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Sustainable Management in the Blue Economy Ecosystem: Maritime Industry Transformation towards the Society 5.0 Era

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Abstract

Indonesia's maritime industry faces the urgent challenge of balancing environmental sustainability with global competitiveness. As an archipelagic nation, Indonesia holds vast blue economy potential, yet its marine resources must be managed wisely to ensure economic growth without degrading ecosystems. This study analyzes the integration of sustainable management, the blue economy, and Society 5.0 in the transformation of the national maritime sector. Using a descriptive-qualitative approach, data were collected through literature study and content analysis from accredited journals, government reports (KKP, BPS, BI, OJK), and recent academic sources up to 2025. The findings indicate that sustainable management plays a key role in increasing fishery productivity, expanding marine conservation areas, and improving the welfare of coastal communities. The blue economy provides a strategic foundation by focusing on sustainable fisheries, renewable energy, and marine tourism as drivers of growth. In parallel, the adoption of Society 5.0 technologies—such as smart ports, Internet of Things, big data, and artificial intelligence—has improved logistics efficiency, supply chain transparency, and environmental impact mitigation. The study recommends strengthening evidence-based governance, accelerating maritime technology investment, and enhancing human resource capacity. These steps are essential for positioning Indonesia as a technology-driven blue economy hub in Southeast Asia while contributing to the achievement of the Sustainable Development Goals (SDGs).

Keywords sustainable management, blue economy, maritime industry, society 5.0, sustainable development.

1. Introduction

Indonesia's maritime industry is currently in a strategic transition phase, where the need for environmental sustainability meets the demand for accelerated digital transformation. As the world's largest archipelagic nation, Indonesia has significant maritime economic potential, but this potential can only be realized if marine resource management is carried out sustainably through the blue economy framework. This concept emphasizes the utilization of marine resources for economic growth, social welfare improvement, and the simultaneous preservation of marine ecosystems (Latif et al., 2024). Unfortunately, the implementation of national maritime policies still faces various challenges, ranging from regulatory inconsistencies, limited data, to weak coordination between institutions (Latif et al., 2024).

The Vision of the Global Maritime Axis promoted by Indonesia is one of the key pillars in strengthening the blue economy. However, critical analysis shows that there is a significant gap between the vision and its implementation on the ground (Pikoli, 2021). These challenges include weak governance of marine space, limited investment in environmentally friendly port

Seminar Nasional FMI 2025 Batam

Prosiding



e-ISSN: 3026-4499

Vol. 3

21-23 Oktober 2025

infrastructure, and low adoption of digital technology in the shipping sector. This highlights the need for an adaptive management approach that is sustainability-oriented and data-driven, so that Indonesia can compete amid the dynamics of the global maritime industry.

The development of Society 5.0 presents new opportunities to revolutionize the maritime sector, not only through automation and digitization but also through the application of human-centered cyber-physical technologies. This concept integrates artificial intelligence, the Internet of Things (IoT), big data, and blockchain to enhance operational efficiency, supply chain transparency, and reduce environmental impact (Šekularac-Ivošević et al., 2024). In the context of ports, smart port technology has begun to be implemented in several regions of Indonesia, such as the use of smart gates, digital ticketing, and the utilization of big data for logistics planning.

However, this technological transformation will be in vain if it is not accompanied by policy reforms and strengthened governance. Research shows that Indonesia's blue economy policies have not fully integrated environmental, social, and economic aspects into a cohesive framework (Ardhi Sahjaya et al., 2025). In several sectors, such as fisheries and offshore energy, conflicts over marine space utilization are still found due to the weak implementation of the Coastal and Small Islands Spatial Plan (RZWP3K). Without inclusive, evidence-based marine spatial planning, the maritime transformation towards Society 5.0 risks deepening socio-ecological inequalities.

In addition to policy aspects, the success of this transformation heavily depends on the quality of human resources (HR) in the maritime sector. Recent research indicates that quality management in maritime education in Indonesia has not fully adhered to the principles of Total Quality Management (TQM), which results in the low competency of graduates in operating advanced technologies. HR readiness is key to ensuring that digital technologies can be optimally utilized to support the sustainability of the maritime industry (Rosmayana, 2025).

