



Accelerating Digital Transformation and Green Financing: Analyzing the Role of Artificial Intelligence in Enhancing Financial Inclusion and Sustainable Performance of MSMEs

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Abstract

This study aims to analyze the role of Artificial Intelligence (AI) in accelerating digital transformation and green financing to enhance financial inclusion and sustainable performance among culinary MSMEs in Medan City, North Sumatra. The research was conducted from April to October 2025, targeting the population of local culinary MSME actors. Utilizing a purposive sampling technique based on criteria of at least 3 years of operation and registration in the digital ecosystem, the sample comprised 130 survey respondents alongside 10 MSME owners participating in Focus Group Discussions (FGDs). Data analysis techniques integrated qualitative-quantitative descriptive analysis and inferential statistics using Structural Equation Modeling (SEM) via SmartPLS 4.0, incorporating path analysis and the Sobel test for mediation effects. The findings demonstrate that smart technology integration significantly enhances operational efficiency while unlocking access to a transparent and inclusive green financing ecosystem. The study's implications provide an AI-driven digital transformation acceleration strategy model for policymakers to optimize digital credit scoring and reinforce Environmental, Social, and Governance (ESG) compliance in the culinary MSME sector.

Keywords: *Green Financing, Artificial Intelligence, Financial Inclusion, Sustainable Performance*

INTRODUCTION

In the era of technological disruption, the culinary sector stands as a pivotal pillar of the national digital transformation. A report by the Boston Consulting Group (BCG) and Telkom Indonesia confirms that the culinary sector records the highest rate of digital technology adoption compared to other industrial sectors [1]. This national phenomenon is distinctly articulated at the local level, particularly in Medan City. Data from the Department of Cooperatives, SMEs, Industry, and Trade of Medan City (2023) records the dominance of the culinary sector at 41% (70 business entities) out of a total of 170 MSMEs registered in the local e-catalog [2]. This figure underscores the strategic role of the culinary industry in driving regional economic development

through digital acceleration.

However, beneath this rapid digitalization lies a structural paradox that threatens the sustainability of the sector. Massive digital commercialization has not been accompanied by equitable access to sustainable finance. The majority of culinary MSMEs in Medan City continue to face significant barriers to accessing green financing and exhibit low levels of literacy regarding smart technology application. Meanwhile, as the demands of Industry 4.0 intensify, compliance with Environmental, Social, and Governance (ESG) principles has transformed from a mere regulatory obligation into a critical determinant of competitive advantage. A distinct research and practical gap exists between the use of basic digital platforms—such as digital wallets (e-wallets)—and the strategic adoption of Artificial Intelligence (AI), particularly in AI-based credit scoring mechanisms. Without AI integration, the potential for green financing remains difficult to tap into due to information opacity, high operational data asymmetry, and the absence of formal credit histories among micro-scale enterprises.

To elucidate these dynamics, this study is anchored in the theoretical framework of the Resource-Based View (RBV). Under the RBV perspective, organizational success is determined by the ownership of resources that are valuable, rare, inimitable, and non-substitutable (VRIN). The integration between environmentally focused financial capital (Green Financing) and smart technological capabilities (AI) generates a unique resource synergy [3]; [4]; [5] Within this context, digital transformation is not merely the utilization of technical instruments, but rather a dynamic capability that enables MSMEs to reconfigure internal resources to respond to market dynamics grounded in green products and responsible governance [6]; [7]; [8]; [9]; [10].

Empirically, the drivers of financial inclusion and sustainable performance have become a subject of rigorous debate within management literature. Green financing has been proven to broaden financial inclusion for previously unbankable segments of society by requiring transaction digitalization [11]. Conversely, AI adoption serves as a primary enabler that remodels credit risk assessment mechanisms through big data processing and predictive analytics [12]; [13]; [14]; [15]. AI integration mediates administrative barriers by automating operational data transparency, thereby facilitating financial institutions in objectively evaluating creditworthiness. Once financial inclusion is achieved, MSMEs gain capital flexibility to shift from short-term operational priorities toward long-term investments oriented toward ESG compliance.

Although studies on MSME digitalization are abundant, the majority of prior literature tends to examine digitalization generically (such as e-commerce or e-wallet adoption) without linking it to Green Financing schemes and Artificial Intelligence (AI) capabilities within a single, integrated framework.

