

THE ROLE OF ARTIFICIAL INTELLIGENCE IN REDUCING NON-PERFORMING FINANCING (NPF) IN ISLAMIC BANKING: A SYSTEMATIC LITERATURE REVIEW

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Abstract: The application of artificial intelligence (AI) in the banking sector has been extensively studied; however, there is a significant gap in research regarding its specific implementation in Islamic banking to mitigate Non-Performing Financing (NPF) risks. Islamic banks face unique challenges, such as adhering to Shariah principles and managing risk differently from conventional banks. This study aims to explore the role of AI in identifying, mitigating, and reducing NPF risks within Islamic banking, contributing to more efficient and sustainable banking practices. Using the Systematic Literature Review (SLR) method guided by the PRISMA framework, this study analyzes 28 selected peer-reviewed articles published between 2014 and 2024. These articles were identified through a rigorous screening process, focusing on topics such as NPF in Islamic banking, AI, and machine learning-based early warning systems. The findings of this research highlight the potential of AI technologies in enhancing risk management and addressing the challenges associated with NPF in Islamic banking. The study provides critical insights and innovative strategies to help Islamic banks improve financial risk mitigation through modern AI solutions.

Keywords: Non-performing financing, artificial intelligence, islamic banking.

Introduction

Islamic banking plays an important role in providing fair and transparent Sharia-based financing. However, the challenge of NPF is one of the significant threats that can disrupt financial stability and customer trust in this banking system. Supriyatni & Nurjamil (2021) define Non-Performing Financing as the risk that arises from bank financing which is grouped based on the quality of the funding that is bad, substandard, doubtful, or problematic. Islamic banks must pay special attention to Non-Performing Financing because it is a benchmark for evaluating the performance of productive assets Perdani et al. (2020) . Islamic banks must pay close attention to the quality of financing because it can minimize the risk of losses through strict risk management (Putri et al., 2024) . The table below shows the total financing disbursed by Islamic Commercial Banks along with the Non-Performing Financing figures:

Table 1. Financing and Non-Performing Financing of Islamic Commercial Banks

Information	Year				
	2019	2020	2021	2022	2023
Funding provided (Billion Rupiah)	25,353	26.116	26,926	30,176	32,060
NPF (%)	3.23	3.13	2.59	2.35	2.41

Source: OJK Sharia Banking Statistics, 2023

Although financing provided by Islamic Commercial Banks (BUS) continues to experience a significant increase from IDR25,353 billion in 2019 to IDR32,060 billion in 2023, the challenge of maintaining financing quality remains an issue that needs attention. The Non-Performing Financing (NPF) ratio did show a downward trend from 3.23% in 2019 to 2.35% in 2022, reflecting improvements in risk management. However, in 2023, the NPF ratio increased again to 2.41%, which although it looks small, can be an early indication of potential risks in financing management.

This condition raises concerns regarding the sustainability of quality financing growth. With the increase in total financing provided, the main challenge is to ensure that the NPF remains under control so as not to exceed the risk threshold set by the OJK. If not anticipated, the increase in the NPF ratio can affect the financial stability of BUS, reduce customer trust, and hurt the growth of the Islamic banking sector as a whole. Therefore, there needs to be a comprehensive evaluation of the BUS risk management strategy to maintain financing quality amidst sustainable growth.

The risks that always exist in financial institutions cannot be eliminated and will continue to affect bank operations at all times (Wahyudi et al., 2013). This happens because every financing given to customers has the potential to face problems or losses. The financing risk known as Non-Performing Financing (NPF) is the possibility of losses that arise when funds distributed by Islamic Banks cannot be returned by customers (Ismail, 2017). In the Indonesian Islamic Banking Statistics report, NPF is defined as financing with a status of less than smooth, doubtful, to stuck (Djamil, 2022). Interestingly, the NPF ratio in Islamic Banks tends to be lower than the Non-Performing Loan (NPL) ratio in Conventional Banks, which are usually influenced by macroeconomic fluctuations (Poetry and Sanrego, 2011). There are three main factors that cause problematic financing, namely: (1) Internal factors from Islamic Banks or their weaknesses; (2) Factors from customers as borrowers; and (3) Other factors beyond the control of Islamic Banks or customers.