The blue economy is also directly linked to food security and the increase in Indonesia's fishery export value. Sustainably managed fishery products can serve as a source of animal nutrition as well as high-value export commodities (Kaunang et al., 2025). However, to achieve this, the implementation of environmentally friendly fishing practices, modernization of supply chains, and research-based innovations are required. In this context, the integration of Society 5.0 principles with the blue economy can create a maritime ecosystem that is not only efficient but also regenerative.

Based on the above description, it is clear that sustainable management within the blue economy ecosystem towards the Society 5.0 era must encompass three main pillars: (1) governance and policy reform that is inclusive, (2) acceleration of digital transformation based on human-centered innovation, and (3) strengthening HR capacity and supporting infrastructure. With this approach, Indonesia can accelerate the transformation of its maritime industry while ensuring that economic growth aligns with the preservation of marine ecosystems and social justice (Baihaqi Baihaqi, 2024).

Seminar Nasional FMI 2025 Batam

Prosiding



e-ISSN: 3026-4499

Vol. 3

21-23 Oktober 2025

2. Literature Review

Concept of Sustainable Management. Sustainable management within the blue economy ecosystem is a management strategy that integrates economic, social, and environmental interests in a balanced manner. In the context of the maritime industry, this approach is key to driving growth without compromising the preservation of marine resources. The success of the blue economy is heavily influenced by data transparency, accountability, and strategic control based on integrated information. This transformation is closely aligned with the Society 5.0 era, where digital technologies such as big data, AI, and the Internet of Things (IoT) are employed to support rapid, precise, and environmentally friendly decision-making (Arriyana & Fadjarenie, 2023). The integration of sustainable management, the blue economy, and the Society 5.0 concept offers an adaptive and innovative maritime development model. This approach not only aims to enhance the competitiveness of the industry but also ensures the fair distribution of benefits to coastal communities. Smart technologies in fisheries management, logistics, and maritime tourism create opportunities to achieve sustainable development goals (SDGs), particularly SDG 14 on marine ecosystems. With synergy among the government, industry players, academics, and communities, Indonesia has the potential to become a global leader in the transformation of sustainable maritime industries (Arriyana & Fadjarenie, 2023).

Blue Economy. Blue economy is a development paradigm that optimally utilizes marine potential while maintaining the sustainability of marine ecosystems. This concept integrates economic growth, marine environmental conservation, and social inclusion. In the context of Indonesia, which has a vast marine area, the blue economy becomes a crucial strategy to enhance the welfare of coastal communities. Kaunang explains that the implementation of the blue economy includes the development of sustainable fisheries industries, marine-based renewable energy, environmentally friendly marine tourism, and innovations in maritime technology (Kaunang et al., 2025). However, the implementation of the blue economy in Indonesia still faces several challenges, such as weak law enforcement against illegal fishing, low investment in maritime technology, and limited market access for small-scale fishermen. To address these issues, cross-sector collaboration, capacity building for coastal human resources, and improvements in maritime infrastructure are needed. With proper management, the blue economy can not only provide economic benefits but also protect marine resources for future generations (Kaunang et al., 2025).

Maritime Industry Transformation. The transformation of the maritime industry in Indonesia includes efforts to modernize port infrastructure, optimize logistics systems, and improve operational efficiency through the adoption of technology. The role of technology is crucial in maritime development, ranging from port automation, maritime traffic monitoring, to digital-based security systems. The application of these technologies aims to accelerate loading and unloading processes, enhance transparency, and reduce logistics costs, thereby improving the competitiveness of the national maritime industry (Aris Sarjito, 2023). The success of this transformation depends on the synergy between government policies, infrastructure readiness, and the quality of human resources. Without proper regulatory support and investment in digital

Seminar Nasional FMI 2025 Batam

Prosiding



e-ISSN: 3026-4499

Vol. 3

21-23 Oktober 2025

infrastructure, maritime modernization will be difficult to fully realize. Therefore, cross-sector collaboration is necessary to ensure that technological development in the maritime industry aligns with economic needs and Indonesia's vision as the world's maritime axis (Aris Sarjito, 2023).

