, multicollinearity, and heteroscedasticity, to ensure that the regression model met statistical requirements. Partial tests (t-tests) were used to measure the effect of each independent variable on the dependent variable, while simultaneous tests (F-tests) were conducted to examine their joint effects. The coefficient of determination (R^2) was calculated to determine the contribution of X1 and X2 to variations in sustainable tourism performance.

3. Results and Discussion

3.1. Respondent characteristics.

Length-of-service information applied only to internal respondents (n = 22), with less than 1 year (18.2%), 1–3 years (36.4%), 3–5 years (22.7%), and more than 5 years (22.7%). Table 2 illustrated the characteristics of respondents based on gender, age, and role or position in activities at the Jabal Arafah Mosque religious tourism destination. By gender, respondents were predominantly male, although the proportion of female respondents was relatively balanced. This reflected fairly equal participation by both genders in activities and in perceptions of destination management. In terms of age group, the majority of respondents were within the productive age range, specifically those aged 18–35 years. This condition indicated that the respondents involved in the study were predominantly socially and economically active individuals who had a high level of interaction with tourism activities and the destination environment. Based on role or position, respondents were drawn not only from

internal destination management, such as cleaners, security officers, and mosque staff, but also included vendors, stakeholders, and visitors. This diversity of respondent characteristics provided a comprehensive perspective for assessing waste management implementation, green technology adoption, and sustainable tourism performance at the research site.

Table 2. Respondent characteristics

Characteristics	Category	Number	Percentage
Gender	Male	28	56%
	Women	22	44%
Age	18–25 years	14	28%
	26–35 years	18	36%
	36–45 years	10	20%
	46–55 years	8	16%
Role/Position	Janitor	5	10%
	Security Officers	4	8%
	Mosque Management	6	12%
	Merchants/Tenants	7	14%
	Stakeholders	10	20%
	Visitors	18	36%

3.2. Summary of classical assumption test.

Table 3 presented a summary of the results of the classical assumption tests conducted to assess the feasibility of the multiple linear regression model used in this study. The normality test results indicated that the significance value exceeded the established threshold, suggesting that the residual data were normally distributed. This condition confirmed that the normality assumption was satisfied. Furthermore, the multicollinearity test results showed that the tolerance values were above 0.10 and the Variance Inflation Factor (VIF) values were well below the critical limit of 10. These findings indicated that no strong correlations existed among the independent variables, ensuring that the regression model was free from multicollinearity.

Table 3. Summary of classical assumption test.

Test	Indicator	Value	Conclusion
Normality (Shapiro–Wilk)	Sig. > 0.05	0.089	Normally distributed data
Multicollinearity	Tolerance > 0.10	0.622	No multicollinearity
	VIF < 10	1.608	No multicollinearity occurs
Heteroscedasticity (Glejser)	Sig. > 0.05 (X1)	0.213	No heteroscedasticity
	Sig. > 0.05 (X2)	0.331	No heteroscedasticity occurs

The heteroscedasticity test results also showed significance values greater than 0.05 for all independent variables, indicating the absence of heteroscedasticity. With all classical assumptions met, the regression model was deemed feasible and satisfied the statistical requirements for testing the effects of waste management implementation and green technology adoption on sustainable tourism performance. The fulfilment of these classical assumptions, as detailed in Table 3, was crucial because it ensured that the regression model produced Best Linear Unbiased Estimators (BLUE). This technical foundation guaranteed that the subsequent analysis of the effects of waste management and green technology adoption was statistically sound and not biased by data distribution issues.

3.3. Multiple linear regression results.

Table 4 presented the results of the multiple linear regression analysis examining the effects of waste management implementation (X1) and green technology adoption (X2) on sustainable tourism performance (Y). The analysis results indicated that both independent variables had positive and significant influences on the dependent variable. This finding was consistent with the principle that structured management and technological support were critical for improving organisational and destination performance.

Table 4. Multiple linear regression results.