In responding to these challenges, Artificial Intelligence (AI) technology is a potential solution for improving risk management in Islamic banking. With capabilities such as machine learning and predictive analytics, AI enables faster and more accurate data analysis compared to traditional methods. This technology can detect risk patterns earlier, identify high-risk customers, and provide an early warning system that can help Islamic banks mitigate financing risks. In addition, AI can also be used to automate the decision-making process by Sharia principles.

This is reinforced by research conducted by Rahayu & Naja (2023) entitled "Application of Artificial Intelligence as an Innovation in the Era of Disruption in Reducing the Risks of Islamic Microfinance Institutions" highlighting the important role of AI in risk management of Islamic Microfinance institutions. This study concludes that competition in the financial sector drives the need for maximum implementation of AI. In the context of risk management, AI has been shown to help overcome and minimize various operational problems, which can ultimately optimize income and reduce losses of Islamic microfinance institutions. This strengthens the relevance of AI as a strategic tool in increasing the efficiency and competitiveness of Islamic-based financial institutions.

Another study conducted by Siregar et al. (2024) entitled "Application of Artificial Intelligence as Innovation in the Era of Disruption in Reducing the Risk of Islamic Banking" highlights the importance of implementing AI in risk management in Islamic banking. This study concludes that AI can be a competitive strategy that helps identify and reduce risks and minimize losses. The application of AI is expected to increase the efficiency and income of the Islamic banking industry, as well as strengthen its competitiveness in the market. Another study

conducted by Ishak & Mohamed (2023) entitled "Harmonization of Islamic Economics with Artificial Intelligence: Towards an Ethical and Innovative Economic Paradigm" discusses the possibility of integrating Islamic economic principles with artificial intelligence (AI) to create an ethical and innovative economic paradigm. This study concludes that AI applications, such as machine learning and big data analysis, can improve operational efficiency and decision-making by Islamic values. In addition, this study emphasizes the importance of maintaining a balance between technological innovation and Islamic moral principles, with a focus on economic empowerment, equitable distribution of wealth, and prudent risk management. The results of this study show that harmonization between Islamic economics and AI can open up innovative solutions to contemporary economic challenges.

Despite numerous studies discussing the application of artificial intelligence (AI) in banking, there is a significant gap in the literature regarding the application of AI specifically in the context of Islamic banking, especially in terms of mitigating Non-Performing Financing (NPF) risks. Most previous studies have focused more on the conventional banking sector, with little attention paid to the unique challenges faced by Islamic banks, such as different principles of Shariah compliance and risk management. Research on how AI can be applied to identify, mitigate, and reduce NPF in Islamic banking is very limited. Therefore, there is an urgent need to conduct more in-depth research in this area to fill the existing knowledge gap and provide relevant and innovative solutions for Islamic banks to manage the financial risks they face. The objective of this study is to explore the role of artificial intelligence (AI) in mitigating Non-Performing Financing (NPF) risks in Islamic banking. The study aims to understand how the application of AI technology can help improve risk management in Islamic banking and provide effective solutions to address the challenges associated with NPF. Thus, this research is expected to contribute to the development of more efficient and sustainable Islamic banking practices through the use of modern technology.

Literature Review

1. The role of Artificial Intelligence (AI) in Reducing Non-Performing Financing (NPF)

NPF is an important indicator in banking that measures the quality of bank assets. A high NPF can indicate a bank's financial and operational problems. AI can be used to increase accuracy and efficiency in the credit analysis process. AI algorithms can process large amounts of data and identify patterns that may not be visible to humans. This allows banks to make better credit decisions and reduce NPF risk. AI can also be used to monitor and manage credit risk proactively. AI systems can provide early warning of potential credit problems and help banks to take early corrective action.

2. Sharia Banking and NPF

Islamic banking operates based on sharia principles which prohibit usury (interest) and transactions that are not in accordance with sharia. Islamic banking also faces challenges related to NPF. Several factors that can influence NPF in sharia banking include economic conditions, internal bank factors, and characteristics of sharia financing. AI can help Islamic banking reduce NPF by improving operational efficiency, credit analysis and risk management.

Method

This study uses the Systematic Literature Review (SLR) method to analyze the application of artificial intelligence (AI) in reducing Non-Performing Financing (NPF) in Islamic banking. The review process was carried out following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency

and quality at every stage. Article searches used Harzing Publish or Peris software, focusing on topics related to Non-Performing Financing in Islamic Banking, Artificial Intelligence, Early Warning Systems in Islamic Finance, and Machine Learning for NPF.

