

# Machine Learning in Islamic Finance

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This study aims to see the development of research on the topic of "Machine Learning in Islamic Finance" and research plans that can be carried out based on journals published on the theme. This research uses a qualitative method with a bibliometric analysis approach. The data used is secondary data with the theme "Machine Learning in Islamic Finance" which comes from the Dimension database with a total of 30 journal articles. Then, the data is processed and analyzed using the VosViewer application with the aim of knowing the bibliometric map of research development "Machine Learning in Islamic Finance" in the world. The results of the study found that there are 5 clusters with the most used words are finance, model, technology, Islamic bank, machine, industry, fintech, and system. Then, the research path topics related to Machine Learning in Islamic Finance are Machine Learning for Islamic Bank Efficiency, Machine Learning in Islamic Fintech, Customer Behavior and Machine Learning, Islamic Economic Growth and AI Innovation, and Blockchain for Global Zakat Distribution.

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## INTRODUCTION

The development of machine learning (ML) is a complex narrative that spans decades, characterized by significant theoretical advances and practical applications. The origins of machine learning can be traced back to the 1940s. In 1943, Walter Pitts and Warren McCulloch introduced the first mathematical models of neural networks, which laid the foundation for the future development of artificial intelligence (AI) and ML (Barilla, 2024). Then, the 1960s marked a crucial time for ML, particularly with the introduction of the perceptron model by Frank Rosenblatt. However, the publication of "Perceptrons" by Marvin Minsky and Seymour Papert in 1969 highlighted the significant limitations of single-layer networks, which contributed to what became known as the first "AI winter" - a period marked by reduced funding and interest in AI research due to unmet expectations (International Organization for Standardization, n.d.; Firican, n.d.).

Despite this setback, progress continued with the introduction of multilayered neural networks in the mid-1980s. These networks enabled more complex learning tasks and were crucial in reviving interest in ML (Barilla, 2024). Machine Learning involves algorithms that can detect patterns and make predictions based on input data, adapting their behavior as new data becomes available. Machine learning encompasses a variety of methodologies, including guided learning (where models are trained on labeled data sets), unguided learning (which handles unlabeled data), and reinforcement learning (where models learn through trial and error).

The integration of machine learning (ML) into the financial sector has grown significantly over the past few decades, driven by technological advances, increased data availability, the need for more sophisticated analytical tools, and the development of complex algorithms. Financial institutions are increasingly adopting ML techniques to improve decision-making processes across functions such as risk management, trading, and customer service (Financial Stability Board, 2017). The same can be found in the context of Islamic finance.

The integration of machine learning (ML) in Islamic finance has emerged as a transformative force, improving operational efficiency, risk management and Shariah compliance. This development reflects the growing recognition of the potential benefits that advanced analytics can offer to this unique financial system, which adheres to Islamic law. Islamic finance

operates on principles that prohibit interest (riba), excessive uncertainty (gharar), and gambling (maysir), emphasizing ethical investment and risk sharing. The application of machine learning in this context began to gain traction in the early 21st century, along with advances in data analytics and computing power. Recent studies highlight that despite the ethical mandates unique to Islamic finance, the sector has been slower to embrace predictive modeling compared to conventional finance (Dey et al., 2024).

There are a number of virtues of applying ML to Islamic finance. As Dey et al (2024) explain, machine learning algorithms can be used to ensure that financial products comply with Sharia principles. By analyzing transaction data and identifying patterns that align with Islamic law, ML can help institutions maintain compliance while offering innovative financial solutions. In addition, ML techniques are increasingly being applied in risk assessment and management in Islamic banks. These methods enhance predictive capabilities regarding potential risks associated with non-compliance and market fluctuations. For instance, machine learning models can analyze vast data sets to predict default risk and optimize portfolio management, thereby supporting better decision-making processes (Dey et al., 2024; Bakather & Bin Makhshen, 2024). In addition, machine learning facilitates the development of Shariah-compliant financial products by analyzing customer preferences and market trends. This capability enables Islamic financial institutions to innovate and customize their offerings more effectively, thereby increasing competitiveness in a rapidly evolving market (Dey et al., 2024; Irfan et al., 2024).