The novelty of this study lies in three primary aspects:

- a. AI Mediation Model: Empirically integrating AI as an intervening variable that bridges the relationship between Green Financing, Financial Inclusion, and Sustainable MSME Performance.
- b. Automated Data Transparency: Positioning AI as a mechanism to resolve administrative bottlenecks and mitigate information asymmetry within green financing schemes.
- c. Comprehensive Performance Measurement: Combining ESG Compliance dimensions with Smart Technology (predictive analytics) as a novel conceptual indicator for measuring the sustainable performance of culinary MSMEs at the local level (Medan City).

Driven by the aforementioned empirical catalysts and theoretical gaps, this study formulates the



following research questions:

1. Does Green Financing have a direct effect on Financial Inclusion among culinary MSMEs in Medan City?
2. Does Green Financing have a direct effect on the Sustainable Performance of culinary MSMEs in Medan City?
3. What is the role of Artificial Intelligence (AI) in mediating the relationship between Green Financing and Financial Inclusion?
4. What is the role of Artificial Intelligence (AI) in mediating the relationship between Green Financing and Sustainable MSME Performance?
5. Does Financial Inclusion have a direct effect on the Sustainable Performance of culinary MSMEs in Medan City?

In alignment with these research questions, this study aims to:

- a. Analyze the direct impact of green financing schemes on the level of financial inclusion and sustainable performance of culinary MSME actors.
- b. Empirical validate the crucial role of AI as an intervening variable that accelerates the relationship between green financing and the enhancement of the financial ecosystem.
- c. Formulate an AI-based digital transformation strategy acceleration model adaptable for policymakers to improve digital credit scores and ESG compliance among MSMEs.

This study is expected to provide a dual contribution:

- a. Theoretical Contribution: Extending the application of the Resource-Based View (RBV) by validating the synergy between green resources (green financing) and technological capabilities (AI) in elevating sustainable performance at the micro-and-small business scale.
- b. Practical & Policy Contribution: Providing a practical benchmark for policymakers and financial institutions in designing MSME-friendly, AI-based credit scoring models, while simultaneously assisting culinary entrepreneurs in overcoming data transparency constraints to achieve ESG-oriented efficiency.

METHOD

1. Research Design and Approach

This study employs a quantitative approach utilizing an explanatory research design. This design was selected to test hypotheses and explain causal relationships, as well as the mediating effects among the investigated variables, namely Green Financing (X), The Role of AI (M), Financial Inclusion (Y^1), and Sustainable Performance (Y^2).

2. Research Location and Time Frame

The research was conducted in Medan City, North Sumatra Province. This location was chosen due to the rapid growth of the culinary Micro, Small, and Medium Enterprises (MSMEs) sector, which is actively adapting to the local digital financial ecosystem. The study took place over a seven-month period, spanning from April 2025 to October 2025.

3. Population, Sample, and Unit of Analysis

- a. Unit of Analysis: The unit of analysis in this study is the organization/business unit, represented by the owners or managers of culinary MSMEs in Medan City.
- b. Population: The target population encompasses all culinary MSME operators actively operating within Medan City.
- c. Sampling Technique: A non-probability sampling technique was applied using the purposive sampling method. The specific sample criteria were defined as follows:
 - i. Culinary MSMEs that have been operating for a minimum of 3 years.
 - ii. Registered within the local digital ecosystem/e-catalog accessible via the North Sumatra



TPAKD portal (<https://tpakd.sumutprov.go.id/>).

- d. **Sample Size:** The sample size was determined based on multivariate guidelines, specifically 10 times the number of indicators. As this study involves 13 primary indicators, the minimum required sample size was set at 130 respondents ($10 \times 13 = 130$).

4. Operational Definition of Variables and Research Instrument

The primary research instrument employed was a structured questionnaire utilizing a 5-point Likert Scale (ranging from 1 = Strongly Disagree to 5 = Strongly Agree). The research constructs and their respective indicators are detailed below:

Table 1. Operational of Variables

Variable Type	Operational Variable	Primary Indicators
Independent (X)	Green Financing	1. Green credit accessibility 2. Green project profitability 3. Blockchain adoption 4. ESG compliance 5. Transaction cost reduction
Intervening (M)	The Role of AI	1. Efficiency & automation 2. Decision accuracy 3. Service innovation (Chatbots/Personalization)
Dependent 1 (Y1)	Financial Inclusion	1. E-wallet usage intensity 2. Fintech (P2P) access 3. Digital credit scoring
Dependent 2 (Y2)	Sustainable Performance	1. Operational efficiency 2. Environmental sustainability 3. Return on Investment (ROI)

Source: (Kadir et. al., 2026; Aisyah,2026; Pramesti,2023)

6. Stages of Analytical Procedures

The quantitative data processing and analysis procedure in this study follows a systematic sequence.

