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FINTECH ADOPTION IN MALAYSIA'S AQUAFARMING INDUSTRY: CHALLENGES, STRATEGIC PATHWAYS, AND FUTURE OPPORTUNITIES FOR SUSTAINABLE DEVELOPMENT

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Abstract:

Financial technology (Fintech) presents viable pathways to accelerate the digital transformation of Malaysia's aquafarming sector. This conceptual study employs an integrative literature review and policy analysis to examine the structural barriers and strategic enablers governing Fintech adoption within the Malaysian aquafarming ecosystem. While prior literature has broadly addressed Fintech in general agriculture, sector-specific operational realities of aquafarming such as biological production risks, high informality, and fragmented cold chains remain underexplored. Addressing key empirical gaps, this study identifies four primary structural barriers: credit exclusion resulting from strict physical collateral demands and unrecorded cash histories, supply chain fragmentation exacerbated by downstream cold-chain deficits, digital literacy and trust deficits among smallholder producers, and regulatory ambiguity concerning aquaculture-tailored financial mechanisms. To mitigate these challenges, this study proposes a targeted four-pillar strategic framework comprising alternative data-driven micro-financing (including Shariah-compliant instruments), blockchain-enabled supply chain traceability, community-based digital capacity building, and collaborative regulatory sandboxes. Furthermore, the study connects emerging technologies directly to operational aquafarming functions: artificial intelligence (AI) and big data for parametric risk assessment and water-quality automation, decentralized finance (DeFi) for peer-to-peer working capital, and green

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Fintech for sustainability-linked credit and ESG validation. This paper provides actionable insights for policymakers, financial institutions, and aquaculture operators seeking to enhance financial inclusion and build resilient, sustainable food production systems.

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Aquafarming, Fintech Adoption, Sustainability

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Introduction

The aquafarming sector contributes significantly to Malaysia's socio-economic development, food security, and rural livelihoods, especially in recent years. With the increasing demand for fish and other aquatic foods, aquafarming has become a viable alternative to capture fisheries and a strategic part of the national food system. Further, the industry creates employment and income opportunities, particularly in rural and coastal areas and contributes to nutritional security and the growth of other economic sectors. As the industry grows in significance day by day, it still faces several challenges, including slow technology adoption, restricted access to capital, and supply chain issues. These constraints are bigger for the small-scale producers who are informal and lack access to business development support and capital (Mhlanga, 2023).In Malaysia, aquafarming has undergone significant changes in recent decades due to the country's new development priorities and technological advances. Small-scale production has shifted toward technology-based, commercially oriented production. These changes have strengthened and made the national food system more accessible, improved rural livelihoods, and contributed to the development of the country's food sector (Jumatli & Ismail, 2021). This has led to the inclusion of aquafarming in Malaysia's long-term policies on economic sustainability and food security.

Aquafarming is one of the fastest-growing areas of the fisheries industry and contributes approximately 30% to fish production in Malaysia, as part of this overall transformation. Seaweed farming (54%) and brackish water fish farming (26%) are the largest share of aquaculture production, followed by freshwater fish farming (20%). Inland fisheries, on the other hand, produce approximately 1% of total fish production. Food is not the only product of the industry which has economic value. The ornamental fish industry also produces about 234 million ornamental fish and 24 million tonnes of aquatic plants each year, adding further diversification to the industry's economic base. However, food fish production remains the main segment, contributing almost 97% of the industry's value, while other non-food species

such as ornamental fish contribute 3% (FAO, 2024). Despite these achievements, the fishery and aquafarming sector still faces a dynamic future environment that presents opportunities and challenges. The increasing rate of urbanisation is predicted to reach 85% of the population by 2040 (United Nations, 2018), changing consumer preferences and increasing demand for quality, variety, and convenience aquatic products. These evolving consumption trends open new market opportunities, but at the same time increase strain on current production systems and reveal value chain shortcomings in terms of competence (Obi et al., 2025). To overcome these challenges, innovative solutions that can help optimize operations, ensure better product access and boost supply chain resilience are needed.

In this context, the aquafarming industry faces many structural challenges that financial technology (Fintech) can address. Digital payment, micro-lending platforms, crowdfunding and blockchain-based traceability are potentially key areas where Fintech could bring benefits, such as enhancing access to financial services, creating transparency, linking markets, and facilitating the digitalization of aquafarming activities (Mohammad et al., 2026; Vasudevan et al., 2025; Mhlanga, 2023). Innovations are particularly relevant to small producer groups, who may have difficulty in accessing formal financing and modern supply chains.It was even more evident during the Covid-19 pandemic when digital financial solutions played a significant role in mitigating the supply chain disruptions and continuity of operations (Rowan & Laffley, 2020). There is growing evidence that digital technologies and innovative farming practices are instrumental in better resource utilization, better sustainability, and higher inclusion of smallholders into agricultural value chains (Rayhan et al., 2024). Apart from Fintech's application in aquafarming, there are also broader implications for the strengthening of food security and enhancing the resilience of supply chains (Palma & Viegas, 2022), as aquafarming is recognised as a sub-sector of agriculture (USDA, 2020).