Despite its potential, the application of machine learning in Islamic finance faces several challenges. Key issues include ensuring compliance with ethical standards set by Shariah law and addressing the regulatory framework governing AI technologies. Scholars emphasize the need for robust guidelines outlining acceptable practices for using ML in this context to mitigate risks associated with misuse or non-compliance (Dey et al., 2024; Bakather & Bin Makhshen, 2024). Similarly, Lakhchini et al (2022) and Zakaria et al (2023) state that the potential for machine learning to revolutionize finance is immense, however, its successful implementation depends on addressing these challenges while leveraging its ability to improve financial stability and efficiency.

Based on this background, it is important to see the extent of the current development of *Machine*

*Learning in Islamic Finance* through research, and one method that can be used to see the development of research is bibliometrics using VosViewer. The method is able to create and display author journal maps and research paths based on co-citation data or keyword maps based on co-occurrence data. Some research that examines *Machine Learning in Islamic Finance* is [Ahmed et al \(2022\)](#) reviewing the literature of artificial intelligence (AI) and machine learning (ML) in finance. The results of this study revealed an upward trajectory in publication trends starting from 2015 and found applications of AI and ML in bankruptcy prediction, stock price prediction, portfolio management, oil price prediction, anti-money laundering, behavioral finance, big data analysis, and blockchain. In addition, the United States, China, and the United Kingdom are the top three contributors to the literature.

[Polyzos et al \(2023\)](#) examined how the adoption of Islamic banking to varying degrees affects economic outcomes. The results show that although Islamic banking systems tend to reduce economic activity, financial stability and societal happiness increase. In addition, a banking sector that utilizes Islamic principles across all its members is better equipped to handle banking crises as contagion to economic activity and societal well-being is greatly reduced. At the same time, the adoption of the profit-sharing paradigm (PLS) by banks may also slow down economic growth. [Lakhchini et al \(2022\)](#) described the intellectual development of AI and ML in financial research. The study concluded seven research areas namely Portfolio Management and Robo-Advisory, Financial Risk and Distress Management, Financial Fraud Detection and Anti-Money Laundering, Sentiment Analysis and Investor Behavior, Algorithmic Stock Market Prediction and High Frequency Trading, Data Protection and Cybersecurity, Big Data Analytics, Blockchain, FinTech.

[Pal et al \(2024\)](#) discussed the transformative impact of artificial intelligence (AI) and machine learning (ML) technologies on the Islamic Capital Market (ICM). The research explains, as the global financial landscape evolves, ICM is no exception, facing the same challenges and opportunities. AI and ML have emerged as important tools to improve efficiency, reduce risk, and drive innovation in Islamic finance. The research also discusses key areas where AI and ML are applied, including Shariah-compliant investment screening, risk management, asset allocation, trading strategies, and customer service.

[Rabbani et al \(2023\)](#) provided a recent overview of P2P lending in Bahrain especially for the small and medium enterprise (SME) sector and proposed a machine learning-based Islamic Fintech model for P2P lending. This research suggests how P2P lending platforms (especially debt-based platforms) can follow Shariah principles and can meet the needs of customers who believe in lending in accordance with Islamic finance. The research also proposes an Islamic Fintech model for people-to-business (P2P) lending suitable for small and medium-sized enterprises. It is high time new credit methods are introduced and promoted to give a boost to the sector and save hundreds of thousands of jobs.