The literature search process involved articles published in the last 10 years, namely in the period 2014–2024, which are relevant to the use of AI or Machine Learning in reducing NPF in Islamic banking. Inclusion criteria include research articles (original research) and literature reviews discussing the topic in English or Indonesian. Articles published before 2013, not relevant to NPF or AI in the context of Islamic banking, and the form of opinions, editorials, or non-research reports, were excluded from the analysis.

In the selection process, 600 relevant articles were found, and then through screening based on inclusion and exclusion criteria, 28 articles were selected that were suitable for further analysis. These articles were then evaluated to identify their contribution to the development of AI technology for NPF risk management in Islamic banking.

Result and Discussion

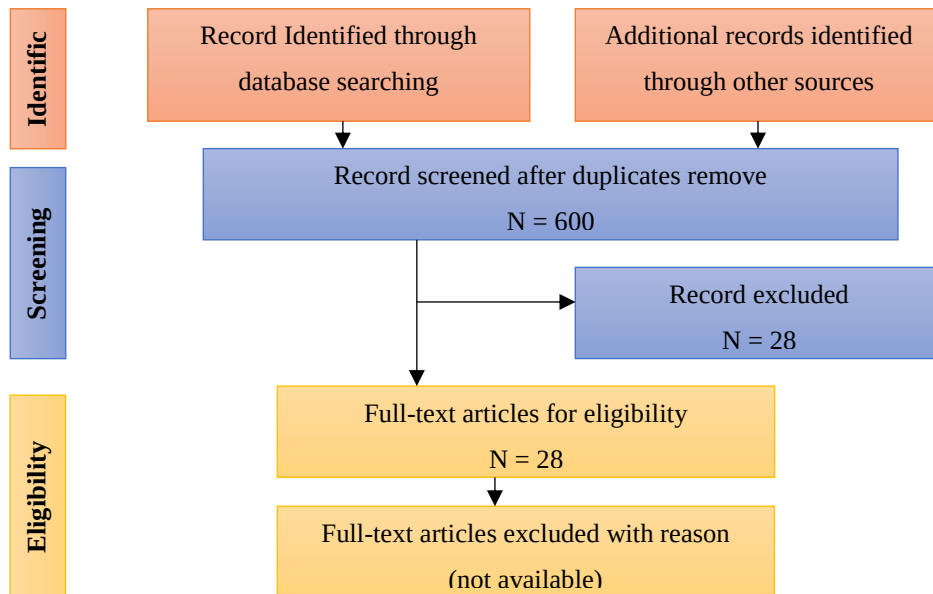
Data collection

Data were collected using a systematic research method that identifies the steps required to conduct a literature review with the PRISMA approach being an accepted standard for presenting evidence in systematic reviews and meta-analyses. Only peer-reviewed journals were considered in this study. Reports, conference proceedings, books, and theses were not considered. The following are the inclusion and exclusion criteria:

- a. Inclusion Criteria:
 1. Publication Year: Articles published in the last 5–10 years (e.g., 2014 to 2024).
 2. Topic Relevance: Articles discussing AI or Machine Learning to reduce Non-Performing Financing (NPF) in Islamic banking
 3. Article Type: Research articles (original research) and reviews of relevant literature.
 4. Language: Articles written in English or Indonesian.
- b. Exclusion Criteria:
 1. Publication Year: Articles published before 2013.
 2. Topic Relevance: Articles that do not discuss NPF or AI in the context of Islamic banking.
 3. Article Type: Opinion articles, editorials, or reports that are not research.
 4. Language: Articles that are not in English or Indonesian.

In the selection process, 600 relevant articles were found, and then through screening based on inclusion and exclusion criteria, 28 articles were selected that were suitable for further analysis. These articles were then evaluated to identify their contribution to the development of AI technology for NPF risk management in Islamic banking.

Table 2. PRISMA diagram



Next, we conducted a thematic analysis of the remaining articles to identify themes that related to our research patterns and trends. This resulted in five sub-themes, which provided us with the data needed to answer the research questions.