Variable	B	Beta	t	Sig.
Constant	0.811	–	3,770	0.000
X1 – Waste Management Implementation	0.521	0.562	4.521	0.000
X2 – Green Technology Adoption	0.318	0.368	2.890	0.005

Partially, waste management implementation (X1) had a regression coefficient of B = 0.521, with a t-value of 4.521 and a significance level of p = 0.000. These results indicated that improvements in waste management quality significantly enhanced sustainable tourism performance. The standardised beta coefficient of 0.562 further indicated that X1 exerted the most dominant influence in the regression model. The adoption of green technology (X2) also had a positive and significant effect on sustainable tourism performance, with a coefficient of B = 0.318, a t-value of 2.890, and a significance level of p = 0.005. The standardised beta coefficient of 0.368 indicated that although the effect of X2 was smaller than that of X1, the implementation of environmentally friendly technology still made a meaningful contribution to improving destination sustainability.

The overall feasibility of the regression model was supported by a coefficient of determination (R^2) of 0.758, indicating that the combined effects of waste management implementation and green technology adoption explained 75.8% of the variation in sustainable tourism performance. In addition, the simultaneous test results yielded an F-value of 74.800 with a significance level of p = 0.000, confirming that the overall regression model was statistically significant and adequately explained the relationships among the variables examined in this study. These findings confirmed that effective waste management played a key operational role in influencing sustainable tourism performance in religious tourism destinations, while green technology adoption served as an important supporting factor for long-term sustainability.

3.4. Descriptive statistics of research variables.

Table 5 showed that all research variables had average scores ranging from good to excellent. The sustainable tourism performance variable (Y) had the highest average score (mean = 4.21), indicating that respondents rated the sustainability performance of the Jabal Arafah Mosque religious tourism destination positively. Waste management implementation (X1) also showed a high average score (mean = 4.12), reflecting that waste management practices had been implemented relatively well at the research site. Meanwhile, the adoption of green technology (X2) had a lower average score compared to the other variables (mean = 3.87), although it still

fell within the good category. These findings indicated that the implementation of environmentally friendly technology in religious tourism destinations still had room for improvement to support optimal sustainable tourism performance.

Table 5. Descriptive statistics of research variables.

Variable	Mean	Standard Deviation	Minimum	Maximum
X1 – Waste Management Implementation	4.12	0.51	3.00	5.00
X2 – Green Technology Adoption	3.87	0.58	2.80	5.00
Y – Sustainable Tourism Performance	4.21	0.49	3.20	5.00

The relatively low standard deviation values across all variables indicated that respondents' perceptions tended to be homogeneous, reflecting a shared understanding or consistent experience among stakeholders regarding the management practices being evaluated. The high average score for sustainable tourism performance (Y), as shown in Table 5 and Figure 1, reflected a strong synergy between management efforts and visitor satisfaction. The high score for waste management implementation (X1) suggested that existing operational standards at MJA were perceived as a key driver of this positive performance. However, the comparatively lower score for green technology adoption (X2) identified a specific area where MJA could further innovate to achieve its full sustainability potential.

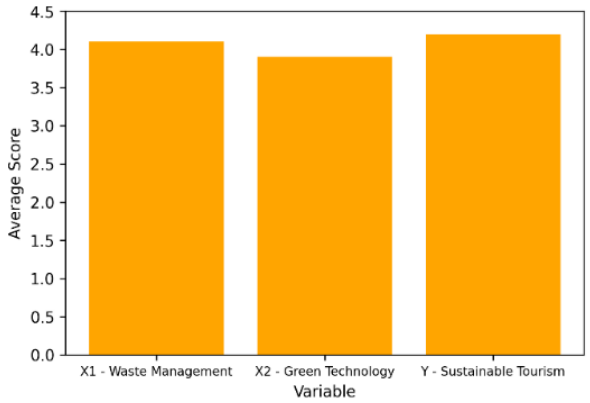

Figure 1. Average descriptive statistics of research variables.

Figure 1 showed that the sustainable tourism performance variable (Y) had the highest average value (4.21), while green technology adoption (X2) had the lowest (3.87), suggesting that the adoption of green technology still had room for improvement compared to the other variables. To examine the effects of waste management implementation (X1) and green technology adoption (X2) on sustainable tourism performance (Y), a multiple linear regression analysis was conducted. This analysis aimed to test the partial and simultaneous effects of the independent variables on the dependent variable and to determine the model's explanatory power using the coefficient of determination (R^2). The contribution of the R^2 value is visualised below.