[Kusuma et al \(2024\)](#) investigated the potential of blockchain technology to revolutionize Islamic finance. This research explains that financial technology (FinTech) has emerged as the application of innovative and disruptive technologies to provide financial services, which gained significant attention in the late 2010s. The origins of FinTech can be traced back to the global financial crisis of 2008, which necessitated a re-evaluation of the traditional financial system. The Islamic financial system emerged as a resilient response to this crisis, offering an alternative solution. [Sarea et al \(2021\)](#) describe the application of artificial intelligence (AI) in the Islamic finance and banking sector. [Muksalmina et al \(2024\)](#) describe artificial intelligence in Islamic finance. [Rahim et al \(2018\)](#) examine artificial intelligence, smart contracts, and Islamic finance. [Gafar & Wang \(2023\)](#) explain the implementation of machine learning for Islamic financing assessment in the Indonesian MSME sector. [Khan & Rabbani \(2021\)](#) explain artificial intelligence and NLP-based Chatbot for Islamic banking and finance.

This research was conducted to complement existing research and fill the gaps of previous research and to expand the literature related to *Machine Learning in Islamic Finance* through the research path. In particular, the purpose of this research is to see the development of "*Machine Learning in Islamic Finance*" research published by journals with this theme and see future research opportunities by formulating a research agenda.

## METHOD

In this research, various scientific journal publications related to the theme "*Machine Learning in Islamic Finance*" around the world are used as data sources. Data is collected by searching for journal

publications indexed in the Dimension database using the keyword "Machine Learning in Islamic Finance". After that, scientific articles or journals that are relevant to the research theme will be selected based on the publication data that has been collected. Journals equipped with DOI are the criteria in the filtering process and data processing using software. There are 30 journal articles published from within the research theme "Machine Learning in Islamic Finance". The development of publication trends related to the research topic was analyzed using VOSviewer software, which can generate bibliometric maps and allow for more detailed analysis.

In order to build the map, VOSviewer uses the abbreviation VOS which refers to Visualizing Similarity. In previous studies, the VOS mapping technique has been used to obtain bibliometric visualizations which are then analyzed. Furthermore, VOSviewer is able to create and display author journal maps based on co-citation data or keyword maps based on co-occurrence data. Therefore, this study will analyze journal maps related to "Machine Learning in Islamic Finance", including author maps, and keywords which are then analyzed for research paths that can be carried out in the future through clusters in *keyword mapping*.

This research uses a descriptive qualitative approach with meta-analysis and descriptive statistical

literature study based on 30 journal publications that discuss the theme "Machine Learning in Islamic Finance". Meta-analysis is a method that integrates previous research related to a particular topic to evaluate the results of existing studies. Furthermore, the qualitative method used in this research is also referred to as a constructive method, where the data collected in the research process will be constructed into a more understandable and meaningful theme. The sampling technique used in this research is purposive non-probability sampling method, which aims to fulfill certain information in accordance with the desired research objectives. Studies with bibliometric analysis in research with other Islamic financial economics topics can be seen in Napitupulu, et al., (2024); Yenice et al., (2022), Rusydiana (2021), Khalifah et al., (2024), Mi'raj & Ulev (2024), Rusydiana et al., (2023), and also Ozdemir & Selçuk (2021).

## RESULT AND DISCUSSION

### Research Map

The figure below describes the trend of keywords appearing in research on the theme of "Machine Learning in Islamic Finance" and the larger shapes are the most used words in journal publications on the theme of "Machine Learning in Islamic Finance".

