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Transformation of Sustainable Aquaculture Policy: The Blue Economy Perspective in Promoting Food Security

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ABSTRAK

ABSTRACT

The high potential of aquaculture does not automatically correlate with the achievement of sustainable food security due to the weak implementation of local aquaculture practices in the region. Therefore, this study aims to identify the potential of aquaculture, the challenges of local practices, and recommendations for blue economy-based aquaculture policy transformation in promoting food security in West Aceh Regency. Data collection was conducted using a qualitative approach with in-depth interviews, field observations, and documentation studies. Informants were selected using purposive sampling techniques involving policy actors and key stakeholders in the aquaculture sector, including local government (policy actors), academics and knowledge institutions, as key actors, and private parties involved in the production and distribution chain. Data analysis was carried out through data condensation, data reduction, data verification, and conclusion drawing. The results show that the increase in aquaculture potential in West Aceh Regency is not directly proportional to sustainability and food security due to the gap between production expansion and governance capacity. The main obstacles include low adoption of eco-friendly technologies, limited capacity of farmers, and weak waste management, which reflect the lack of integration of blue economy principles such as resource efficiency and zero waste. This study identifies strengthening governance, zero waste-based waste management, and multisectoral collaboration as key leverage points in sustainable aquaculture transformation. These findings indicate that strengthening aquaculture as a pillar of local food security requires policy leverage on governance reform, particularly zero waste management, capacity building and extension services for farmers, and cross-sector collaboration based on the blue economy.

Keywords: sustainable aquaculture; blue economy; policy transformation; local food security; regional fisheries governance; West Aceh

INTRODUCTION

Food security remains a strategic issue that demands serious attention, both globally and locally, due to the increasingly complex challenges affecting the sustainability of a region's food system. In West Aceh Regency, the issue of food security is not only related to the availability of natural resources, but also closely linked to how the aquaculture sector is managed and directed through appropriate policies. Aquaculture has a strategic position as a source of animal protein and a pillar of the community's economy, but its contribution to regional food security has not been fully optimized (Gul et al., 2024). Globally, increased aquaculture production has contributed significantly to meeting the demand for fish as a source of protein that is considered healthier and relatively more eco-friendly than red meat (Naylor et al., 2023).

Since the early 2000s, the rapid growth of the aquaculture sector has made it an important part of the global food system, with significant contributions to food security, income generation, and trade at both the local and global levels (Verdegem et al., 2023). Asia has consistently been the center of global aquaculture production, accounting for more than 91% of total global production in 2017 with a volume of 102.9 million tons (Tacon, 2020). In this context, Indonesia occupies a strategic position as one of the three largest aquaculture producers in Asia, along with China and India (Garlock et al., 2020). Although demand for aquaculture products continues to increase (Jacinda et al., 2021), the sector still faces a number of fundamental problems that could potentially weaken its role in supporting sustainable food security.

A number of crucial problems include pollution and uncontrolled habitat use (Bănăduc et al., 2024), threats to biodiversity due to the use of non-native species and genetic impacts (Anderson et al., 2019), price instability and food security affecting community access (Yunaidi et al., 2019), limited water availability due to the El Niño phenomenon (Tarigan et al., 2024), and low participation and human resource capacity in aquaculture groups (Sonia et al., 2023). Without

adequate policy and governance reforms, these risks have the potential to structurally weaken regional food security. In response to these challenges, the concept of the blue economy is often introduced as an approach to sustainable fisheries development. The blue economy emphasizes economic growth, innovation, and job creation while maintaining environmental sustainability.

However, in many regional contexts, including West Aceh Regency, the blue economy is still largely understood as a normative discourse or policy trend, without being accompanied by concrete governance and institutional transformation. As a result, the implementation of the blue economy risks becoming merely a policy symbol, without any real ability to improve failed aquaculture practices and strengthen food security. The experiences of a number of countries show that the success of sustainable aquaculture is largely determined by the quality of governance and policy reform. As highlighted in a study by (Valenti et al., 2021), the aquaculture sector in Brazil has shown significant growth potential, but at the same time faces a number of obstacles. This strategy is essentially supported by science-based innovation, including the application of new technologies and disruptive innovations to drive productivity gains.

In addition , the country also takes advantage of its geographical advantages, such as its long coastline, and is supported by the government and a strong scientific community in aquaculture research. Furthermore, a study by (Afewerki et al., 2023) in Norway identified that innovation in the Norwegian aquaculture sector has been comprehensive and covers the entire production chain. This ranges from the development of increasingly sophisticated cultivation technologies, such as the evolution from traditional floating nets *(sea pens)* to modern large-scale systems, the adoption of automatic feed barges, and the pioneering of offshore cultivation concepts and land-based recirculating aquaculture systems that enable optimal environmental control and reduce the risk of cultivation failure and environmental damage.