However, Fintech penetration in the aquafarming industry remains relatively low in Malaysia despite its potential. Previous research has identified some obstacles such as a lack of digital literacy, disconnected digital infrastructure in rural areas, low trust in digital platforms, and a lack of policy incentives that address technological adoption (Oi, 2023). These challenges constrain the sector's capacity to fully benefit from the transformative power of digital financial innovations and impede effective, inclusive, and sustainable development results. From a policy perspective, Fintech in aquafarming is closely linked to the United Nations Sustainable Development Goals (SDGs), with SDG 1 (No poverty), SDG 2 (Zero hunger), and SDG 8 (Decent work and economic growth) as the most relevant (FAO, 2024). Fintech can play a significant role in making aquafarmers more financially inclusive, efficient, and resilient, and in building a more competitive and sustainable industry. e-Wallets, blockchain technologies, and other financing methods can improve transparency, boost productivity, and stimulate inclusive growth.

Financial technology (Fintech) such as digital platforms, peer-to-peer (P2P) lending, InsurTech, and blockchain-based traceability provides solutions to enhance agricultural access to finance, supply-chain transparency, risk management and producer–buyer connectivity (Ramdhan et al., 2024; Shebanina et al., 2025). Previous research, however, has mainly focused on agriculture as a whole or on the specific application of Fintech in general supply-chain financing and not on the specific financing and supply chain context of aquafarming. This distinction is particularly relevant in Malaysia, where Fintech scholarship remains concentrated on areas such as blockchain, crowdfunding, cryptocurrencies, electronic wallets, and general P2P financing (Urus & Mohamed, 2024; Sak et al., 2025). Consequently, the intersection

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
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Volume: 8 Issue: 29 (September 2026) PP. 840-859

between Fintech adoption and aquafarming-specific supply-chain and institutional dynamics in Malaysia remains comparatively underexplored.

The potential of agriculture and financial technology has drawn increasing scholarly interest but most of the existing literature has been focused on crop production, rural finance and agricultural value chains in general, neglecting the aquafarming industry. Thus, the special operating features of aquafarming, such as the segmentation of production, the volatility of aquaculture outputs, and the need for coordination in the supply chain at every stage, have not been examined extensively. In addition, the existing research has largely focused on the advantages of Fintech adoption, with a relative lack of focus on understanding the challenges of Fintech implementation and the strategic pathways that can be used to maximize the benefits of Fintech. Although Fintech has become an important enabler for aquafarming in achieving food security and sustainable economic development, empirical evidence on Fintech integration in aquafarming remains limited in the Malaysian context. A key gap in sector-specific knowledge is the lack of empirical evidence on Fintech integration in aquafarming.

This paper thus seeks to identify the major challenges faced during the implementation of Fintech in the aquafarming industry in Malaysia, as well as provide recommendations to increase its role in sustainable aquafarming development. The study's emphasis on the link between digital financial innovation and aquafarming contributes to the literature on agricultural digitalisation and provides insights that could be useful for policymakers, financial institutions and other industry stakeholders seeking to foster more financial inclusion, efficiency, and sustainability in the aquafarming sector.

Literature Review

Key Issues in Fintech Adoption in Malaysia's Aquafarming Industry

Limited Access to Financial Services

One key challenge in Fintech adoption is limited access to financial services, especially for small and rural farmers in Malaysia's aquafarming industry. Financing sources are one of the major challenges faced by many aquafarming businesses. This is costly because many producers lease or use communal land, which is unsuitable as collateral for bank loans. Furthermore, aquafarming is considered a high-risk enterprise, and traditional lenders are hesitant to lend on aquafarms because of the environmental hazards, such as disease epidemics, floods, water pollution, etc. (FAO, 2024). Access to finance is a key determinant of productivity, sustainability and improvement of livelihoods in the agricultural and aquafarming value chains. The lack of formal financial services has been widely documented in the literature to limit farmers' capacity to invest in productive factors, cope with risks faced during operations, and enhance long-term profitability (Raza et al., 2023). For instance, Chandio and Jiang (2018) found that the distance to financial institutions, loan informativeness, and interest rates limit the availability of formal credit to farmers in Sindh province of Pakistan. Small-scale aquafarmers in Malaysia will probably also be faced with such constraints.

