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Digital Transformation and The Blue Economy: Penta-Helix Model For Catfish Farmers In West Java

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Abstract: This study aims to analyze the impact of digital transformation in increasing the income of catfish farmers in several ways: (1) Analyze who benefits from the implementation of digital transformation; (2) Analyze the creation of jobs with the use of digital transformation; (3) Analyze the motivation of catfish farmer groups in entrepreneurship; (4) Analyze the use of digital transformation in the implementation of the blue economy. Qualitative methods were used to collect initial data related to the potential of catfish farmers in West Java Province, Indonesia. Participatory observation, in-depth interviews, surveys, and Penta-Helix model were also utilized. This study also formulates hypotheses and builds instruments for quantitative measurement. Smart-PLS is the statistical tools used to analyzed the data for the hypothesis testing. Our research focus on one province which may not generalizable to other cities and provinces in Indonesia. The study found that West Java proximity to Jakarta provides a logistical advantage for catfish distribution. It is signified that digital transformation positively influence the income ($\beta=0.857$; $p<0.001$) and entrepreneurial motivation ($\beta = 0.911$; $p = 0.001$) of the catfish farmers. A penta-helix collaboration (government, stakeholders, academia, community, industry) should develop infrastructure for cultivation, processing, logistics and digital management. The future research may conduct in other cities or provinces because Indonesia is well known as archipelagic country in the world that has great potential for blue economy in the marine and fisheries sector.

Keyword: Blue Economy; Digital Transformation; Catfish farmers; Penta-Helix Model.

INTRODUCTION

The concept of a Blue Economy integrated with the United Nations' Sustainable Development Goals (SDGs) can develop local wisdom on a global scale (Lee et al., 2020). Globally, policy discussions have begun to focus on the world's blue resources. If these resources are managed sustainably, this will have positive environmental and economic implications (Alharthi & Hanif, 2020). Not only focusing on the blue resources to empower

the blue economy, but the global needs in digital skills should also be adopted by the aquaculture workforce. The requirement for skills is changed, thus training related to adoption of technology should be implemented (McDonald et al., 2024). Aquaculture sector unfolded a rapid growth among the food sector globally. It is documented that rather than wild-caught fish, aquaculture industry produce more fish for the consumption of human. To meet the global population, the continues innovation of aquaculture is essential in regards of uptrend seafood demand (Rowan, 2023).

The blue economy, emphasizing sustainable marine and freshwater resource use, has gained traction in Indonesia due to its archipelagic geography, comprising 17,504 islands and 6.4 million km² of waters (Badan Pusat Statistik, 2023). This framework aligns with Indonesia's 2025 - 2045 National Long-Term Development Plan (Rita & Dwi, 2023), which prioritizes aquaculture to enhance food security and economic growth. Catfish farming, contributing 12.7% of national aquaculture production (Kementerian Kelautan dan Perikanan, 2025), exemplify sectors where sustainable practices can reduce environmental degradation while boosting yields. However, fragmented regulation and overfishing threaten coastal ecosystems, necessitating integrated blue economy policies (Radiarta et al., 2016).

Globally, Indonesia's seas have extraordinary natural wealth, not only from its marine products but also the coral triangle which makes it a habitat for 76% of coral reef species and 37% of coral reef fish species in the world (Donesia et al., 2023). Indonesia's vast river systems and coastal plains provide ideal conditions for catfish farming, which thrive in freshwater ponds and cages. South Sumatra and West Java account for 40% of national catfish production (Kementerian Kelautan dan Perikanan, 2023a). However, climate variability, such as flooding and salinity intrusion in coastal areas, disrupts production cycles (Yuliana & Suryanto, 2021). Remote inland regions also face logistical hurdles, limiting farmers' access to markets and technology. These geographic constraints highlight the need for adaptive strategies, including digital tools to mitigate risks and improve supply chain efficiency.

Blue Economy aims to create a marine and fisheries industry that can increase income and sustainable marine and fisheries natural resources. Implementing the Blue Economy is considered a new instrument to strengthen the development of a circular economy (Silvestri et al., 2024). Through the Blue Economy, Indonesia's economy grew by 10.5% per year throughout the 2012-2022 period which exceeded the National growth of 5%. The Blue Economy contributes enormous potential both in terms of economic growth and large absorption of the labour force. It is projected that the value of the Blue Economy can reach USD 7.4 trillion - USD 9.8 trillion (Pratama, 2023). The GDP per capita of the Indonesian economy in 2023 reached USD 4,919.7 indicating a growth of 5.05%. However, the growth of GDP in the fisheries sector in the fourth quarter of 2023 showed a decline in growth of -17.70% (Kamar Dagang Indonesia, 2023).