Step 1: Data Quality Evaluation (Validity & Reliability)

a. **Validity Test:** Assesses the extent to which indicators accurately measure their corresponding variable (via Pearson Product-Moment or Outer Loadings). An indicator is deemed valid if $r_{\text{calculated}} > r_{\text{table}}$ or if the significance value is $p < 0.05$.

b. **Reliability Test:** Evaluates instrument consistency using Cronbach's Alpha. A construct is considered reliable if the Cronbach's Alpha value exceeds 0.70.

Step 2: Descriptive Statistical Analysis

Used to delineate the demographic profile of respondents, the characteristics of culinary MSMEs in Medan City, as well as the frequency distribution and mean scores of respondent answers for each variable indicator.

Step 3: Inferential Analysis (Path Analysis)

Utilized to test structural direct effects among variables based on the formulated path diagram. The structural equations capture the effect of Green Financing (X) on The Role of AI (M), as well as the effects of both X and M on Financial Inclusion (Y1) and Sustainable Performance (Y2).

Step 4: Mediation Analysis (Sobel Test)

To evaluate the significance of the indirect effect of Green Financing (X) on Financial Inclusion (Y1) and Sustainable Performance (Y2) mediated by The Role of AI (M), the Sobel Test was

applied. A mediating effect is statistically significant if the calculated Ztext value > 1.96 at a 5% significance level.

RESULTS AND DISCUSSION

A. Results

Table 2.1. Research Indicator Validity Test Results

Variables	Indicator	r-Calculated	r-Table	Note
Green Financing (X)	X1.1	0.782	0.361	Valid
	X1.2	0.815	0.361	Valid
	X1.3	0.756	0.361	Valid
	X1.4	0.842	0.361	Valid
	X1.5	0.790	0.361	Valid
Role of AI (M)	M1.1	0.881	0.361	Valid
	M1.2	0.824	0.361	Valid
	M1.3	0.856	0.361	Valid
Financial Inclusion (Y1)	Y1.1	0.795	0.361	Valid
	Y1.2	0.833	0.361	Valid
	Y1.3	0.802	0.361	Valid
Sustainable Performance (Y2)	Y2.1	0.847	0.361	Valid
	Y2.2	0.819	0.361	Valid
	Y2.3	0.788	0.361	Valid

Source: Author's calculated by SEM PLS

The validity test was conducted to ensure that each questionnaire statement item accurately measures the intended variable. Based on the r-table for $df = N - 2$ ($30 - 2 = 28$) at a significance level alpha of 0.05, the critical value r table is 0.361. All indicators yielded calculated values r calculated exceeding 0.361. Consequently, it can be concluded that all statement items in the questionnaire are statistically valid and fit for subsequent data collection.

Table 2.2. Variable Reliability Test Results

Variable	Cronbach's Alpha	threshold	Note
Green Financing (X)	0.865	0.70	Reliabel
Role of AI (M)	0.892	0.70	Reliabel
Financial Inclusion (Y1)	0.841	0.70	Reliabel
Sustainable Performance (Y2)	0.858	0.70	Reliabel

Source: Author's calculated by SEM PLS

The reliability test aims to assess the internal consistency of the research instrument. An instrument is deemed reliable if the Cronbach's Alpha coefficient exceeds 0.70. The reliability test results indicate that all variables exhibit Cronbach's Alpha values above 0.70. This demonstrates that the questionnaire possesses high internal consistency, ensuring stable and reproducible results upon repeated measurements at different times.

Classical Assumption Test Results

4.1. Normality Test

The normality test aims to evaluate whether the error terms or residuals in the regression model follow a normal distribution.

Table 2.3. One-Sample Kolmogorov-Smirnov Normality Test Results

Note	Unstandardized Residual
N	130
Kolmogorov-Smirnov Z	0,068
Asymp. Sig. (2-tailed)	0,200

Source: Author's calculated by SEM PLS

Based on the One-Sample Kolmogorov-Smirnov test results, an Asymptotic Significance (Asymp. Sig) value of 0.200 was obtained. Referring to the criteria established by Ghazali (2018), since the significance value exceeds 0.05, it can be concluded that the residual data are normally distributed.

In the context of culinary MSMEs in Medan City, the trend toward normal distribution within the sample (N = 130) is grounded in the Central Limit Theorem. Given the high heterogeneity of the culinary MSME population—ranging from diverse menu offerings to varying levels of digital literacy—a relatively large sample size allows fluctuations in respondent answers to counterbalance one another. Substantively, this indicates that despite ongoing digital transformation in Medan, MSME owners' perceptions regarding AI usage and access to green financing have established a stable distribution pattern, free from extreme outliers.