This is further compounded by the fact that many aquafarming businesses are informal. There are many operators who are unregistered, have limited financial records, and do not have credit histories. They are therefore not always eligible for the lending requirements of commercial banks and thus are not accepted for conventional loan products (Mat Zain & Lee, 2022). The

financial exclusion hinders their ability to invest in infrastructure, grow production and use new technologies. These constraints can be overcome by Fintech solutions. More flexible and inclusive financial options are offered by digital lending platforms, mobile microfinance services and peer-to-peer (P2P) financing. These platforms do not rely solely on traditional banking data like credit scores and histories to determine borrowers' creditworthiness, but also on other sources of information including mobile usage patterns, transaction histories, and behavioural data. Fintech can help achieve financial inclusion among the underserved aquafarming communities by cutting down on the use of collateral and making loans easier to obtain. Having easier access to capital can help small-scale producers modernise their operations, utilize innovative technologies, and help to build industry sustainability in the longer term (Setiawan et al., 2021).

Supply Chain Inefficiencies

The aquafarming industry in Malaysia still faces significant supply chain inefficiencies despite its strategic role in strengthening food production resilience and rural development. The post-harvest processing capacity was constrained by weak cold chain infrastructure, and the disjointed logistics chains have contributed to post-harvest losses and hardships for producers (Goedhals-Gerber & Khumalo, 2020). These inefficiencies not only affect the operations but also limit small-scale aquafarmers' access to formal markets and decrease their competitiveness in increasingly technology-enabled value chains.

The current environment of increasing complexity of seafood supply chains has created a greater need for transparency, traceability and coordination between stakeholders. Fintech technologies such as blockchain systems have significant potential to enhance the performance of the supply chain in this regard. Blockchain technology ensures that transactions are recorded in a secure and tamper-resistant manner, and it can also facilitate end-to-end traceability of products, eliminating information asymmetry, the risk of fraud, and boosting stakeholder confidence (Chandan et al., 2023). Such transparency is increasingly pertinent to food safety standards and consumer confidence, both nationally and globally.

These technologies can be complemented by other digital payment technologies like e-payment systems, digital lending platforms, and electronic invoices, further enabling aquafarmers, suppliers, and buyers to transact. These technologies offer advantages to reduce transaction delays, improve cash flow, and improve coordination down the supply chain (Rowan, 2023). Together, IoT and predictive analytics can help improve real-time inventory and distribution monitoring, which can result in increased responsiveness and reduced waste. As a whole, the innovations reflect the promise of Fintech to overcome systemic inefficiencies and enhance the resilience and competitiveness of the aquafarming industry in Malaysia.

Low Digital Literacy and Trust Deficits

Digital literacy is significant in the development of individuals to understand, use and gain from digital technologies (Abdul Kareem & Oladimeji, 2024). Users with fundamental skills in the use of smartphones, computers, and internet applications will be able to communicate better with digital platforms and also have less cognitive load when using them. Digital literacy is also associated with users' confidence in the reliability and usability of technological systems (Abdul Kareem & Oladimeji, 2024).

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 840-859

Despite these efforts, low digital literacy levels are still an obstacle to the adoption of Fintech in the Malaysian aquafarming industry, especially in rural areas. Most aquafarmers have limited experience with the use of digital technologies and do not always have the skills to use mobile applications, make online payments or access digital financial services effectively (Oi, 2023). Consequently, financial inclusion is lower, operational efficiency is lower, and there is uncertainty and hesitation in the minds of people with regard to Fintech platforms.

Digital literacy is not only technical skills, but also awareness of cybersecurity, privacy protection and risk management. This knowledge helps users to recognize reliable platforms, prevent fraudulent activities, and better control financial risks (Van Laar et al., 2017). Digital competence is therefore related to trust, which has always been considered as one of the main factors that influence technology acceptance (Bélanger & Carter, 2008). Users that have a basic understanding of Fintech systems and how their personal information is safeguarded are much more inclined to embrace Fintech technologies.

Therefore, a comprehensive approach is needed to address digital literacy and trust issues. To mitigate scepticism and foster confidence in digital financial systems, it is critical to improve cybersecurity practices, improve the transparency of transactions, and launch targeted educational and awareness campaigns. This would stimulate aquafarmers' increased use of Fintechs and contribute to the overall efforts to enhance financial inclusion and technological readiness in the aquaculture sector (Altoukhov, 2020).