The Blue Economy is very much related to fishery productivity which has an impact on increasing income (Kementerian Komunikasi dan Informatika RI, 2021). Digital transformation is one factor that can improve good governance (Dewi et al., 2022) in the fisheries industry. Digital transformation is believed to be able to capture quickly and be integrated into seeing market needs and demands. Entrepreneurs can sell their products in the form of raw products or processed products through e-marketplaces (Elia & Indrajaya, 2022). Environmentally friendly industrialization in the fisheries sector must be evenly distributed and supported by open access to labour, digital technology, creativity, and product innovation to improve the chain from upstream to downstream and achieve the Blue Economy (Indonesian Chamber of Commerce and Industry). Digital transformation must help fisheries business actors develop innovations in terms of: financial technology; innovative technology; digital human resources; and e-commerce.

Compared to conditions before the pandemic, the number and percentage of unemployment in 2023 are still higher (Badan Pusat Statistik, 2023). For this reason, the use of digital transformation can help increase employment opportunities which also has an impact on increasing income in entrepreneurship in the fisheries farming group. The Global Entrepreneurship Monitor (GEM) shows that Indonesia has successfully entered the top 10 of the National Entrepreneurship Context Index in 2022. Indonesia is in 7th position after the United Arab Emirates, Saudi Arabia, Taiwan, India, the Netherlands, and Lithuania (Santika, 2023).

Total volume of fisheries production (tons) in Indonesia shows that aquaculture data contributes greater production (16,967,518.25 tons) compared to capture fisheries (7,248,410 tons) in West Java. There is a very large potential for aquaculture in Indonesia (Kementerian Kelautan dan Perikanan, 2023c). Java Island ranks third in terms of aquaculture production after Sulawesi Island and Maluku-Papua Island (Kementerian Kelautan dan Perikanan, 2023b).

Digital adoption is critical for Indonesian catfish farmers to expand market reach. A 2024 Food and Agriculture Organization report noted that only 35% of small-scale aquaculturists use mobile apps for real-time water quality monitoring, despite IoT solutions reducing mortality rates by 20% (Food and Agriculture Organization of the United Nations, 2024). E-commerce platforms like Tokopedia and Shopee have enabled direct sales, bypassing traditional middlemen who often underprice harvests (Obukhova et al., 2020). Social media marketing via Instagram and WhatsApp has also empowered farmers in Central Java to target urban consumers, increasing profit margins by 15–30% (Akhir, 2023; Riani, 2016; Yuliana et al., 2021).

This is interesting to study the income increase of catfish farmers on Java Island. To obtain optimal results, a collaboration between the five Penta-helix elements (Community, government, business actors, media and academics) needs to be attempted (Sholehah et al., 2024). With good cooperation between these five important elements, the natural and human resources available in this area can be more useful to support the regional economy (Prayoga et al., 2024). Digital technology support can also be a means of integrated marketing and communication (Utomo et al., 2025).

Integrating blue economy principles with digital innovation can position Indonesia as a global aquaculture leader. For instance, adopting satellite-based climate forecasting could mitigate geographic risks, while virtual marketplaces could connect catfish farmers to international buyers (Badan Pusat Statistik, 2023). Policymakers must prioritize cross-sector collaboration, funding for R&D, and inclusive digital policies to unlock the sector's \$15 billion potential by 2030 (World Bank, 2022).

West Java, with its dense river networks and proximity to Jakarta's consumer markets, is a strategic hub for catfish farming. The Rizki Berkah Barokah fish farming group, operating in West Java, exemplifies the intersection of traditional aquaculture and digital adoption. Comprising smallholder farmers, the group produces ~50 tons of catfish annually but faces challenges such as price volatility and limited market access (Susanti, 2024). A 2023 survey revealed that 70% of members rely on middlemen, reducing profit margins by 25–40% (World Bank, 2024).

If the results of fish farming in West Java can be increased, of course, this can have a positive impact on the economic cycle on the Java Island. This is interesting to study the income increase of catfish farmers on Java Island. To obtain optimal results, a collaboration between the five Penta-helix elements (Community, government, business actors, media and academics) needs to be attempted (Sholehah et al., 2024). With good cooperation between these five important elements, the natural and human resources available in this area can be more useful to support the regional economy (Utomo et al., 2025). This can have an impact on increasing employment opportunities, increasing income in the region (Nasution, 2022).

This research is considered interesting because it will examine in depth the role of digital transformation in the sustainable fisheries industry based on the Blue Economy to prepare an entrepreneurial spirit and income increase. Therefore, Soesetio et al., (2024) stated that entrepreneurial spirit with the use of digital transformation needs to be socialized to increase motivation (Vu et al., 2025).