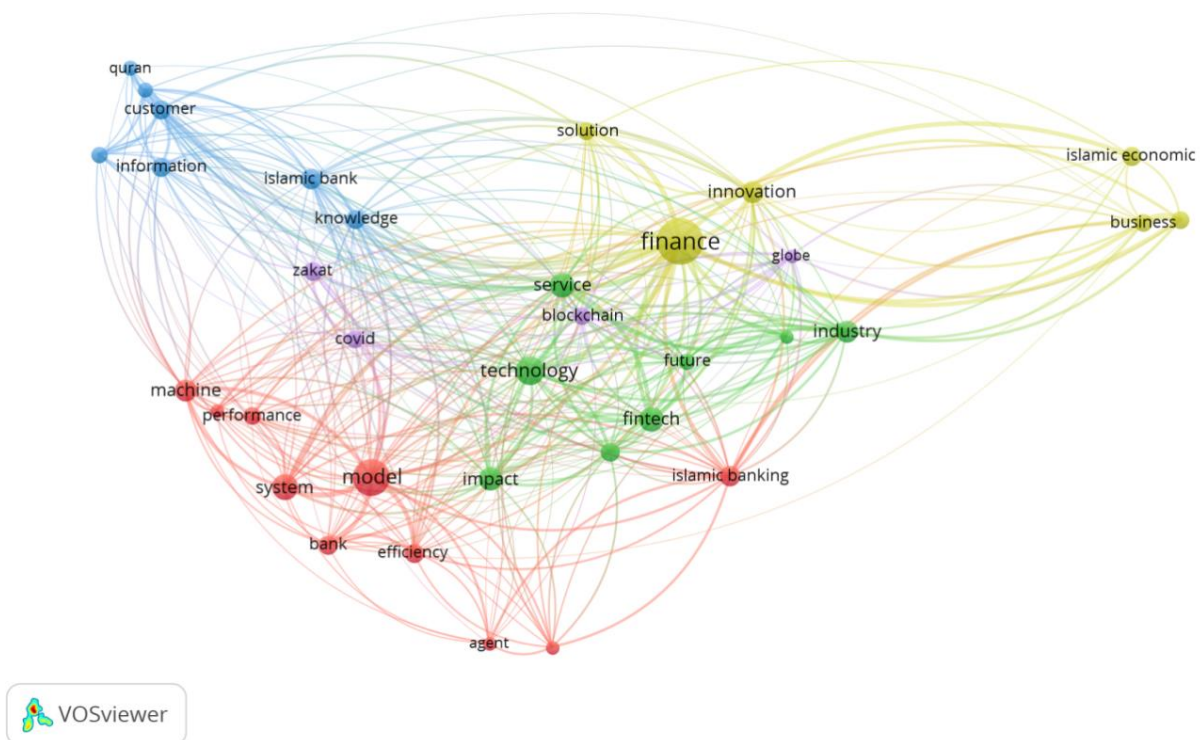


Figure 1. Machine Learning and Islamic Finance

As for the mapping, the keywords that appear most in the publication "*Machine Learning in Islamic Finance*" include finance, model, technology, Islamic bank, machine, industry, fintech, and system, which are then divided into 5 clusters, as follows:

### Cluster 1: Machine Learning for Islamic Bank Efficiency

This cluster has 10 keyword items, namely agent, bank, efficiency, financial stability, Islamic banking, machine, model, performance, system, use. Based on these keywords, the relevant topic for future research is related to the utilization of machine learning (ML) for the efficiency of Islamic banks. Along with the rapid development of the technological world, ML is increasingly being used to improve efficiency in Islamic banking both through improving risk management, Sharia compliance, and operational optimization. ML can assist in automating Sharia audits and monitoring transactions for compliance. In the research of [Maryadi et al \(2024\)](#) explained, AI-driven systems in mobile banking can control consumption patterns to be in line with Islamic principles, such as avoiding excessive spending or non-halal purchases. In addition, research from [Hamadou et al \(2024\)](#) also highlighted the role of AI in automating processes, improving decision-making, and personalizing customer recommendations, and challenges in implementation costs, cybersecurity risks, Sharia compliance, and ethical issues.

However, there are not many studies that specifically discuss machine learning for Islamic bank efficiency. A number of relevant studies include [Assous \(2022\)](#) who examined the main determinants of efficiency of conventional and Islamic banks in Saudi Arabia and determined the most suitable model among machine learning prediction models namely, support vector machine (SVM), Chi-squared automatic interaction detector (Chaid), linear regression, and neural network (NN). The results show that the efficiency of conventional and Islamic banks is strongly influenced by profitability, liquidity, and managerial practices. Then, the best prediction model with the highest R2 in the training and testing phases with/without feature selection is the CHAID model. The best predictor of cost efficiency for Saudi banks is capital ratios, namely total CAR and tier 1 CAR.