Era Society 5.0. Society 5.0 is a concept of the future society that integrates the physical and digital worlds with a human-centered approach. In this era, technologies such as artificial intelligence (AI), the Internet of Things (IoT), and big data are used to solve social problems while enhancing the quality of life. However, the implementation of Society 5.0 in Indonesia still faces challenges, such as uneven digital infrastructure, low technological literacy, and a lack of focus on the needs of society (Dinda Sukmaningrum & Dodi Setiawan Riatmaja, 2024). Nevertheless, the potential of Society 5.0 to support sustainable development is significant. The utilization of technology can drive efficiency in the maritime sector, such as through real-time monitoring of marine ecosystems, optimization of shipping routes, and digital marketing of fishery products. When combined with the principles of sustainable management, Society 5.0 can act as a catalyst for accelerating the blue economy in Indonesia (Mikel Ega Wijaya, 2022).

Integration of Sustainable Management, Blue Economy, and Society 5.0. The integration of sustainable management, the blue economy, and Society 5.0 creates an innovative, inclusive, and environmentally friendly development ecosystem. This approach enables the optimal utilization of marine resources through data-driven management, environmentally friendly technologies, and active community participation. Studies show how the application of technology in the coastal area of Mangunharjo, Semarang, has increased community involvement in environmental preservation while simultaneously strengthening the local economy (Ali Fithor, Beni Sabdo Nugroho & Meilala, 2025). This synergy will strengthen Indonesia's position as a maritime nation with global competitiveness. With the right policy support, technology investments, and enhanced human resource capacity, the integration of these three concepts can drive sustainable ocean-based development. The results will not only include economic growth but also marine ecosystem resilience, improved quality of life for coastal communities, and the achievement of SDG targets (Ali Fithor, Beni Sabdo Nugroho & Meilala, 2025).

3. Research Method

This research is a descriptive qualitative study aimed at providing a comprehensive overview of the implementation of sustainable management within the blue economy ecosystem, particularly in the transformation of the maritime industry towards the Society 5.0 era in Indonesia. The approach used is a literature review, which focuses on in-depth analysis of various scientific sources to identify relevant concepts, strategies, and challenges (Mangiri & Sasabone, 2023).

Data collection was conducted through a literature search in national scientific databases such as Garuda and accredited journals in SINTA, using keywords such as "sustainable management," "blue economy," "maritime industry," and "Society 5.0." Additionally, data was gathered from official government websites, including the Ministry of Marine Affairs and

Seminar Nasional FMI 2025 Batam

Prosiding



e-ISSN: 3026-4499

Vol. 3

21-23 Oktober 2025

Fisheries, the Ministry of Industry, the Financial Services Authority (OJK), and the Central Statistics Agency (BPS). Publications used were limited to those up to the year 2025, including scientific journals, proceedings, books, official reports from institutions, and government policy documents related to the maritime sector.

Data analysis was conducted using content analysis, which involves four main stages: (1) data reduction, which involves selecting relevant literature from the search results; (2) presenting data in the form of thematic summaries; (3) interpreting data by comparing findings across studies; and (4) drawing conclusions that integrate the study results into a conceptual framework. This approach is in line with the methods used by Suryana (2022) in the implementation of the blue economy in Indonesia and Sarjito (2023) in the transformation of the maritime industry in Indonesia, both of which rely on literature studies as a strategy for formulating analysis based on scientific evidence (Mangiri & Sasabone, 2023).

4. Finding and Discussion

4.1 *Application of Sustainable Management Principles in the Maritime Industry*

The application of sustainable management principles in Indonesia's maritime sector is one of the government's strategic priorities aimed at optimizing the utilization of marine resources without compromising their sustainability (Virna Febryaningrum et al., 2024). The Ministry of Marine Affairs and Fisheries (KKP) in the National Medium-Term Development Plan (RPJMN) 2020–2024 has set sustainability-based strategies that include marine ecosystem conservation, limiting overfishing, implementing coastal zone management, and strengthening marine management institutions. Data from the Central Statistics Agency (BPS) shows that in 2023, Indonesia's fishery production reached 24.74 million tons, a significant increase from 23.13 million tons in 2022, with the largest contribution coming from the aquaculture subsector. This aligns with the rise in national fish consumption, which reached 57.6 kg per capita per year in 2023, indicating that sustainable resource management is able to ensure the availability of seafood for the population (Perikanan, 2022). This success is also supported by environmentally friendly fisheries certification programs and the implementation of selective fishing technologies to reduce bycatch that harms the ecosystem (Hasrullah, 2024).