This study aims to answer the above issues as follows: to analyze digital transformation in increasing the income of catfish farmer; to analyze who are the beneficiaries of the use of digital transformation by catfish farmers; to analyze the creation or increase of employment opportunities; to analyze entrepreneurial motivation in catfish farmers groups; to analyze the use of digital transformation in the sustainable fisheries industry based on the blue economy. In addition, it is also hoped that this study can provide benefits to the academic field, the business world, and policymaking.

To address the first study aims, it is propose under first hypothesis, that is digital transformation positively influence income of the catfish farmer. The more digital transformation utilize by a catfish farmer, the higher income they could gain. (Mariam et al., 2024; Miao et al., 2024) found that digital transformation has positive effect on income. The study objective (Miao et al., 2024) is 1,240 manufacturing firms and 9,029 items listed on the A-share market in China. Meanwhile, (Mariam et al., 2024) study the culinary MSMEs in Depok City, Indonesia.

Additionally, to address the fourth study aims, it is propose under second hypothesis, that is digital transformation positively effect the fish farmer entrepreneurial motivation. (Dabbous et al., 2023; Kim & Jin, 2024) signified in their study entrepreneurial motivation is defined by digital transformation. Finally, this research will contribute differently compared to previous works that using Penta-Helix model for smart cities (Calzada, 2020) and seaweed production (Jompa et al., 2024)

METHOD

This study employs a mixed-methods approach: qualitative techniques (participatory observation, interviews, surveys) gather initial data, assess the potential, and design measurement tools, while quantitative methods (structured questionnaires, statistical analysis) test hypotheses. Secondary data complements both phases to enhance analytical rigor.

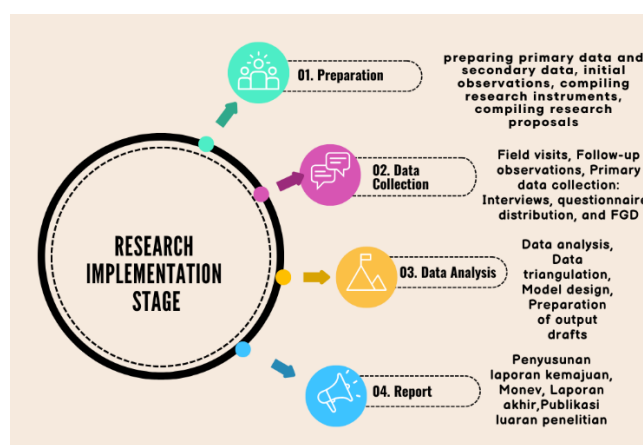


Figure 1. Research Implementation Stage

Quantitative research was conducted to see the influence of digital transformation strategies on the development of fisheries of the Rizki Berkah Barokah fish farming group in West Java. The study employed a 1–5 Likert scale (1=strongly disagree, 5=strongly agree) to

evaluate responses across 22 statements. Data was collected from 40 participants. A quantitative approach using Structural Equation Modeling (SEM) was applied, with data processed and analyzed via Smart PLS 3 software (Partial Least Squares method). The study's Average Variance Extracted (AVE) and Composite Reliability (CR) values met the required thresholds for validity and reliability. As per (Hair et al., 2017), acceptable standards include $CR > 0.70$ and $AVE \geq 0.50$, which were satisfied in the analysis.

The study's variables demonstrated satisfactory validity and reliability metrics, with Composite Reliability (CR) and Average Variance Extracted (AVE) values meeting established thresholds: digital transformation ($CR = 0.938$; $AVE = 0.605$), entrepreneurial motivation ($CR = 0.915$; $AVE = 0.644$), and Income ($CR = 0.933$; $AVE = 0.700$). All variables also exceeded the Cronbach's Alpha criterion (>0.60), confirming internal consistency. Discriminant validity was validated through three criteria: (1) the Fornell-Larcker criterion, where each construct's AVE exceeded its correlations with other variables; (2) cross-loading analysis, confirming stronger alignment of indicators with their respective constructs; and (3) HTMT ratios below 0.90, adhering to guidelines (Henseler et al., 2014). These results collectively affirm the robustness of the measurement model.

RESULTS AND DISCUSSION

Impact of digital transformation on increasing catfish farmers' income

Catfish also known as *patin* fish in Indonesia, a freshwater type of fish, has become an increasingly important commodity in Indonesia, with increasing domestic and export demand (Hasan & Shipton, 2021). To fully capitalize on the opportunities presented by the blue economy, catfish farmer must adapt to changing market conditions and leverage digital transformation to improve their operations and increase their revenues.