[Ali et al \(2023\)](#) analyzed the factors affecting the performance of Islamic banks in Indonesia using the variables Return On Assets (ROA), Operating Expenses to Operating Income (BOPO), Capital

Adequacy Ratio (CAR), Non Performing Financing (NPF), Financing to Deposit Ratio (FDR) and Potential Losses (PK) using machine learning with multiple linear regression. The results found that BOPO, CAR, NPF, FDR and PK simultaneously affect ROA. Then the value of ROA is simultaneously influenced by the value of BOPO, CAR, NPF, FDR and PK. [Polyzos et al \(2023\)](#) examined the impact of Islamic banking on the efficiency of the banking sector and public happiness, by revealing that although it can reduce economic activity, Islamic banking increases financial stability and public welfare. This study uses machine learning and agent-based modeling to quantify the welfare benefits of the profit and loss sharing paradigm, highlighting its potential to mitigate banking crises.

### Cluster 2: Machine Learning in Islamic Fintech

This cluster has 8 keyword items, namely financial technology, fintech, future, impact, industry, islamic fintech, service, technology. There is very limited research on "Machine Learning in Islamic Fintech". ML can revolutionize Islamic fintech by addressing Sharia compliance, risk management, and operational efficiency while driving financial inclusion. Research from [Kilic & Türkan \(2023\)](#) and [Dey et al \(2024\)](#) explains that ML algorithms automate Sharia audits by analyzing transaction patterns to detect non-compliant activities, such as interest-based transactions or unethical investments. In addition, deep learning models scan transaction data to flag anomalies, ensuring compliance with Islamic principles such as the prohibition of riba (interest) ([Kilic & Türkan, 2023](#); [Ifran et al., 2023](#)). ML models such as Support Vector Machines (SVM) and neural networks can also predict loan defaults and liquidity risks by analyzing historical data and macroeconomic indicators ([Dey et al., 2024](#)). ML is thus a transformative force in Islamic fintech, enabling ethical automation, risk mitigation, and inclusive financial services.

A number of studies relevant to the topics in this cluster include [Khan et al \(2021\)](#) proposing an Artificial Intelligence-based FinTech model as a solution for affected SMEs and individuals to survive the economic consequences of the Covid-19 pandemic. The results show that Qardh-Al-Hasan is a great selfless financial service in the Islamic financial system, which should be used together with financial technology such as artificial intelligence to save the poor and SMEs affected by this pandemic.

Awais et al (2024) explain the evolution in Islamic fintech and Islamic economics. This study explains that in order to stay competitive and provide the best services to their customers, financial institutions have invested in technology to make their services more efficient and productive. The same applies to Islamic financial institutions. Some of the services provided at financial institutions include Shariah-compliant digital banking, peer-to-peer lending, crowdfunding, payment and money transfer services, and wealth management. Shariah-compliant Fintech services are becoming very popular in both Islamic and non-Islamic countries. Rabbani et al (2023) present a machine learning-based Islamic Fintech model for P2P lending aimed at small and medium-sized enterprises (SMEs) in Bahrain, which addresses the current lending landscape and identifies gaps in the system. The research emphasizes the need for new credit methods that adhere to Shariah principles to increase lending opportunities and support job preservation in the SME sector.

### Cluster 3: Customer Behavior and Machine Learning

This cluster has 7 keyword items namely customer, data mining, information, islamic bank, knowledge, quran, strategy. Machine learning (ML) has become a cornerstone in analyzing and predicting customer behavior, allowing businesses to optimize marketing strategies, personalize experiences, and improve operational efficiency. As explained in the research of Abdullah & Iqbal (2024) and Meddah (2024), AI-powered tools such as chatbots and robo-advisors improve the quality of interactions by providing real-time and context-aware responses, increasing satisfaction and retention.