4.2. Multicollinearity Test

This test is performed to ensure the absence of high correlation among independent variables that could distort the estimation of regression coefficients.

Table 2.4. Multicollinearity Test Results

Independent Variable	Tolerance	VIF	Note
<i>Green Financing</i> (X1)	0,742	1,348	Multicollinearity Free
<i>Artificial Intelligence</i> (M1)	0,742	1,348	Multicollinearity Free

Source: Author's calculated by SEM PLS

According to the criteria outlined by Hair et al. (2019), a model is free from multicollinearity if the Tolerance value is > 0.10 and the Variance Inflation Factor VIF is < 10. As displayed in Table 5, all variables yield VIF values below 1.35, confirming that no severe correlation exists between Green Financing and the Role of Artificial Intelligence.

Technically, this demonstrates that although Green Financing and AI both serve as key pillars in MSME modernization, they remain distinct policy and operational entities. MSME actors in Medan City are able to differentiate between capital requirements for eco-friendly investments and the adoption of AI technology as a business automation tool. Thus, both variables uniquely contribute to financial inclusion without conceptual overlap.

4.3. Heteroscedasticity Test

The heteroscedasticity test determines whether there is an unequal variance of residuals across observations in a regression model.

Table 2.5. Glejser Test Results (Heteroscedasticity Test)

Independent Variable	Significance Value (Sig.)	Note
<i>Green Financing</i> (X1)	0,415	no homoscedasticity occurs

<i>Artificial Intelligence</i> (M1)	0,628	no homoscedasticity occurs
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Source: Author's calculated by SEM PLS

The Glejser test was performed by regressing the absolute residuals against each independent variable. The results reveal that the significance values for all variables exceed the 0.05 threshold. This indicates that the variance of the residuals remains constant across observations (homoscedasticity).

Within the context of digital transformation in Medan's culinary MSME sector, this finding implies that the accuracy of the regression model is consistent across the entire spectrum of respondents. Whether assessing MSMEs just beginning to adopt electronic catalogs on the TPAKD portal or those proficient in utilizing AI, the model maintains a stable prediction error rate. This guarantees that the estimated effects of the variables on sustainable performance are unbiased by firm size or level of technological readiness.

This descriptive statistics table provides a general overview of respondent perceptions regarding the research variables measured on a 1–5 Likert scale.

Table 2.6. Descriptive Statistics of Research Variables (N = 130)

Variabel	N	Minimum	Maximum	Mean	Std. Deviation
Green Financing (X)	130	3	5	4.12	0.542
Role of AI (M)	130	3	5	4.35	0.485
Financial Inclusion (Y1)	130	3	5	4.08	0.612
Sustainable Performance (Y2)	130	3	5	4.21	0.528

Source: Author's calculated by SEM PLS

The mean values for all variables ranged from 3.8 to 4.5, indicating that, on average, respondents rated them in the High category. This indicates that the MSMEs in this sample have begun adopting green financing principles and are experiencing the positive impacts of AI integration.

1. Linear Regression Analysis (Path Model I & II)

This analysis employs a stepwise regression method to examine the effects of Green Financing (X) and the Role of AI (M) on Financial Inclusion (Y1) and Sustainable Performance (Y2).

Table 2.7. Linear Regression Analysis (Path Model I & II)

Model I: Pengaruh X terhadap M				
Variabel	B	Beta	t-value	Sig.
(Constant)	1.250		3.450	0.001
Green Financing (X)	0.752	0.812	15.620	0.000
<i>R-Square: 0.659</i>				
Model II: Pengaruh X, M, Y1 terhadap Y2				
Variabel	B	Beta	t-value	Sig.
(Constant)	0.850		2.120	0.036
Green Financing (X)	0.315	0.320	4.150	0.000



Peran AI (M)	0.420	0.385	5.210	0.000
Inklusi Finansial (Y1)	0.210	0.245	3.110	0.002
<i>R-Square: 0.742</i>				

Source: Author's calculated by SEM PLS

2. Path Analysis Summary

This table 5 summarizes the structural relationship strengths between variables to demonstrate the mediating effect.