It is shown in Table 1 that digital transformation positively influence the income of catfish farmers. Social media-driven digital transformation boosts catfish farmers' income by enabling direct marketing and wider customer reach, eliminating intermediaries for better pricing. Catfish farmers showcase products, sustainable practices, and certifications to build trust and secure premium prices. Real-time communication and trend adaptation via platforms reduce marketing costs while fostering sales growth through online communities and targeted promotion.

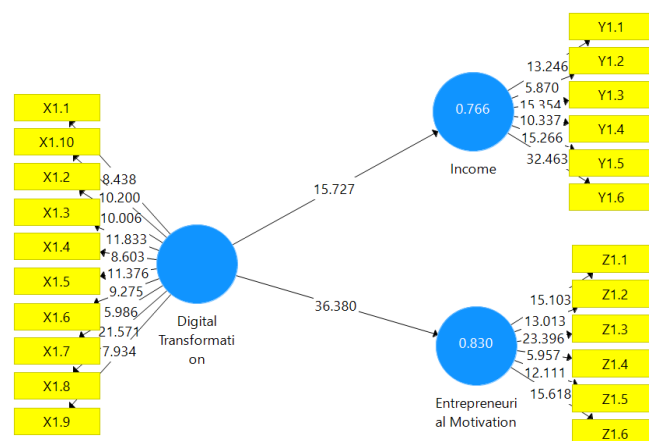


Figure2. Outer Model Analysis

The influence of entrepreneurial orientation and IoT capabilities on sustainable competitive advantage has been the subject of extensive research in the fisheries sector. The findings suggest that small-scale fishers, who are the main producers of catfish, can benefit significantly from adopting digital technologies and cultivating an entrepreneurial mindset to maintain a sustainable competitive advantage (Damayanti, 2021; Wiryati et al., 2021).

Table 1. Hypotheses Results

Hypothesis	Path Coefficients	T-Value	P-value	Conclusion
Digital transformation positively influence income (H1)	0.875	15.727	0.000	Accepted
Digital transformation positively influence entrepreneurial motivation (H2)	0.911	36.38	0.001	Accepted

Source: Primary Data

The benefits of digital transformation implementation analysis

In addition, the collaborative nature of the Penta-Helix model allows catfish farmers and entrepreneurs to access broader resources, knowledge, and support, which ultimately contributes to their business in the long term. This makes all stakeholders in the Penta-Helix model feel the benefits of digital transformation implementation. The Penta-Helix model involving collaboration between government, academics, industry, community, and media has proven to be a successful approach in driving innovation and economic growth in various sectors (Hamzah, 2022). By adopting this model, catfish farmers can leverage the expertise and resources of these various stakeholders to improve their operational efficiency, improve product quality, and expand their market reach.

The use of e-commerce platforms and digital marketing strategies can help catfish producers reach a wider customer base, both domestically and globally, while providing valuable insights into customer preferences and market trends (Akasse & Ramansyah, 2023; Bambang, 2018; Yuliana et al., 2021; Yusuf & Suyanto, 2019). While the potential for digital transformation in the catfish industry is evident, implementing such strategies requires a coordinated effort across stakeholders. By leveraging the Penta-Helix model, catfish farmers can leverage the expertise and resources of government, academia, industry, communities, and the media to address challenges and capitalize on opportunities presented by the blue economy (Mnatsakanyan & Kharin, 2021).

Governments can provide policy support and funding to facilitate the adoption of digital technologies, while academia can contribute research and innovation to address industry challenges. Industry players can share their expertise and best practices, communities can provide valuable insights into consumer preferences, and the media can help raise awareness and promote industry achievements. By leveraging the synergistic collaboration enabled by the Penta-Helix model, catfish farmers can overcome barriers to digital transformation and capitalize on opportunities presented by the blue economy. By leveraging this collaborative approach, catfish farmers can leverage the expertise and resources of these diverse stakeholders to drive digital transformation and enhance their competitiveness (Mazuki et al., 2020).

The analysis of job creation using digital transformation

Through the Penta-Helix approach, catfish business actors can access various resources, expertise, and support to improve their competitiveness. The government can provide policy support, funding, and infrastructure to facilitate the adoption of digital technologies. Academics can contribute research and innovative solutions to address industry challenges. Industry players can share best practices and collaborate in developing new products and services. Communities can offer valuable insights into consumer preferences and market trends. Meanwhile, the media can help raise awareness and promote the achievements of the catfish industry (Patil et al., 2016)..

Digital transformation has the potential to significantly increase the competitiveness and profitability of catfish businesses. By integrating digital technologies, such as the Internet of Things and data analytics, catfish businesses can optimize their operational efficiency, improve resource management, and expand their market reach (Situmorang et al., 2021; Hasibuan &

Darmawan, 2020; Sari et al., 2021). This, in turn, can lead to increased revenue and income for the actors involved.