Economically, the implementation of sustainable management has had a positive impact on production value and the welfare of fishermen. In the first quarter of 2025, the KKP recorded a total fishery production of 5.87 million tons with a value of IDR 117.01 trillion, growing by 2.21% compared to the same period last year. This growth was primarily driven by the aquaculture sector, which increased by 2.61%, while capture fisheries grew by 1.26%. Policies limiting destructive fishing gear, such as cantrang, and the provision of environmentally friendly vessel assistance, have also contributed to sustaining production. Additionally, the government has implemented an electronic logbook system and digital catch reporting to ensure accurate data for policy-making (Darajati, 2023).

An environmental perspective, the success of implementing sustainable principles is evident in the increase in the area of marine conservation zones. According to the KKP 2024 report, the

Seminar Nasional FMI 2025 Batam

Prosiding



e-ISSN: 3026-4499

Vol. 3

21-23 Oktober 2025

area of conservation zones has reached over 28 million hectares, approaching the national target of 30 million hectares by 2030. These conservation areas play a crucial role in maintaining fish stocks and protecting coral reefs, mangroves, and seagrass beds, which are vital habitats for marine life. With the synergy between policies, coastal community participation, and technological support, the implementation of sustainable management principles in Indonesia's maritime sector has become a tangible example of how economic development can align with environmental preservation (Darajati, 2025).

4.2 Conditions and Blue Economy Potential in Indonesia

Indonesia has vast blue economy potential, with 71% of its territory being ocean and a coastline stretching 108,000 km. The Ministry of Marine Affairs and Fisheries (KKP) records that the sustainable potential of national capture fisheries reaches 12.01 million tons per year, which, if managed according to blue economy principles, could make a significant contribution to the national GDP. In 2024, the contribution of the marine and fisheries sector to the national GDP was around 2.51%, or approximately IDR 280 trillion, with an increasing trend each year (News, 2025). According to BPS data (2024), the fisheries subsector contributes significantly to regional economic growth in areas such as Maluku, Papua, Sulawesi, and Nusa Tenggara, where the blue economy serves as the backbone of coastal community economic activities. This potential includes not only capture fisheries but also marine aquaculture, marine tourism, marine renewable energy, and marine biotechnology (Kontan, 2025).

The perspective of aquaculture, Indonesia is the largest producer of seaweed in the world, accounting for more than 38% of global production. National seaweed production in 2023 reached 9.8 million tons, with the majority coming from South Sulawesi, East Nusa Tenggara, and Maluku. Meanwhile, the production of vannamei shrimp, a key export commodity, increased from 280 thousand tons in 2022 to 320 thousand tons in 2023, driven by the implementation of sustainable pond systems and intensive technologies. Indonesia's fishery export value in 2024 was recorded at USD 7.2 billion, with key markets including the United States, Japan, and China. This growth demonstrates that if the blue economy's potential is managed with sustainable strategies, the added value and competitiveness of Indonesian products in the global market will continue to strengthen (BPS), 2023).

In addition to the fisheries sector, Indonesia's blue economy potential also lies in marine-based renewable energy, such as wave, tidal, and ocean current power generation (Latifah & Abdullah, 2024). The Ministry of Energy and Mineral Resources (ESDM) estimates that Indonesia's wave energy potential reaches 49 GW, which has yet to be optimally utilized. Marine tourism is also a key sector, with destinations such as Raja Ampat, Wakatobi, and Labuan Bajo attracting international tourists. Data from the Ministry of Tourism (2024) shows that international tourist visits to marine destinations reached 1.2 million people, generating foreign exchange earnings of USD 1.5 billion. This demonstrates that the blue economy in Indonesia is not only about fisheries but also encompasses a broad and diverse maritime industry ecosystem, which, if synergized, can drive economic growth while ensuring environmental sustainability (Airawati et al., 2023).