No.	Subtheme	Number of selected articles
1.	Non-Performing Financing in Islamic Banking and Artificial Intelligence	10
2.	AI for Credit Risk Assessment and Early Warning Systems in Islamic Finance.	14
3.	Machine Learning for NPF Prediction in Islamic Banks.	4
Total		28

Table 3. Theme Identification

Discussion

Non-Performing Financing in Islamic Banking and Artificial Intelligence

Artificial Intelligence (AI) offers an effective solution to reduce Non-Performing Financing (NPF) in Islamic banking through various innovative approaches. Federated Machine Learning, which enables data analysis without violating privacy, helps identify customers who are likely to default on Islamic financing (Anannya et al., 2023). Meanwhile, Nnaomah et al. (2024) conducted a comparative analysis showing that AI can predict credit risk and improve the quality of Islamic financing portfolios. In addition, Quan & Sun (2024) used a Factorization Machine model that can identify complex relationships between variables, thereby increasing the accuracy of NPF predictions.

Machine Learning can help manage financing portfolios by analyzing customer payment patterns to identify potential defaults early. In the context of mobile banking (Amato et al., 2024). Arkaan et al. (2023) through bibliometric analysis, found that AI improves the efficiency

of financing management and helps identify high-risk customers. Financial Information Service System (SLIK) data with AI algorithms improves the accuracy of financing risk analysis, thus contributing to a decrease in NPF (Tobing, 2023).

AI not only supports financing management by ensuring compliance with Sharia principles but also reduces credit risk through data analysis (Ridzuan et al., 2024). On the other hand, Shamim et al. (2023) found that AI can identify environmentally friendly projects that are worth financing, thereby reducing the risk of NPF in Sharia-based financing. Esaputra (2024) argues that AI is a solution to overcome challenges in Sharia financing risk analysis by utilizing big data processing and automation of the credit assessment process.

Artificial intelligence (AI) offers significant solutions in reducing Non-Performing Financing (NPF) through big data analysis capabilities, risk prediction, and more accurate personalization of financing products. The application of this technology not only accelerates the credit evaluation process but also improves the monitoring of customer behavior, allowing Islamic banks to detect early signs of payment difficulties and fraud. Thus, AI helps Islamic banks in making more informed decisions and reducing the level of problematic financing (Masrina et al., 2024).

AI for Credit Risk Assessment and Early Warning Systems in Islamic Finance.

The use of artificial intelligence (AI) in credit risk management and early warning systems has had a significant impact on the financial sector, including Islamic banking. AI uses techniques such as Machine Learning (ML), Deep Learning (DL), and network analysis to analyze complex datasets that include historical data, customer behavior, and macroeconomic indicators. Algorithms such as Neural Networks (ANN), Support Vector Machines (SVM), and Decision Trees enable the identification of risk patterns that were previously difficult to detect with traditional methods (Hassan et al., 2023; Namaki et al., 2023). In addition, sentiment analysis data obtained from social media and news provides insight into market sentiment, which can affect the stability of credit risk in the future (Namaki et al., 2023). Generative AI also helps identify risks related to customers (moral hazard), business activities, market conditions, and operational risks. This is done through fast and precise big data analysis.

AI also plays an important role in improving the accuracy of credit risk prediction and early detection of Non-Performing Financing (NPF). AI-based systems enable real-time data processing, providing early warning signals to banks before risks worsen. This allows for earlier mitigation measures to be taken, thereby reducing the potential for large losses. Empirical studies show that AI can increase the accuracy of risk prediction by up to 20% compared to traditional methods, with the Neural Network algorithm producing highly accurate predictions (Hassan et al., 2023). AI must comply with Islamic ethics in every implementation, requiring supervision from regulators (Hendarti et al., 2024). Not only that, Explainable AI (XAI) is a key element in increasing the transparency of AI-based decisions, so that regulators and stakeholders have more confidence in this system (Riani, 2023).

AI utilizes advanced algorithms, such as Deep Neural Networks (DNN) and Markov Switching Vector Auto Regression (MS-VAR), to analyze complex data patterns and monitor changes in economic and financial conditions in real time (Primambudi & Jati, 2024). This system can predict changes in risk levels with high accuracy, even up to 97%, as found in research (Zhuang & Wei, 2023). In addition, AI enables analysis of transition probabilities between risk levels (low, medium, high), providing early signals that can help Islamic banks respond to risks more quickly and appropriately. AI can also utilize macroeconomic data, such as the stock market, bonds, and foreign exchange, to detect systemic risk. In addition, microdata, such as customer behavior and payment patterns, are used to identify potential risks

at the individual or portfolio level. In AI-based systems, this monitoring is done automatically and continuously, providing the advantage of a more responsive response to changes in risk compared to manual or traditional approaches (Namaki et al., 2023). For example, AI can detect suspicious behavior in customer transactions, such as irregular payment patterns or activities that do not match the customer profile, so that risks can be minimized early on (Hamadou et al., 2024).