Conventionally, Partners have been able to sell catfish per kilogram that is raised and obtain very adequate profits. Based on the availability of existing workers, it is no longer possible to diversify marketing including the implementation of Digital Transformation. Therefore, to implement the Digital Transformation, it is necessary to add workers, by utilizing residents or residents around the pond location.

If Partners have 12 ponds, and to implement Digital Transformation in the marketing aspect, then 3 new workers will be needed. To implement this idea, it is assumed that 20% of the production from 12 ponds is sold with the implementation of Digital Transformation. The production of 1 pond unit in one cycle is approximately 5,700 kg. Assuming 20% is programmed to be sold through the implementation of digital transformation. The analysis description can be seen in Table 2 and Table 3.

Table 2. Conventional Marketing for 1 Pond

No.	Description	Value (IDR)
1	Production of 1 cycle of catfish 5,700 kg at a price of IDR 14,000	79,800,000
2	Production cost	41,390,000
3	Labor costs	8,550,000
4	Advantage	29,860,000

Source: Primary Data

The production portion programmed for sales with the implementation of digital transformation is assumed to be only 20% so that business partners with traders or middlemen continue to run. According to the table, the amount of production in one cycle sold through the implementation of Digital Transformation is around 1,140 kg.

Based on the table above, the selling price of the fish after digital transformation increases very significantly, from IDR 14,000 per kg to IDR 26,000 per kg. Furthermore, based on the interviews at several food stores, the purchase price can reach approximately IDR 30,000 per kg.

Additional monthly profit per 1 pond for pond owners in one cycle of catfish cultivation is IDR 140,706 or an increase of approximately 7%. The additional accumulation or profit margin for 12 ponds is IDR 1,688,472, which increases from IDR 23,868,000 to IDR 25,556,472. Furthermore, the implementation of Digital Transformation of the 12 ponds is assumed to be able to be carried out by 3 new workers. From Table 3, it is known that those who implement digital transformation will be able to earn an income of IDR 3,161,600 per month, a fairly adequate nominal amount. In reality, the business partners in their daily activities can still do other activities; and if improvements are made to the management aspect, especially from the marketing aspect by implementing marketing digitalization, it is believed that the management margin of the partner's pond business will be able to increase significantly more

Table 3. Implementation of Digital Transformation Marketing for 1 Pond (An assumption)

No.	Description	Value (IDR)
1	80% of production is sold conventionally, 4,560 kg, price IDR 14000 (1 pond)	63,840,000
2	20% of production is sold through digital transformation, 1,140 kg is sold at a price of IDR 26,000 per kg (1 pond)	29,640,000
3	Reception of 1 pond in 1 cycle 60 % (29,640,000 X 60 % of owner's receipt)	17,784,000
4	Digital transformation workforce share 1 pond in 1 cycle 40 % (29,640,000 X 40 % owner acceptance)	11,856,000

5	Total Owner Receipt for 1 Pond: IDR 63,840,000 + IDR 17,784,000	81,624,000
6	Production cost	49,965,000
7	Owner's benefit for 1 pond (1 cycle)	31.659.000
8	Pond owner's profit per month for 1 cyclus or 15 months (31,659,000 : 15 months)	2,110,600
9	Additional profit of pond owners per month per pond in 1 cycle of 1 pond (2,110,600:15)	140,706 (7,1%)
10	Additional profit of the pond owner per month for 12 ponds (140,706 X 12 ponds)	1,688,472
11	Digital Transformation Implementation Labor Section for 1 Pond 1 Cycle IDR 11,856,000 : 15 months	9,484,800
12	If there are 3 employees, then the income per employee in 1 month (IDR 11,856,000 X 12 months: 15 months: 3 people)	3,161,600

Source: Primary Data

The motivation analysis of catfish farmer groups to be entrepreneurs

Business partners made a big decision in their lives like resigning from an electric company because they were also motivated by their Korean managers who moved to Thailand. At the time of resigning, their salary was IDR 6,000,000 per month which was above the regional minimum wage set by the government, which was IDR 3,200,000. They realized that fish is a food for all ages, because it contains unsaturated fatty acids, so it is not at risk for cholesterol and blood pressure. So this is an attraction for them to try their luck in fields other than the work they do at the electric company office.

Fish provides all the essential amino acids, making it a complete protein source. Fish consumption has been shown to have many health benefits. Fish oil, peptides and hydrolysates contribute to the health benefits of fish consumption. Fish oil protects blood vessels from atherosclerotic lesions. Essential vitamins and various fatty acids make fish a perfect nutrient for better health. Although some studies claim that increased fish consumption may cause toxicity, its immense health benefits make it a great choice as a nutrient-rich food (Dale et al., 2019; Gil & Gil, 2015; Nurbaiti et al., 2023).