Regulatory and Policy Constraints

Another barrier to the digitalisation of Malaysia's aquafarming industry is regulatory and policy related. Sector governance is complex and encompasses environmental regulations, disease control measures, and quality assurance standards (Obi et al., 2025). A notable example is the implementation of the Good Aquaculture Practices (GAqP) certification programme since it was launched in 2004 and was revised in 2017 to match the ASEAN Good Aquaculture Practices (GAqP) standard (Manap & Pauzi, 2020). While these regulations are necessary to ensure the quality and sustainability of the product, they are also very expensive for producers to comply with.

There have been more frameworks introduced in the regulatory environment, such as the Malaysian Biosafety Act 2007 and the ASEAN guidelines in managing biosecurity risks associated with emerging biotechnologies (Ghazali & Kadir, 2025). These policies are essential to protect the environment and public health but may also lead to an 'overlap effect' which could make industry more inefficient to operate and create an administrative burden for the industry players.

Besides sector-specific regulations, there is a huge hurdle in the adoption of technology due to uncertainty about Fintech governance. While the Fintech industry in Malaysia has grown significantly, there are limited policies that are specifically focused on Fintech applications in aquafarming (Woffenden, 2024). There are no specific rules and incentives, which makes it hard to determine what is required for compliance and makes long-term investments in digital technologies less appealing for businesses. Governments and financial institutions therefore need to create policies that foster innovation and at the same time provide consumer protection and financial stability (Deloitte, 2020).

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 840-859

The findings from previous studies suggest that the institutional environment could either foster or impede technological innovation when it comes to regulatory uncertainty (Frederiks et al., 2022). However, the general rule for uncertainty is that it scares investors off and delays the adoption of technology. It is hence important to have clear, stable and conducive policies that foster the growth of Fintech and help secure sustainable development of the aquafarming industry in Malaysia.

Strategic Framework for Strengthening Fintech Adoption in Malaysia's Aquafarming Industry

Enhancing Financial Inclusion Through Fintech Platforms

Improving financial inclusion is essential in sustaining and competitizing the aquafarming industry in Malaysia in the long term. The lack of financing options for many small-scale operators, makes Fintech platforms another option for increasing access to financial resources. For credit, digital lending services, peer-to-peer financing, and microfinance schemes with a specific focus on aquafarming enterprises can help increase credit accessibility by leveraging alternative data sources such as transaction history, production records, and behavioural data to assess borrowers' creditworthiness (Setiawan et al., 2021). These methods could streamline the credit assessment process and alleviate financing challenges for small and medium-sized enterprises (SMEs) as compared to traditional credit mechanisms.

This is especially the case in rural and coastal regions where access to the physical financial system is often restricted. The adoption of digital financial platforms provides more inclusive and flexible financing opportunities, which help to bridge the financial inclusion gap between formal financial institutions and marginalised aquafarming communities (Sadhana et al., 2025). Moreover, the presence of special products, such as Islamic financial products, which are compliant with Islamic law, could also help increase financial participation and financial inclusivity while strengthening the financial ecosystem to fit Malaysia's socio-economic matrix (MIDA, 2023). As a result, financial inclusion through Fintech could help to increase investment potential, productivity and economic resilience of aquafarming businesses.

Strengthening Supply Chain Efficiency Through Blockchain Technology

Another key factor of digital transformation in the aquafarming sector is the improvement of the supply chain. There are significant opportunities for blockchain technology to increase transparency, tracking and accountability in seafood value chains. Blockchain is a decentralised and tamper-resistant system, thus enabling transparency and security of information and allowing stakeholders to trace the product origin and track transactions along the value chain (Zhang et al., 2021). It is becoming ever more important for food safety, regulatory requirements, and building consumers' trust in both national and international markets (Pan et al., 2023).

Besides traceability, blockchain applications can also enhance operational efficiency by using smart contracts to execute transactions automatically and reduce the need for intermediaries. These processes can help reduce costs, ensure fair pricing, and prevent fraud (Zhang et al., 2021; Babu et al., 2023). Major aquafarming stakeholders could participate in pilot projects to gain insight into the feasibility and scalability of blockchain applications in Malaysia's aquafarming industry (Mileti et al., 2022). Digital marketplaces and financial technology can

also help producers connect directly with buyers, improving market access and boosting the profitability of small and medium-sized enterprises (SMEs) (FAO, 2024). Collectively, these innovations can improve the resilience and competitiveness of Malaysia's seafood industry supply chain on the international stage.

Improving Digital Literacy and Strengthening Trust

A more important condition for the successful adoption of Fintech is human capital development. Beyond the technological infrastructure, the effective use of digital financial services relies on users' understanding and skills to access digital platforms. Digital literacy can be enhanced and awareness raised on Fintech applications through education programmes such as workshops, mobile training programmes, and online learning platforms (Jayashankar et al., 2018). The effectiveness of capacity building programmes in improving digital literacy and productivity and income generation within the aquafarming sector has been demonstrated in previous studies (Haque et al., 2024; Rowan, 2022).