Research that discusses research related to "Customer Behavior and Machine Learning" includes Li et al (2019) discussing machine learning-based methods for predicting customer behavior. The results show that the prediction effect of decision trees is better than cluster analysis and Naïve Bayesian algorithms, and has a higher promotion rate. Customers who are 45-55 years old and travel 1-2 kilometers are more likely to make a purchase if they do not own a car or have a car at home.

Khodabandehlou & Zivari Rahman (2017) provided a predictive framework regarding customer churn through six stages for accurate prediction and prevention of customer churn in the business field. The results found that the number of items, acceptance of

returned items, discounts, distribution time, and gifts in addition to recency, frequency, and monetary (RFM) variables (RFMITS DP), were selected as the best predictor variables. The proposed model with 97.92 percent accuracy, compared to RFM, has significantly better performance in churn prediction and among supervised machine learning methods, artificial neural network (ANN) has the highest accuracy, and decision tree (DT) is the least accurate. Results show the substantial superiority of the boosting version in prediction compared to simple models and bagging.

Segun-Falade et al (2024) explored how machine learning algorithms are used to enhance predictive analytics in customer behavior studies, driving a more informed and strategic decision-making process in business. The application of ML in predictive analytics starts with data collection from various sources, such as transaction records, social media interactions, and customer feedback. This data is then processed to ensure its quality and relevance before being fed into the ML model. Through techniques such as clustering, classification, and regression, ML algorithms can group customers, predict purchasing behavior, and identify potential quitters. Through machine learning predictions, businesses can customize their marketing efforts, product recommendations, and customer service interactions, thereby increasing customer satisfaction and loyalty.

Chaubey et al (2023) present a comparative study of various machine learning techniques that have been applied to the problem of predicting customer purchase behavior. Experiments were conducted using guided classification machine learning techniques such as logistic regression, decision trees, k-nearest neighbors (KNN), Naïve Bayes, SVM, random forest, stochastic gradient descent (SGD), ANN, AdaBoost, XgBoost, and dummy classifier, as well as some hybrid algorithms that use stacking such as SvmAda, RfAda, and KnnSgd. The models were evaluated using cross-validation techniques. Furthermore, confusion matrices and ROC curves were used to calculate the accuracy of each model. Finally, the best classifier was a hybrid classifier that used the ensemble stacking technique (KnnSgd), with an accuracy of 92.42%. KnnSgd provides the highest accuracy with maximum features because the KNN and SGD errors are minimized by KNN at the end.

Choudhury & Nur (2019) proposed a machine learning approach to identify potential customers for a convenience store. To increase the revenue margin and

stay ahead of the competitors, it is important to understand the buying behavior of customers. Various business industries propose various policies to explore potential customers based on statistical analysis. This research proposes an engineering approach to classify potential customers, based on their previously recorded purchase behavior. Using this classification as the ground truth, it then applies machine learning algorithms to find patterns to predict potential customers with 99.4% accuracy.

#### **Cluster 4: Islamic Economic Growth and AI Innovation**

This cluster has 6 keyword items namely business, finance, innovation, Islamic economy, series, solution. AI technologies, including machine learning and big data analytics, are critical in driving growth in the Islamic finance and business sectors. AI innovations significantly improve operational efficiency, enhance transaction transparency, and expand access to Islamic financial services. For example, AI integration can simplify processes such as risk assessment and compliance monitoring, which are critical to maintaining Shariah compliance in financial transactions (Firnando & Wahyudi, 2024). The intersection of AI and the Islamic economy presents many opportunities for innovation. Technologies such as blockchain combined with AI can enhance the execution of Shariah-compliant contracts through smart contracts that ensure transparency and accountability. This synergy not only fosters trust among stakeholders but also opens up new avenues for service delivery in sectors such as fintech and e-commerce (Fadhilah et al., 2024).