Catfish, also known as colorful shark, is a valuable species in Indonesia, especially in the province of West Java. This fish has gained popularity due to its favorable characteristics, including rapid growth, adaptability to various cultural conditions, and high market demand (Gustiano et al., 2021; Wardani et al., 2021). The Indonesian catfish industry can be categorized based on different types of businesses, ranging from small-scale farms to medium-scale enterprises and large-scale commercial operations. Each of these business models presents challenges and unique opportunities in catfish farming (Yusuf & Suyanto, 2019).

Small-scale farmers often face limitations in terms of resources, technology, and market access, which can hinder their ability to maximize catfish production. Limited financial resources, outdated farming techniques, and difficulties in reaching wider markets can limit the productivity and profitability of small-scale operations (Diatin et al., 2021). In contrast, medium-scale enterprises and large-scale commercial operations have access to greater resources, advanced technology, and better market connections. These larger businesses can often achieve higher levels of catfish production by exploiting economies of scale, investing in modern farming equipment, and developing efficient supply chain networks.

Understanding the potential of catfish production in various types of businesses is essential to developing effective policies, strategies, and support mechanisms to improve the productivity and sustainability of the catfish industry in Indonesia as a whole. The regional focus on the province of West Java is significant, as these areas have emerged as major centers of catfish farming in Indonesia. By addressing the unique challenges faced by each business model and leveraging the strengths of various stakeholders, the industry can strive to reach its

full potential and contribute to the country's food security and economic development (Layuk et al., 2023).

It can be seen in Table 2 that digital transformation positively influences entrepreneurial motivation among catfish farmers. Social media-driven digital transformation enhances entrepreneurial motivation among catfish farmers by fostering market connectivity, exposure to trends/success stories, and peer collaboration. Direct engagement with customers and peers via platforms inspires confidence, encourages innovation, and helps farmers adopt problem-solving strategies. Access to real-time feedback, training resources, and online communities reduces isolation, enabling them to view their ventures as scalable businesses and pursue growth opportunities.

Additionally, the catfish farmers observed the massive pond opportunities in West Java, increasing their confidence in achieving a better future financially. Then they decided to start a pond business with a joint venture system, namely with Mr. Salimin, Mr. Robet, and Mr. Aci. The capital collected was IDR 20,000,000 or IDR 5,000,000 per person. The funds collected were spent to buy catfish seeds and pellets until they were transferred to the rearing pond. Unfortunately, before the rearing period was harvested according to the normal size for harvesting, a disaster occurred in the form of a drought in the fifth month. Finally, the fish were harvested resulting in 2 tons with sales of IDR 20,000,000 and a loss of IDR 1,000,000. The losses experienced in the fish farming cycle did not dampen his determination to develop the catfish pond business. His three colleagues no longer continued the fish farming business. With strong determination, the research partner continued the business alone, expanding from one pond to two, and currently, he has 12 ponds. Based on the results of the analysis of 12 ponds, the research partner net profit currently is IDR 1,989,000 per pond per month or IDR 23,868,000 per 12 ponds per month. This is a very fantastic income for a pond entrepreneur on a household scale. The analysis of the business can be seen in Table 4.

Aquaculture plays a vital role in Indonesia's food security and economic development, providing a steady supply of fresh and nutritious fish products to the population. Within this rapidly growing aquaculture sector, catfish has emerged as a leading commodity, attracting both producers and consumers (Oktopura et al., 2020).

Table 4. Analysis of the Pond Business

No	Description	Production Cost (IDR)	Revenue (IDR)
1	nursery seedlings size 2000 heads x IDR. 200	400,000	
2	2 months nursery feed 16 sacks x 30 kg x IDR 38,000	18,240,000	
3	feed in a 7-month enlargement pond; 7 months x 4 weeks x IDR 500,000	1,400,000	
4	First harvest 1200 kg x IDR 14,000		16,800,000
5	feed 3 months until the second harvest; 3 months x 4 weeks x IDR 500,000	6,000,000	
6	second harvest 2000 kg x IDR 14,000		28,000,000
7	feed 3 months until the third harvest; 3 x 4 x IDR 500,000	6,000,000	
8	third harvest 2500 kg x IDR 14,000		35,000,000
9	labor cost 5.7 tons x IDR 1,500,000	8,550,000	
10	Pond Rent: IDR 7,500,000 x 1 year 3 months	9,375,000	
	Sum	49,965,000	79,800,000
	Profit	29,835,000	
	Profit per month (IDR 29,835,000 : 15 months in 1 cycle)	1,989,000	
	Total profit of 12 ponds per month; 12 ponds x IDR 1,989,000	23,868,000	

Source: Primary Data

Pelabuhan Ratu, West Java, has become a leading catfish production centre, capitalizing on its abundant natural resources and strategic location. However, the industry faces several challenges that hinder its full potential. Destruction, seasonality, and logistical constraints often limit the economic impact of the fisheries sector in West Java, preventing it from reaching its true economic contribution (Nurhayati et al., 2018).