Figure 2 displayed the proportion of the contribution of R^2. The graph showed that the regression model explained 75.8% of the variation in the Y variable, while the remaining 24.2% was unexplained by the model (e.g., community participation, policies). The graph indicated

that the combination of X1 and X2 had high explanatory power for the dependent variable, suggesting that the model was suitable for continuation in the subsequent inferential analysis.

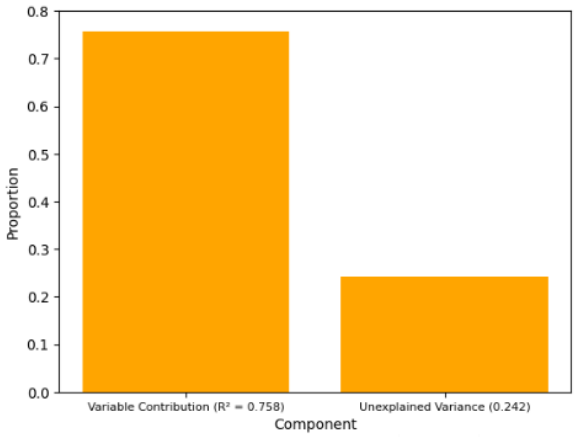

Figure 2. R^2 contribution to sustainable tourism performance.

Figure 3 showed that the t-test results indicated X1 (t = 4.521) had a more significant partial influence on Y than X2 (t = 2.890), emphasising the dominant role of X1. Overall, the inferential analysis results indicated that both waste management implementation (X1) and green technology adoption (X2) had positive and significant effects on sustainable tourism performance (Y), both partially and simultaneously. This was evidenced by the calculated t-values for each variable, which exceeded the t-table values, with significance levels of 0.000 and 0.005, respectively. In addition, the simultaneous test using the F statistic confirmed that the regression model was appropriate for describing the relationships among the research variables. The coefficient of determination (R^2) of 0.758 indicated that 75.8% of the variation in sustainable tourism performance was explained by the implementation of waste management and the adoption of green technology, with the remaining 24.2% attributable to factors outside the model. These findings confirmed that both independent variables were important factors in improving sustainable tourism performance at MJA.

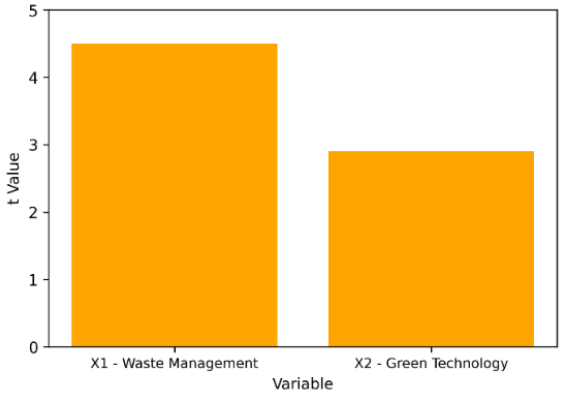

Figure 3. t-Test results for research variables.

The path diagram below illustrates the direction and causal relationships among waste management implementation (X1), green technology adoption (X2), and sustainable tourism performance (Y). The diagram showed that both independent variables had arrows pointing directly to Y, indicating a direct influence of each variable on sustainable tourism performance.

This visualisation demonstrated that waste management implementation and the adoption of green technology were primary components of sustainability in tourist destinations, as supported by statistical tests showing significant effects of both variables. The diagram helped clarify the structure of the regression model and facilitated understanding of each variable's role in improving sustainable tourism performance.

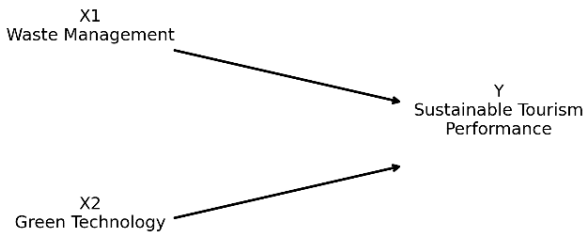

Figure 4. Research model path diagram.