But for widespread adoption, technical skill is not enough. Another element crucial to technology acceptance is trust. Transparency, user-friendly design, and reliable service delivery are crucial to maintaining users' trust in Fintech applications (Jayashankar et al., 2018). Community-based Fintech support centres can provide an avenue for ongoing support, information sharing, and peer learning between the users of digital financial services, supporting the shift towards digital financial services (Oi, 2023). In addition, targeted awareness-raising and engagement efforts can reduce uncertainty, address negative perceptions of digital technologies, and increase uptake of Fintech solutions among aquafarmers. This is why building digital literacy and trust is essential to achieve an inclusive digital transformation.

Establishing Supportive Regulatory and Policy Frameworks

To foster innovation and speed up Fintech adoption in the aquafarming industry, a supportive regulatory framework is crucial. Regulatory sandboxes have become a significant tool, enabling Fintech companies to test new products or services in a controlled environment with less stringent regulatory oversight (Goo & Heo, 2020; Zheng & Wu, 2024). While the impact of these can differ depending on institutional settings, they can help to decrease uncertainty and foster technological innovation (Raudla et al., 2024).

The harmonisation and minimisation of regulatory frameworks of aquafarming and digital finance is also important. Industry players could be encouraged to adopt new technologies through streamlined regulatory procedures that ease adoption and reduce administrative burden (Manap & Pauzi, 2020; Obi et al., 2025). Therefore, there is a need for effective coordination between the regulatory agencies to balance out the objectives of innovation with concerns regarding consumer protection, environmental sustainability and financial stability (Ghazali & Kadir, 2025; Obi et al., 2025).

Cooperation and financial incentives can also contribute to the acceleration of the sector's digitisation. Tax incentives, subsidies and innovation grants are some of the policy instruments that can motivate investments in Fintech applications (Nugraha et al., 2022). Likewise, public-private partnerships (PPP) can contribute to the development of integrated digital ecosystems and improve the coordination and interaction between governments, financial institutions, technology providers and aqua-farming enterprises (Mhlanga, 2023). Extension of knowledge

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 840-859
sharing and implementation of best practices can be realized through cooperation and alignment of international organization and regulation, which will lead to the long-term sustainability and competitiveness of aquafarming industry in Malaysia (Nugraha et al., 2022). To summarise, financial inclusion, streamlining supply chains, digital literacy and trust, and supporting regulatory frameworks are part of a broader digital transformation programme. The strategic pillars are not separate from one another but complement each other and thus work towards a more sustainable, resilient and inclusive aquafarming industry. The opportunities offered by Fintech solutions for the aquafarming sector could help Malaysia realise its vision of addressing national food security, rural development, and sustainable economic growth, while also supporting the agenda of the United Nations Sustainable Development Goals.

Future Directions in Aquafarming

Emerging technologies are clearly linked to specific operational and financial points in the aquaculture value chain. Artificial intelligence (AI) and big data analytics directly interact with farm risk management by harnessing continuous real-time data from the IoT, such as water-quality and production data, for predictive monitoring and decision-making (Idris et al., 2025; Agyemang & Anokye, 2025). These digital technologies have significant potential to enhance disease management, production efficiency, traceability, and on-farm decision-making (Agyemang & Anokye, 2025). Another potential use of digitally enabled aquaculture risk management (digital ARM) is integrating these technologies with financing and insurance mechanisms (Tolentino-Zondervan et al., 2022).

At the same time, decentralized finance (DeFi) offers a possible solution to overcome the issue of capital constraints in fisheries and aquaculture value chains. DeFi applications based on blockchain could help provide access to financing, capital, and insurance, especially in markets where these are not available (Tolentino-Zondervan et al., 2022). Blockchain and smart contract architectures are also establishing a framework for increased automation and transparency in aquaculture value-chain transactions (Tolentino-Zondervan et al., 2022; Theofania, 2024). Another new application of blockchain in Aquaculture Value Chains (AVCs) is through digital payment applications (Tolentino-Zondervan et al., 2022; Theofania, 2024). Lastly, blockchain technology can contribute to sustainability and transparency across aquaculture value chains by maintaining a traceable record of production and value chain operations, ensuring transparency and traceability (Tolentino-Zondervan et al., 2022; Theofania, 2024). When integrated with Internet of Things (IoT) data collection, digitally recorded information could further enhance the quality and credibility of production information (Tolentino-Zondervan et al., 2022; Idris et al., 2025).