To address these challenges, innovative business models and technological interventions have emerged as promising solutions. Leveraging factors such as production efficiency, supply chain optimization, and marketing strategies can unlock the true economic potential of the fisheries sector in West Java and beyond. By fostering an environment conducive to aquaculture development, Indonesia can further strengthen its position as a producer and exporter of high-quality catfish, contributing to the nation's food security and economic growth (Yuliana et al., 2021).

Despite these challenges, the catfish industry holds great promise. Catfish production in Indonesia has witnessed a consistent upward trend in recent years. According to the Ministry of Marine Affairs and Fisheries, national catfish production reached 1.15 million tons in 2019, a testament to the growth of the industry. Notably, most of this production is concentrated in the province of West Java, which has established itself as the centre of catfish farming in the country (Manalu et al., 2019).

The increasing demand for catfish can be attributed to several factors. As Indonesia's economy grows, consumers are increasingly aware of the importance of including fish in their diets as a source of high-quality protein. Catfish, with its affordable price and delicious taste, has emerged as a popular choice among households. In addition, catfish's versatility has made it a sought-after raw material for the booming food processing industry.

While catfish production continues to increase, market dynamics are not without challenges. Fluctuations in consumer prices can be influenced by a myriad of factors, including seasonal harvests, fish supplies from other regions, and the evolving domestic and export trade landscape. To ensure a harmonious balance between supply and demand, a comprehensive strategy must be implemented. Efforts to increase aquaculture productivity, stabilize distribution channels, and expand domestic and international market opportunities will play an important role in maintaining the growth of the catfish industry. As the aquaculture sector continues to develop, the catfish industry in Indonesia, especially in West Java, is poised to play an increasingly important role in meeting the nutritional needs of the population while contributing to the nation's economic prosperity.

The analysis of digital transformation usage in the application of the blue economy

The blue economy is an enrichment of the green economy with the motto: blue sky - blue ocean: the economy grows, the people prosper, but the sky and sea remain blue. (Indonesian Chamber of Commerce and Industry, n.d.) Blue Economy as Green 2.0 or the perfected Green Economy. Meanwhile, UNEP (United Nations Environmental Programme) does not recognize the Blue Economy. UNEP has published a Special Report entitled "Green Economy in A Blue World" namely the principles of the Green Economy applied to the marine sector. The components of the Blue Economy consist of low-carbon economic development; an economy based on biological resources, energy resources and renewable energy; sustainable management and provision of services according to regional capacity, and the interests of the socio-economic welfare of the community (UNDP, 2023). The essence of the Blue Economy refers to "learning from nature" and the logic of the ecosystem (Ministry of National Development Planning/ National Development Planning Agency, 2023). Learning from nature as a blue economy concept that imitates nature, namely by working according to what nature provides efficiently that does not reduce but actually enriches nature (shifting from scarcity to abundance). Meanwhile, the logic of ecosystems is made into a blue economy mode. That is,

like water flowing from a mountain, it carries nutrients and energy to meet the basic needs of life of all ecosystem components. Waste becomes food for others, waste from one process becomes raw materials/energy sources for others. Only by gravity is the energy distributed efficiently and evenly without external energy extraction.

By leveraging the synergy of the Penta-Helix model and embracing digital transformation, catfish farmers can position themselves for long-term success in the blue economy, drive revenue growth, and create a more sustainable and prosperous future for the industry. By leveraging the synergy created by this multi-stakeholder collaboration, catfish businesses can optimize their operations, improve product quality, and expand their market reach both around and outside the west java area. The holistic approach enabled by this Penta-Helix model can ultimately increase the competitiveness and income of catfish farmers, contributing to the sustainable development of the blue economy in Indonesia.

The integration of digital technologies, such as the Internet of Things and e-commerce platforms, can significantly increase the efficiency and profitability of the catfish business. Meanwhile, the adoption of e-commerce platforms can help catfish businesses expand their market reach, such as deliveries made by partners to markets in Muara Angke, Jakarta. This can also provide valuable insights into customer preferences and market trends. By harnessing the power of digital transformation, catfish farmers can increase their competitiveness and increase their income in the blue economy. To take full advantage of the opportunities presented by the blue economy and digital transformation, catfish farmers must collaborate with various stakeholders through the Penta-Helix model. By leveraging the expertise and resources of government, academia, industry, communities, and the media, catfish businesses can overcome challenges and unlock the full potential of the catfish industry.