Figure 4 presents a path diagram illustrating the causal relationships among the independent variables, waste management implementation (X1) and green technology adoption (X2), and the dependent variable, sustainable tourism performance (Y). In the diagram, both X1 and X2 were shown as sources of influence with arrows pointing directly toward Y, indicating a direct relationship between each independent variable and the dependent variable. The arrow from X1 to Y reflected the statistical finding that implementing waste management practices significantly improved sustainable tourism performance, highlighting that waste-sorting practices, the provision of cleaning facilities, and coordinated waste management were crucial for creating a clean, comfortable, and sustainable tourist destination. Meanwhile, the arrow from X2 to Y represented the positive influence of green technology adoption on sustainable tourism performance, reflecting the contribution of environmentally friendly technologies, such as efficient energy use, waste-processing equipment, and digital support systems for cleanliness, in supporting destination environmental management. Overall, the path diagram confirmed that both independent variables played strategic roles in influencing Y and worked in complementary ways to improve tourism sustainability at MJA. The diagram also provided an intuitive understanding of the structure of relationships in the multiple regression model and reinforced the statistical finding that the model explained most of the variation in sustainable tourism performance.

3.2. Discussion.

A comprehensive analysis of the results showed that the regression model explained 75.8% of the variation in sustainable tourism performance ($R^2 = 0.758$), indicating that waste management (X1) and green technology adoption (X2) were key pillars of sustainability at MJA. The synergy between these factors was essential, as sustainability in tourism required a balance between operational excellence and innovative solutions. Based on partial tests, waste management implementation (X1) had the most decisive influence on sustainable tourism performance (Y), supported empirically by a beta coefficient of 0.562, indicating that improvements in the waste management system had the greatest impact among the variables.

The regression results explicitly demonstrated that waste management implementation was the primary driver of sustainability at MJA. This implied that, even before investing heavily in complex technologies, the mosque's ability to maintain a clean, well-coordinated environment, reflected in the high beta coefficient, was what visitors and stakeholders valued most for long-term tourism performance. This dominance aligned with descriptive statistics and reinforced the theory that sound waste management was a fundamental component in maintaining environmental quality in tourism destinations. Previous studies consistently emphasised that effective solid waste management was not only an operational necessity but also a primary determinant of a destination's long-term viability. Practices such as waste sorting, provision of adequate trash bins, and scheduled transportation supported the cleanliness and aesthetics of MJA's environment. These findings were consistent with prior research [18,5], which highlighted that effective waste management was a key determinant of positive image and visitor satisfaction in tourism areas.

Green technology adoption (X2) also had a positive and significant effect on sustainable tourism performance (Y), although its impact was less pronounced than that of X1, as reflected by a t-value of 2.890 and a significance level of 0.005. The relatively lower mean value of 3.87, the lowest among the variables, indicated that green technology integration at MJA was still in the early stages of development. The use of energy-efficient lighting, water-saving systems, and environmentally friendly materials contributed to reducing the ecological footprint and strengthening the sustainability image of MJA. Although still emerging, this technological adoption acted as a vital catalyst for transitioning toward a circular and sustainable tourism model. Despite having the lowest descriptive mean, X2's critical relationship with Y suggested that every effort to implement green technology contributed substantially to sustainable tourism performance. This finding aligned with the concept that technological innovation is an essential driver of sustainable tourism [19,21].

Simultaneous testing confirmed that X1 and X2 together had a significant impact on Y, demonstrating that sustainable tourism performance at MJA could not rely on a single factor. Integrated efforts combining efficient waste management with the adoption of green technology were necessary. The strength of this relationship was reflected in the R^2 value of 0.758, indicating that the synergy between operational aspects (X1) and innovation (X2) explained 75.8% of the variance in sustainability performance at MJA. These findings reinforced the holistic view that achieving sustainability required integration between operational management factors (X1) and technology factors (X2). The dominance of X1 suggested that basic management practices must be solid before advanced factors could deliver optimal results.