In the future, the aquafarming industry in Malaysia is expected to be significantly influenced by digital technologies, financial innovations and sustainable practices as these will become more vital. The financial landscape and the supply chain formations are also being impacted by the new technologies, as they are by the production line. The incorporation of AI, decentralised finance, digital currencies, and sustainable Fintech solutions can redefine the competitiveness and resilience of the aquafarming sector in this context. The developments are expected to contribute to the industry's efficiency, more financial inclusion and sustainability in the longer term.

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 840-859

Integrating Artificial Intelligence and Big Data into Fintech Ecosystems

Artificial Intelligence (AI) and big data analytics are a significant leap in boosting productivity and sustainability in aquafarming. By leveraging AI-driven financial analytics, aquaculture farmers can gain insights into market trends, price dynamics, and risk management, enhancing their financial decision-making. Another major application of advanced predictive models is to enhance credit assessment and loan evaluation, particularly for small-scale producers who may lack financial records (Kumar et al., 2021). Not only in financial applications, but also the use of AI and big data technologies can help optimize aquafarming operations. In aquafarming systems, predictive analytics has the potential to enhance water quality management, nutrient cycling, and interactions between aquatic plants and fish, leading to increased productivity and minimized environmental impact (Yang et al., 2025).

Additionally, AI-powered automated feeding, environmental monitoring, and fish health assessment can further enhance the utilization of resources and operation of the system (Khatei et al., 2025; Huang & Khabusi, 2025; Jayandan et al., 2024). Water temperature and dissolved oxygen level monitoring along with the behaviour of fish could help in early detection of disease outbreaks and reduce losses in fish production through an online monitoring system (Mandal & Ghosh, 2023). These technologies represent the opportunities AI and big data can bring to the sustainability of aquaculture systems amid uncertainty in the environment and economy.

Leveraging Decentralised Finance for Inclusive Growth

Decentralised finance (DeFi) represents a new financial paradigm that could help to address these three challenges in aquafarming: transparency, access to finance and resilience. DeFi platforms can provide alternative financing, improving access to finance for aquafarmers, particularly those without access to traditional financial institutions (Wang et al., 2019). By automating processes, improving transparency, and reducing transaction fees, smart contracts can help build trust among participants in DeFi platforms.

These innovations are especially significant in areas where financial resources are limited and prevent the use of high-tech technologies and sustainable agriculture (Masi et al., 2024). The current industry structures, including feed companies offering credit and technical support, could be linked with DeFi platforms to create more flexible and efficient financing solutions. In these agreements, industry stakeholders can be involved as guarantors, and blockchain-powered platforms can provide transparency and accountability in the financing process (El-Sayed et al., 2021). In conclusion, DeFi can help to democratise access to finance and foster more innovation and sustainable development in the aquafarming sector.

Digital Currencies and Cross-Border Trade Integration

Digital currencies are becoming more widespread and are offering new possibilities for enhancing the competitiveness of aquafarming businesses in the international market. Stablecoins are cryptocurrencies that use reserve backing systems to reduce price fluctuations, providing an effective way to make cross-border transactions. Digital currencies can offer numerous advantages over traditional banking systems, including lower transaction costs and faster processing times, which can benefit aquafarming producers, suppliers, and overseas buyers in facilitating global trade (Bizama et al., 2025; Ogunmola et al., 2024).

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 840-859

Digital currencies can also foster greater financial inclusion by enabling greater engagement and participation of small-scale enterprises and under-served populations in global markets (Lal & Jatav, 2024). In addition, using blockchain technology in payments facilitates transparency and traceability, enhancing consumer trust and compliance with food safety and regulatory standards, which is essential to seafood export trade (Ogunmola et al., 2024). These changes will play an important role in improving the efficiency, inclusiveness, and resilience of global aquafarming value chains.

Promoting Sustainable Fintech for Green Aquafarming

As sustainability becomes a major focus in the global food system, green Fintech solutions are likely to play a more integral role in promoting eco-friendly aquaculture practices. Sustainable Fintech solutions can help unlock green financing instruments, carbon-credit markets and sustainability-linked loans, which would incentivise environmentally friendly production processes. These mechanisms offer monetary rewards to aquafarmers for implementing energy-saving technologies, optimising waste management, and minimising carbon emissions. In addition, blockchain can promote environmental transparency by providing a clear, transparent way to report sustainability metrics and track the origins of eco-certified seafood products. Digital platforms can also facilitate environmental, social, and governance (ESG) reporting, enabling producers to demonstrate their commitment to sustainable practices and build trust with environmentally conscious customers and investors (Bhatnagar et al., 2024). Furthermore, AI-driven resource management systems can reduce energy use, feed wastage, and water use, aligning with circular economy principles and sustainable resource use. The adoption of sustainable Fintech solutions is thus likely to have a significant impact on the Fintech industry's green transformation while also enhancing financial efficiency. These innovations offer economic and environmental advantages, along with the potential for social responsibility, and can be valuable in achieving the United Nations Sustainable Development Goals and improving the long-term sustainability of Malaysia's aquafarming industry.