There has not been much research on topics relevant to "Islamic Economic Growth and AI Innovation". A number of relevant studies include Ishak & Mohamed (2023) exploring the potential and challenges in achieving harmonization between Islamic economic principles underlying justice and sustainability with the sophistication of AI technology. The results of the research on the harmonization of Islamic economics with artificial intelligence yielded significant insights into the potential and impact of this integration on the economic paradigm. One of the key findings is that this harmonization opens the door to innovative solutions to address various contemporary economic challenges. Fadhilah et al (2024) analyzed the impact of AI on sustainable economic development in Indonesia from an Islamic economic perspective. This study concluded that AI has great potential in

supporting sustainable economic development in accordance with sharia values, but it must be balanced with proper supervision and regulation so that the benefits can be felt by all levels of society.

#### **Cluster 5: Blockchain for Global Zakat Distribution**

This cluster has 4 keyword items namely blockchain, covid, globe, zakat. Blockchain technology is emerging as a transformative solution to improve the efficiency and transparency of global zakat distribution. This innovative approach can address some of the challenges faced by traditional zakat management systems, including trust issues, inefficiencies in fund allocation, and lack of transparency. A number of studies relevant to this topic include bin Khatiman et al (2021) explaining blockchain technology and its main component, smart contracts, as a basis for collecting zakat and utilizing Ethereum as a platform. In this research, it is explained that there are several problems associated with zakat management, such as zakat payers are not satisfied with the distribution of zakat, and there are claims regarding the lack of transparency in zakat management which causes trust issues among zakat payers to donate their zakat through zakat institutions. One way to respond to these problems is to have transparency in zakat transactions by applying a trust model such as blockchain in zakat management.

Ahmed & Zakaria (2021) describe the use of blockchain to organize zakat distribution. The research shows that it provides a new method, which will contribute to reducing routine procedures and play an effective role to end administrative and financial inefficiencies that have paralyzed zakat institutions. The main important aspect of this research is to establish an active Technology Department for the purpose of serving charity projects and rebuilding trust between zakat management groups and donors. Ikhsan (2023) analyzed whether zakat management institutions need a blockchain zakat system in maintaining transparency of zakat management which can have an impact on increasing the amount of donations collected from muzakki. The results of the study explained that zakat management institutions have a duty to ensure transparent management of the funds they collect as public institutions, and therefore must be trustworthy. By adopting a blockchain-based zakat system, such institutions can enjoy various benefits such as trustlessness, immutability, decentralization, lower costs, peer-to-peer transactions, transparency, and

universal banking. This technology can also help overcome existing problems in zakat institutions.

Khairi et al (2023) described the development and application of blockchain system of zakat collection. The results concluded that the development of blockchain in the zakat collection system can eradicate extreme poverty and improve shared prosperity among people in the country. Hamdani (2020) describes or explains the combination of zakat and blockchain in Indonesia. The results of this study state the importance of blockchain application and implementation for better zakat management. Muharam & Osman (2024) explored the integration of blockchain technology in Islamic social finance to enhance global sustainability, focusing on its potential to improve the management of zakat, waqf, and alms processes. The research highlights the practical application of blockchain in digital philanthropy, exemplified by iBantu's collaboration with Hidayatullah in Indonesia, and emphasizes the need for easy-to-use solutions to encourage widespread adoption and support the Sustainable Development Goals.

## CONCLUSION

This research aims to find out the extent of the development of research on the theme of "*Machine Learning in Islamic Finance*" in the world. The results of the study show that the number of research publications related to "*Machine Learning in Islamic Finance*" there are 30 journal articles indexed by Dimension. Furthermore, in the development of research related to "*Machine Learning in Islamic Finance*" based on bibliometric keyword mapping, the most used keywords are finance, model, technology, Islamic bank, machine, industry, fintech, and system. Based on the frequently used keywords, it is then grouped into 5 research map clusters with topics that discuss *Machine Learning for Islamic Bank Efficiency*, *Machine Learning in Islamic Fintech*, *Customer Behavior and Machine Learning*, *Islamic Economic Growth and AI Innovation*, and *Blockchain for Global Zakat Distributio*.

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