By definition, the Blue Economy is the sustainable use of ocean resources for economic growth, improved livelihoods and jobs, while preserving the health of marine and coastal ecosystems. Observing the pond business technique carried out by Partners, the creation of ponds by utilizing former excavated area. Using an excavator, the land which was dug to make bricks was dug again based on the depth necessities, approximately 2 meters. The purchased catfish seeds are first nursed before being transferred to the rearing pond, for approximately 3 months, and the size of the fish is approximately 55 cm in length. The food for small catfish while in the nursery pond uses pellets.

From the nursery pond, the small catfish are transferred to the rearing pond until they reach a weight of 6 kg per fish. While in the rearing pond, to save production costs, the catfish farmers no longer use pellet food because it is very expensive and not profitable. As an alternative, leftover food from restaurants which has always been restaurant waste is used to feed the fish. Before pond entrepreneurs used food from leftover food from restaurants, the leftover food in the restaurant was a "cost" for the restaurant owner. However, nowadays, leftover food has become economically valuable for restaurant owners. When the farmers first started running the pond, the price of the leftover food was IDR 350,000 per pick-up truck, and now it has increased to IDR 500,000 per small pick-up truck.

In the development of the "blue economy", the development of ponds, especially catfish ponds, is one of the best alternatives. During the process of one cycle of raising catfish, starting from the purchase of seeds which are spread in the nursery pond for approximately 2 months, then transferred to the rearing pond for a total of approximately 13 months, no negative impacts on the environment were found. Likewise, in terms of utilizing leftover food from restaurants, there was also no environmental damage.

From field observations, negative impacts on the physical or non-physical environment were not found; both from the cultivation aspect and from the marketing aspect. Therefore, it is worth considering the business model as a "blue economy" business, especially for residents of the West Java Province. Technically, the planned land for the location of the pond was

originally excavated to make bricks. Land that is no longer economical in the bricks-making business is also economically impossible for residential or housing locations because it requires re-filling of the excavated soil. In addition to the expensive costs, from the technical construction point of view, it also lacks and is even unfeasible because the embankment soil is unstable and does not comply with technical construction standards. Based on the physical consideration of the land used for making bricks, it is much more suitable to be used as a pond. Only a little more excavation is needed to meet the pond depth standards.

CONCLUSION

The integration of digitalization into Indonesia's catfish farming sector demonstrates significant potential to enhance income and motivation among farmers. By adopting digital tools such as data management systems and digital literacy programs, catfish farmers can optimize production efficiency, reduce operational risks, and access broader markets. Studies indicate that digital skills empower catfish farmers to make decisions, directly improving yield consistency and profitability. Furthermore, digital platforms foster greater market visibility, enabling small-scale producers to compete more effectively. This technological empowerment not only elevates income but also strengthens farmers' motivation by reducing uncertainty and creating opportunities for innovation. Moreover, other than digital marketing, there are six crucial digital skills that need to be upgraded such as: technology operation, digital communication, digital literacy, incident management, data management, and data monitoring analysis and interpretation (McDonald et al., 2024).

The Penta-Helix model emerges as a critical framework for sustaining this digital transformation. By aligning the efforts of government, industry, academia, media, and communities, the model ensures holistic support for aquaculture development. For instance, academia provides tailored training in digital skills, industry invests in infrastructure, government facilitates policy and funding, media amplifies success stories, and local communities drive grassroots adoption. This collaborative ecosystem addresses systemic challenges—such as fragmented supply chains and knowledge gaps—while fostering trust and shared accountability among stakeholders. Such synergy is vital for scaling sustainable practices and maintaining Indonesia's competitive edge in aquaculture.

This study contributes to the literature by bridging gaps in understanding how digitalization intersects with traditional aquaculture sectors in emerging economies. It highlights the transformative role of digital skills beyond mere technical adoption, emphasizing their socio-economic impact on rural livelihoods. Additionally, it expands the application of the Penta-Helix model beyond urban or tech-centric industries, demonstrating its adaptability in agricultural contexts. These insights offer a foundation for future research on inclusive digital transitions in resource-dependent communities.

Recommendation to capitalize on these findings for future researcher, academician, and government is that stakeholders should prioritize structured digital literacy programs tailored to catfish farmers, focusing on data management and e-commerce platforms. Governments and industry partners must invest in rural digital infrastructure, including internet connectivity and automated monitoring systems. Policymakers should incentivize private-sector participation through tax breaks or grants for agro-tech innovations. Concurrently, media campaigns can raise consumer awareness of processed catfish products, while academia-industry partnerships develop curricula aligned with farmers' evolving needs. Finally, fostering export-oriented cooperatives under the Penta-Helix framework could diversify market access and mitigate supply-demand imbalances.

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