Implications for Policymakers and Industry Stakeholders

This will require a joint effort from policymakers, financial institutions, technology providers, and industry players to ensure the digital transformation of Malaysia's aquafarming industry. A favourable financial climate, where innovation is allowed, financial inclusion and sustainability are achieved, will be key for their successful implementation, considering the continuous evolution of Fintech technologies. Beyond the operational advantages, the impacts of Fintech use are also economic, social and environmental.

Implications for Policymakers

Policymakers play a key role in providing a context for Fintech innovation, ensuring financial stability, and protecting consumers. Regulatory policies must be able to find the right balance between technology experimentation and adequate regulation. The regulatory sandbox is a relatively new concept that provides financial technology (Fintech) startups with a platform to experiment with new solutions without the fear of regulatory uncertainty and has successfully been used to encourage innovation in the financial industry (Goo & Heo, 2020; Zheng & Wu, 2024). Additionally, the coordination of the duties and jurisdiction of the different government levels can help to prevent overlapping requirements and help to reduce compliance burdens, making aquafarming easier and the Fintech industry more efficient. Furthermore, a coordinated

approach between different government agencies can help reduce duplication of requirements and streamline compliance procedures, which ultimately will improve the efficiency of aquaculture and the Fintech industry (Obi et al., 2025). Digital transformation may also be a function of public policy, and this can be achieved through incentives, such as grants, tax relief, financial support and digital infrastructure initiatives. This is particularly important in rural and coastal areas where connectivity and financial exclusion are still a problem for rural and coastal communities, thus impacting on economic opportunities (Mhlanga, 2023). Moreover, policy interventions on financial inclusion and technology use have direct impacts on various Sustainable Development Goals (SDGs), such as SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 8 (Decent Work and Economic Growth) and SDG 9 (Industry, Innovation and Infrastructure) (FAO, 2024).

Implications for Financial Institutions and Fintech Providers

Aquafarming businesses are at a unique position to benefit from new solutions developed by Fintech service providers and financial institutions. Collateral and financial histories are used in traditional lending processes, excluding many small-scale producers from the formal financial system. Fintech providers can address these issues by using alternative data and digital credit assessment models to improve financial access for underserved communities (Setiawan et al., 2021). Furthermore, the financial sector can help the industry become more resilient by providing financial products specific to the industry. They can be microfinance schemes, peer-to-peer lending platforms, embedded finance solutions, and Shariah compliant Islamic Fintech services (MIDA, 2023). The incorporation of blockchain technologies, artificial intelligence, and big data analytics also has the potential to enhance transparency and visibility of transactions, risk assessment, and efficiency in supply chain financing (Kumar et al., 2021; Zhang et al., 2021). These innovations should help build customer confidence, enhance market efficiency, and enable sustainable development of the aquafarming sector.

Implications for Aquafarming Enterprises

Digital Transformation is a challenge and an opportunity for aquafarming businesses. Fintech embedded companies will likely reap benefits such as enhanced financial access, business efficiency, and competitiveness. Blockchain traceability can also enhance product transparency and traceability, thereby contributing to more stringent food safety standards, and support international market access (Pan & Shieh, 2023). Simultaneously, there is a need to invest in digital skills and organizational capacity in the process of adopting digital technologies. Older research indicates training programs and capacity development boost the technological readiness and productivity of aquafarming communities (Haque et al., 2024; Rowan, 2022). Therefore, digital transformation should not be seen simply as the introduction of new technologies, but as a process that requires learning, upskilling and driving future innovation within the business.

Implications for Sustainable Development and Food Security

The impact of the use of Fintech is not only on economic performance, but also on sustainable development and food security. Digital financial solutions can create financial inclusion, enhance supply chain transparency and resource efficiency. This contributes to the resilience of food systems (Palma & Viegas, 2022). Artificial Intelligence, blockchain, and Internet of Things (IoT) based monitoring systems are some of the new technologies used to support

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 840-859

sustainable resource management, which optimize use of the feed and minimize waste and environmental damage (Mandal & Ghosh, 2023; Yang et al., 2025). Furthermore, sustainable Fintech projects can contribute to facilitating green financing instruments and promote environmental, social and governance (ESG) practices in the aquafarming sector. These use of digital technologies can enhance transparency and traceability, fostering trust with stakeholders and enhancing the market competitiveness of eco-responsible producers (Bhatnagar et al., 2024). Thus, Fintech should not only be considered as a means of economic development, but also as a means of sustainable food production and improving the food security of the country.