The finding that waste management (X1) was the primary determinant was theoretically supported by the argument that environmental cleanliness is the most crucial aesthetic indicator of visitor satisfaction in religious tourism destinations. This was consistent with research [5], which showed that visitors' perceptions of cleanliness strongly shaped the image of a heritage tourism area. The dominance of X1 also confirmed the waste management hierarchy model proposed by [18], in which source sorting and adequate transportation form the operational foundations. Regarding green technology adoption (X2), although its influence was lower than X1, this finding aligned with research [4], which showed that the use of waste-processing technology in sacred areas could significantly reduce carbon emissions and ecological impacts. Theoretically, this supported the circular economy concept in tourism [16], in which

technological innovation functions as a catalyst to convert waste into valuable resources. Practically, the synergy between operational management and green technology at MJA enhanced resource efficiency and supported long-term sustainability in accordance with sustainable tourism performance standards.

4. Conclusions

This study concluded that waste management implementation (X1) and green technology adoption (X2) positively and significantly influenced sustainable tourism performance (Y) at the Jabal Arafah Mosque (MJA). Both variables were partially significant, but waste management implementation emerged as the dominant factor, exerting the greatest influence on sustainable tourism performance. This finding confirmed that operational management aspects, particularly environmental cleanliness and aesthetics, are primary determinants of sustainability at MJA. Simultaneously, the combination of these two variables also had a significant influence with a substantial contribution, indicating that achieving sustainable performance requires an integrated strategy combining efficient waste management with sustainable green technology. Therefore, a key recommendation for MJA management is to maintain and enhance the existing waste management system while expanding the scope and investment in green technology adoption to achieve optimal sustainable tourism performance. From a managerial perspective, these findings provide strategic guidance for MJA management to prioritise the standardisation of waste management operations as a foundational element for sustainability. Given that waste management was the dominant factor, management is advised to implement waste-sorting systems for traders and visitors, supported by more structured transport procedures (SOPs). Meanwhile, the relatively low average score for green technology adoption indicates the need for gradual investment in high-visibility technologies, such as automated water-saving systems or digitalised cleanliness information, to effectively enhance public perception of green tourism. These results provide empirical evidence that the integration of operational management and technology in religious destinations directly supports the achievement of SDG Target 8.9, which promotes sustainable tourism that creates jobs and preserves local culture. Since 24.2% of the variation in sustainable tourism performance remained unexplained by the model, future researchers are advised to enrich the model by including other theoretically relevant variables, such as community participation, environmental education, or local government policy, to provide a more comprehensive understanding of the determinants of performance. Additionally, future research could adopt a mixed-methods or purely qualitative approach to explore in depth the reasons behind the relatively low descriptive mean of the green technology adoption variable, identify specific barriers, and propose practical implementation solutions. To enhance the generalisability of the findings, comparative studies could be conducted between MJA and other religious tourism destinations or city icons in Batam or other regions to evaluate the effectiveness of environmental management practices and generate broader policy recommendations.

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Author Contribution

The authors declare that each author contributed to this research. Nensi Lapotulo developed the research idea, formulated the problem, and established the main hypotheses. Yudha Wardani1 and I Wayan Thariqy Kawakibi Pristiwasa1 designed the methodology, developed the questionnaire, and determined the analytical techniques. Mischella Fransiska1 handled data collection in the field, including coordination with the Jabal Arafah Mosque and verification of data completeness. Widi Hardini and Violetta Cherryline performed data analysis and interpretation. Nensi Lapotulo drafted the manuscript, while Yudha Wardani and I Wayan Thariqy Kawakibi Pristiwasa contributed to revisions and writing improvements. Violetta Cherryline provided supervision and guidance, and Haufi Sukmamedian1 secured funding and resources for the study. All authors have read and approved the final manuscript and are responsible for its content.

Competing Interest

The authors declare that they have no financial, personal, or professional conflicts of interest that could have influenced, or appear to influence, the results of this study. The entire research process, data analysis, and manuscript preparation were conducted independently without intervention from any third parties. If institutional or financial support was provided, it did not influence the interpretation, conclusions, or academic integrity of this study. Therefore, the authors confirm that this research is free from any conflict of interest.

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