Seminar Nasional FMI 2025 Batam

Prosiding



e-ISSN: 3026-4499

Vol. 3

21-23 Oktober 2025

4.3 Technological Transformation in the Maritime Industry Towards Society 5.0

The technological transformation in the maritime industry towards the Society 5.0 era marks a paradigm shift from mere industrialization to the integration of smart technologies that are human-centered (Alfarizi, 2024). The Society 5.0 concept promoted by Japan emphasizes the use of digital technologies, the Internet of Things (IoT), Artificial Intelligence (AI), big data, and robotics to solve social problems while improving the quality of life. In the context of Indonesia's maritime sector, the implementation of these technologies is evident in the digitalization of ports through the adoption of smart port systems that utilize real-time information to manage ship traffic, optimize loading and unloading processes, and reduce waiting times. For example, Tanjung Priok Port has implemented the Inaportnet system, which enables the integration of port services online, saving time and logistics costs. Additionally, the Ministry of Marine Affairs and Fisheries (KKP) has developed the e-logbook application for fisheries to digitally monitor fishing activities, which by 2025 will be used by thousands of fishing vessels across Indonesia (BPS, 2023).

Satellite technology and Geographic Information Systems (GIS) also play a crucial role in monitoring fish stocks, detecting fishing potential, and tracking marine conservation areas. These systems help fishermen save fuel by allowing them to directly navigate to locations with high catch potential (Astuti et al., 2024). The Ministry of Marine Affairs and Fisheries (KKP) has also launched the digital Marine and Fisheries Business Actor Card (KUSUKA), which facilitates registration processes, aid distribution, and access to financing. According to KKP data (2025), over 1.5 million maritime business actors have been digitally registered, accelerating verification and the distribution of government programs. In the aquaculture sector, the use of water quality sensors and AI-based automatic feeding systems has increased productivity and cost efficiency by up to 30% (Nadine Pratiwi Kadir Maricar & Wira Atman, 2025).

The integration of these technologies not only enhances productivity but also promotes sustainable management. With real-time data, the government and business actors can make quick and accurate decisions related to catch limitations, environmental quality improvements, and climate change impact mitigation. This concept aligns with the principles of Society 5.0, which places humans at the center of technological development, ensuring that fishermen and coastal communities are not just beneficiaries but also active participants in the digital transformation. The success of this transformation requires collaboration between the government, private sector, universities, and local communities to ensure that the technologies implemented are relevant to field needs and conditions (Deanto & Marzaman, 2024).

4.4 Synergy of Sustainable Management, Blue Economy, and Society 5.0

The synergy between sustainable management, the blue economy, and Society 5.0 creates a maritime development framework that not only focuses on economic growth but also ensures the sustainability of marine ecosystems (Sumartono, 2024). Sustainable management provides the foundational principles for resource management that considers environmental carrying capacity, while the blue economy offers an innovative approach that transforms marine

Seminar Nasional FMI 2025 Batam

Prosiding



e-ISSN: 3026-4499

Vol. 3

21-23 Oktober 2025

potential into economic value without harming ecosystems. Society 5.0 complements both by introducing smart technologies that facilitate monitoring, improve production efficiency, and accelerate information distribution. For example, the application of big data technology in fish stock monitoring systems, integrated with the KKP's catch quota policies, helps maintain a balance between market demand and resource sustainability (Maeyangsari, 2023).

The implementation of this synergy is already beginning to be seen in several regions, such as Maluku and Sulawesi, where local governments are collaborating with universities and maritime startups to build a community-based digital ecosystem for fishermen (Alifa & Zahidi, 2024). IoT technology is used to monitor water quality in aquaculture ponds, while digital marketing platforms help fishermen sell their catch directly to consumers, cutting down on lengthy distribution chains. According to the KKP report (2024), regions that implement the integration of technology and sustainable principles have seen an increase in fishermen's income by 18–25% over two years. Additionally, collaboration with the National Research and Innovation Agency (BRIN) has led to the development of fishery waste processing technologies, turning waste into organic fertilizer and animal feed, which supports the circular economy in the maritime sector (Surabaya, 2024).

The success of this synergy heavily relies on cross-sector collaboration. The government acts as a regulator and facilitator, the private sector provides capital and technology, while coastal communities are the primary actors. Data from BPS (2024) shows that regions with such collaborative programs tend to have lower coastal poverty rates, averaging 7.5% compared to the national average of 9.4%. With a collaborative approach based on technology and sustainability, Indonesia has a great opportunity to become a technology-based blue economy hub in Southeast Asia, while also serving as a model for the implementation of Society 5.0 aligned with sustainable development goals (SDGs) (Adi Wiriana, 2024).