In summary, digitization of Malaysia's aquafarming industry necessitates the collaboration of various stakeholders, such as policymakers, financial institutions, technology providers, and aquafarming enterprises. To achieve a successful Fintech adoption, institutional support, digital skills and technological innovation must be aligned with sustainability goals, and adequate institutional environments must be created. This comprehensive approach is crucial for boosting the competitiveness, resilience, and long-term sustainability of Malaysia's aquafarming sector.

Conclusion

The aquafarming industry is one of the key sectors that contributes significantly to national food security, economic growth and the development of rural areas in Malaysia. However, the sector still faces significant structural issues that need to be addressed to ensure long-term sustainability and competitiveness. Some of the key challenges to the effective use of financial technology include limited access to financing, inefficiencies in the supply chain, low digital readiness, trust issues and complex regulations. These issues are especially apparent in the case of small-scale operators, who are likely to be financially excluded and lack technological resources. It is crucial to tackle these challenges to improve the resilience, inclusiveness, and long-term viability of Malaysia's aquafarming ecosystem.

The findings of this study highlight the immense possibilities of Fintech to transform the aquafarming industry in Malaysia, thereby making it more economically sustainable, efficient in the supply chain and improving financial inclusion. Yet, adopting the technology is not enough. But it requires a complete solution to Fintech adoption. The proposed strategic framework centres on four interlinked themes: Financial inclusion; Improving supply chain efficiency; Digital readiness and trust; Regulatory and institutional environments. Moreover, as new technologies such as artificial intelligence, big data analytics, decentralized finance, digital currencies, and green Fintech solutions emerge, they are poised to revolutionize the future of aquafarming, enhancing its operational efficiency, transparency, and sustainability.
Theoretically speaking, this research contributes to the field of agricultural digitalization and financial technology by moving the academic lens from the general perspective of land-based agriculture to the specific and highly fragile operating context of aquafarming, where the biological nature of farming is very pronounced. This conceptual novelty of this work is the development of a four-pillar framework for the implementation of Fintech for the structural dynamics of Malaysia's aquafarming industry in an integrated manner, combining alternative data credit scoring, Sharia-compliant micro-financing mechanisms, blockchain-based value chain traceability and community-based capacity building.

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 840-859

In terms of practice, this framework provides clear, actionable value in the whole aquafarming value chain. A harmonized cross-agency oversight framework is recommended, coupled with targeted digital infrastructure incentives, and the establishment of specialized agritech regulatory sandboxes to establish an overarching agenda for policy coordination and regulation among policy makers and authorities, including the Department of Fisheries, Bank Negara Malaysia, and the Securities Commission Malaysia. The financial institutions and the Fintech innovative firms have obtained concrete directions to create non-collateralized lending algorithms, parametric micro-insurance products and Sharia-compliant financing instruments (salam and murabahah) that are specific to rural producers. So, the smallholder aquafarmers and enterprise operators find a strategic avenue to break the cycle of credit exclusion from the traditional credit system, downstream middleman exploitation, product integrity along the cold chains, and access high-value traceable domestic and export markets.

This paper contributes to the growing research literature on digital change and financial innovation and extends the discourse beyond the more researched space of agriculture to aquafarming. This paper is different from the previous studies, which focused primarily on specific technology applications, because it offers a broader perspective that incorporates technological, institutional, financial and sustainability dimensions in a holistic framework for aquafarming enabled by Fintech. In reality, the results show that a combination of innovative financing options, traceability systems on blockchains, specific digital training programs, and adaptation of current legislation will be needed to overcome the current obstacles. Ensuring these efforts succeed will require a coordinated approach and strong partnerships between government, financial institutions, technology service providers, industry stakeholders, and aquafarming communities to ensure an inclusive digital landscape that encourages innovation and resilience in the aquafarm sector.

Fintech should not be considered solely as a technology tool, but rather as an important enabler for sustainable economic transformation of the aquafarming sector. Fintech can build the resilience of food production systems by modernising food production systems, increasing access to financial services, improving transparency in supply chains, and encouraging environmentally sustainable production methods, among other things, and support social and economic development in general. These initiatives are well aligned with the United Nations Sustainable Development Goals (SDGs), particularly SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure) and SDG 12 (Responsible Consumption and Production). Through planning and a sustained initiative, the introduction of Fintech in aquafarming has the potential to be a source of learning and a catalyst for sustainable and inclusive digital transformation in aquafarming sectors for other developing economies.

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Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
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