However, challenges in implementing AI cannot be ignored. Reliance on high-quality data is a major obstacle because incomplete or biased data can reduce prediction accuracy. In addition, the complexity of AI models often makes the decision-making process difficult to explain to regulators and stakeholders. Therefore, the development of Explainable AI (XAI) is essential to ensure transparency and increase trust (Zhuang & Wei, 2023). Other challenges include the need for adequate regulation to protect data privacy and ensure that the implementation of AI remains by Sharia and ethical principles (Al Hammadi et al., 2024).

Machine Learning for NPF Prediction in Islamic Banks

To address the increasing risk of Non-Performing Financing (NPF) in Islamic banks, several studies have explored the use of machine learning techniques to offer more accurate and effective predictive solutions. One of the first studies discussed the application of Logistic Regression combined with Synthetic Minority Over-sampling Technique (SMOTE-NC) (Islahulhaq & Ratih, 2021). This approach addresses the issue of data imbalance between performing and non-performing financing, which often complicates risk prediction. By using this model, banks can improve the accuracy of NPF risk predictions, achieving an accuracy rate of up to 81%, with high sensitivity and precision at 94% and 86%, respectively. Thus, this model enables banks to identify high-risk customers earlier, ultimately aiding in better risk management (Islahulhaq & Ratih, 2021).

Furthermore, two other studies developed Early Warning Systems (EWS) using Artificial Neural Networks (ANNs), designed to detect potential financing issues early on. These models were used not only to predict NPF risks in small and medium-sized enterprise (SME) financing but also to monitor the overall financial performance of banks. ANNs are capable of capturing more complex and dynamic data patterns, making them more effective than traditional methods in dealing with market fluctuations and economic volatility. In these studies, the use of ANNs achieved a 100% accuracy rate in out-of-sample predictions, showing that this technique can provide early signals of potential financial crises. The findings suggest that ANNs can be an extremely valuable tool for preventing bank failures by identifying warning signs earlier (Anwar & Ali, 2018).

Another study examined the use of machine learning to predict loan repayment status at the As-Siddeek Islamic Cooperative in Southern Thailand, focusing on Decision Tree, Logistic Regression, and Random Forest models. Although the results showed lower accuracy than the previous studies (with Decision Tree achieving only 63.1%), it still demonstrated the significant potential of machine learning in identifying customers at risk of NPF. The main challenge here was the data imbalance between loans repaid on time and those that became non-performing, which reduced the model's efficiency. However, the use of these techniques still indicated that machine learning-based predictions could help banks identify high-risk loans earlier, allowing for faster preventive action (Mueankoo et al., 2022).

Overall, these studies show that machine learning technologies, particularly Logistic Regression with SMOTE-NC and Artificial Neural Networks, hold great potential in predicting and managing NPF risks in the Islamic banking sector. By using these techniques, banks can

more effectively identify high-risk customers and take necessary steps to mitigate the potential losses caused by NPF.

Conclusion

The use of Artificial Intelligence (AI) and Machine Learning (ML) in Islamic banking provides new solutions to manage the risk of non-performing financing (NPF). This technology can predict credit risk more accurately and help banks detect customers who are likely to default, and make more informed decisions. Algorithms such as neural networks, support vector machines, and decision trees enable banks to recognize risk patterns that were previously difficult to see.

In addition, AI can aggregate data in real-time, analyze customer payment patterns, and detect signs of financial problems early. This technology also helps select projects on Sharia principles, including environmentally friendly projects, thereby reducing the risk of NPF. Explainable AI (XAI) ensures transparency in AI-based decision-making, making it more trusted by regulators and remaining by Sharia principles.

However, the application of AI has challenges, such as data quality that is not always good, the risk of data bias, and the complexity of models that are difficult to understand. Therefore, rules and regulations are needed that support data privacy and compliance with sharia principles. Overall, AI and ML can improve the efficiency, accuracy, and risk management of NPF in sharia banking, creating a safer and more sustainable financial system.

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