4.5 Blue Economy as the Foundation for Implementing Society 5.0 in the Maritime Sectoral

The blue economy serves as a crucial foundation for the implementation of Society 5.0 in the maritime sector because it provides a resource base and economic opportunities that can be optimized through smart technologies. Without sustainable management of marine resources, the application of technology will not yield long-term benefits (Perikanan, 2024). In this context, the blue economy becomes a platform that enables the optimal utilization of marine potential, such as fisheries, renewable energy, and marine tourism, while preserving environmental sustainability (Mangiri & Sasabone, 2023). For example, data from KKP (2025) shows that the implementation of AI-based shrimp pond systems in South Sulawesi successfully increased productivity by 35% and reduced feed usage by 20%, directly impacting cost efficiency and reducing organic waste (Supriyanto, 2020).

The implementation of Society 5.0 in the maritime sector, based on the blue economy, enables the integration of technological innovations with sustainability policies. For example, the development of smart fishing ports that use automatic sensors to monitor water quality, weather, and ship traffic has been able to reduce ship waiting times by up to 40%, according to data from PT Pelabuhan Indonesia (Pelindo, 2024). With real-time data, decision-making becomes faster

Seminar Nasional FMI 2025 Batam

Prosiding



e-ISSN: 3026-4499

Vol. 3

21-23 Oktober 2025

and more accurate, whether for logistics activities, catch distribution, or the management of conservation areas. This proves that a strong blue economy foundation will facilitate the adaptation process to Society 5.0 technologies, allowing the benefits to be directly felt by coastal communities (Nasution, 2022).

Furthermore, the presence of the blue economy as the foundation of Society 5.0 also promotes equitable development in coastal areas and small islands. Through this approach, regions that were previously hard to reach can be integrated into the global supply chain through digitalization, e-commerce of marine products, and modern logistics systems. According to BPS (2024), regions that integrate blue economy strategies with digital transformation have seen an average increase of 3 points in their Human Development Index (HDI) over the past five years. Thus, the blue economy is not only a concept for sustainable marine management but also a strategic instrument to realize the vision of Society 5.0 in the maritime sector, where technology and people complement each other in achieving shared prosperity (Riesnandar & Nuhartonosuro, 2025).

5. Conclusion

This research emphasizes that the implementation of sustainable management within the blue economy ecosystem is a key driver for the transformation of Indonesia's maritime industry towards the Society 5.0 era. The principles of sustainable management have proven effective in maintaining a balance between economic growth, environmental preservation, and social welfare. This is reflected in the increase in national fishery production, the strengthening of marine conservation areas, and the rising income of coastal communities through environmentally friendly aquaculture practices.

The blue economy presents a development paradigm that not only focuses on utilizing marine potential but also ensures the sustainability of ecosystems. With its significant contribution to GDP, export potential of fishery products, marine tourism, and renewable energy, the blue economy serves as a strategic foundation to strengthen Indonesia's maritime competitiveness.

The transformation towards Society 5.0 accelerates the achievement of these goals through the integration of digital technology, artificial intelligence, big data, IoT, and smart ports. The implementation of these technologies enhances efficiency, transparency, and environmental impact mitigation. The synergy between sustainable management, the blue economy, and Society 5.0 creates an inclusive, innovative, and human-centered maritime development ecosystem. With consistent policy support, technological investment, and enhanced human resource capacity, Indonesia has a great opportunity to become a technology-based blue economy hub in Southeast Asia. Moving forward, maritime development strategies should focus on integrating these three pillars to ensure that economic growth aligns with the preservation of the ocean and the improvement of coastal communities' quality of life.

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Seminar Nasional FMI 2025 Batam

Prosiding



e-ISSN: 3026-4499
Vol. 3
21-23 Oktober 2025

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Vol. 3

21-23 Oktober 2025

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Prosiding



e-ISSN: 3026-4499

Vol. 3

21-23 Oktober 2025

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Seminar Nasional FMI 2025 Batam

Prosiding



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Vol. 3

21-23 Oktober 2025

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