Table 2.8. Path Analysis

Path Connection	Direct cpnnction	Indirect cpnnction (via M)	Total Connrction
X → Y1	0.380	$(0.812 \times 0.410) = 0.333$	0.713
X → Y2	0.320	$(0.812 \times 0.385) = 0.312$	0.632

Source: Author's calculated by SEM PLS

3. Sobel Test (Mediation Significance)

Table 2.9. Uji Sobel

Variable Mediastion	Z-score	P-Value	Note
M (Peran AI) pada X → Y1	4.852	0.000	Signifikan (Partial Mediation)
M (Peran AI) pada X → Y2	4.120	0.000	Signifikan (Partial Mediation)

Source: Author's calculated by SEM PLS

B. Discussion

B.1. Analysis of the Effect of Green Financing on Financial Inclusion and Sustainable Performance

The empirical results demonstrate that Green Financing exerts a positive and statistically significant effect on Financial Inclusion ($t\text{-value}=15.620, p=0.000$). This finding indicates that greater access to eco-friendly financing among MSMEs leads to a broader reach of accessible financial services. In the context of Indonesian MSMEs, green financing is frequently accompanied by the digitalization of payment and reporting systems, which systematically drives business owners into the formal financial ecosystem.

Furthermore, Green Financing directly contributes to Sustainable Performance (Model II). This aligns with the perspective that financial support allocated for clean technology reduces long-term operational costs and enhances resource efficiency (Aisyah, 2026). Access to green capital enables MSMEs to adopt more responsible production standards, thereby improving their competitiveness in a market increasingly conscious of environmental issues.

B.2. The Accelerating Role of Artificial Intelligence (AI)

A critical finding of this study is the significant role of Artificial Intelligence (AI) as a partial mediator, as evidenced by a Sobel test Z-score of 4.852. AI serves as a "bridge" that amplifies the impact of financing on inclusion and performance. AI technology allows MSMEs to automate financial management, conduct more accurate credit risk assessments through big data, and personalize customer services.

In the digital economy era, AI is no longer a mere complement, but a strategic necessity. The implementation of AI in MSME operations helps transform raw data into business insights that support sustainability-oriented decision-making (Kadir et al., 2026). With AI support, geographic and administrative barriers that have historically hindered financial inclusion can be minimized



through rapid and efficient digital verification systems.

B.3. Financial Inclusion as a Catalyst for Sustainable Performance

Financial Inclusion significantly affects Sustainable Performance ($t=3.110, p=0.002$). This result underscores that financial accessibility is a prerequisite for MSMEs to invest in sustainable business practices. Without adequate inclusion, MSMEs remain trapped in short-term operations that are often environmentally unfavorable due to capital constraints. Financial inclusion supported by digital literacy provides MSMEs with the flexibility to manage working capital more stably (Pramesti, 2023), enabling them to withstand economic fluctuations while maintaining social and environmental responsibilities.

B.4. Theoretical Synthesis: Resource-Based View (RBV) and Digital Transformation

These empirical findings lend strong support to the Resource-Based View (RBV). From an RBV perspective, the integration of financial resources (Green Financing) and technological capabilities (Artificial Intelligence) yields a unique, inimitable competitive advantage (Wernerfelt, 1984). Digital transformation via AI acts as a dynamic capability that allows MSMEs to reconfigure their resources in response to market demands for green products. The synergy between financing, technology, and inclusion fosters a resilient ecosystem for MSMEs to simultaneously achieve economic, social, and environmental performance.

CONCLUSION

Based on the results of the data analysis and discussion, the following conclusions can be drawn:

1. Green Financing exerts a positive and significant effect on both Financial Inclusion and the Sustainable Performance of MSMEs.
2. Artificial Intelligence plays a significant role as a partial mediator, accelerating the impact of green financing on enhancing business performance.
3. Financial Inclusion serves as a vital catalyst that directly improves the capacity of MSMEs to adopt sustainable business practices.
4. The research model demonstrates strong explanatory power, with the investigated variables accounting for 74.2% of the variance in Sustainable Performance ($R^2 = 0.742$).

Policy Implications

1. For the Government: Regulatory frameworks should be established to incentivize banks and fintech providers to offer competitive interest rates for MSMEs adopting green technologies and artificial intelligence.
2. For Financial Institutions: It is recommended to integrate AI-based credit scoring models that incorporate Environmental, Social, and Governance (ESG) criteria into MSME credit risk assessments.
3. For MSME Entrepreneurs: Business owners are encouraged to adopt basic AI-driven digital tools to optimize operational efficiency and facilitate access to formal financial institutions.

This study is subject to limitations regarding its sample size ($N = 130$), which may not fully capture the heterogeneity of the entire MSME sector in Indonesia. Furthermore, the findings rely on the subjective perceptions of business operators. Future research is encouraged to incorporate secondary financial reporting data and expand the geographical scope of the investigation.

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