Similarly, Kenya, despite its small Gross Domestic Product, has great potential for food and protein security and for utilizing rural communities as pillars of aquaculture development (Obiero et al., 2019). Seeing the success of other countries in transforming their aquaculture sectors towards sustainability, Indonesia should also take advantage of the same opportunity. As a maritime country with abundant aquatic resources, Indonesia certainly has a great opportunity to develop sustainable aquaculture as a strategy for food security and economic improvement at both the national and local levels. One strategy that can be pursued in realizing sustainable food security today is through policy transformation with the concept of the blue economy.

The blue economy concept, which is currently trending in the fisheries and marine sector (Martínez et al., 2021), is defined as an economic approach that prioritizes and encourages the implementation of sustainable development. This approach is applied to the industrialization of the maritime and fisheries sectors with an emphasis on growth, job creation, and the ability to stimulate technological innovation that does not damage the environment (Sitorus, 2018). Several countries have demonstrated success in the fisheries sector through a blue economy approach in government policy and programs, such as Portugal, which is classified as high in advocating and aligning the blue concept with its national policy to support regional policy commitments set out in the European Union Integrated Maritime Policy (Wuwung et al., 2022).

Chile has also shifted its policy from a "brown" to a "blue" approach by strengthening environmental regulations and public participation in aquaculture (Anbleyth-Evans et al., 2024). Panama is restructuring its legal and institutional framework to ensure the alignment of new blue economy-based policies in the marine and fisheries sectors (de Ycaza et al., 2024). In Norway and Scotland, strategies have focused on aquaculture innovation, more sustainable fisheries spatial planning, and maintaining a balance between economic growth and environmental conservation (Afewerki et al., 2023).

In Indonesia, aquaculture development policy has begun to shift toward the blue economy concept, which emphasizes sustainable resource utilization and comprehensive protection of the economy and the environment (Wenhai et al., 2019). During the administration of President Joko Widodo, a Blue Economy Model centered on the fisheries industry has been implemented (Wahyuddin et al., 2022). The government's policy direction at that time was to prioritize sustainable marine development, both by formulating a national maritime policy and by continuing to commit to contributing to the global sustainable marine and fisheries development agenda through the Blue Economy (Pangesti et al., 2023).

The blue economy approach in the fisheries sector is a policy solution that aims to achieve community prosperity while ensuring

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environmental sustainability, as this concept focuses on several principles in its application, namely zero waste, multiplier effect, social inclusion, innovation, and adaptability (Pauli, 2015). However, the implementation of the blue economy concept is not only important at the national level, but also needs to be realized through strengthening at the local level in areas with potential for sustainable fisheries management (Marwiyah & Lailatul Fitria, 2023), as the implementation gap at the regional level is still significant. To date, West Aceh Regency does not have a policy framework and fisheries management that systematically integrates the principles of the blue economy with the goal of regional food security.

Aquaculture practices are still partial and lack coordination, so the potential for sustainable aquaculture has not been optimally utilized. Previous studies on the development of the fisheries and aquaculture sector consistently show a significant research gap, mainly due to the absence of studies that explicitly and systematically position sustainable aquaculture as a strategic instrument in strengthening food security. Most studies still stop at a macro and global blue economy approach, thus failing to fully capture the dynamics of local practices, regional institutional capacity, and contextual challenges in the implementation of sustainable aquaculture.

In addition, a substantial policy gap remains, as previous studies have not comprehensively examined the implications and requirements for regional policy transformation needed to ensure the effective implementation of sustainable aquaculture. This fundamental research gap constitutes the novelty of this study, particularly in linking sustainable aquaculture development with regional food security objectives. This research is further reinforced by the Strategic Plan of the West Aceh Marine and Fisheries Service for the 2022–2027 period, which identifies aquaculture development as a key priority in the regional fisheries sector. Nevertheless, the strategic plan still requires stronger governance arrangements, institutional capacity building, and the integration of blue economy principles into local policy implementation. Accordingly, this study is explicitly positioned as a policy-oriented analytical inquiry that focuses on governance issues, institutional constraints, and policy misalignments in the development of blue economy–based aquaculture in West Aceh Regency.

This research is qualitative and evaluative-exploratory in nature, aiming to analyze why existing fisheries cultivation policies and practices have not been able to support sustainable food security, as well as how policy transformation can be designed contextually. This study seeks to provide analytical contributions to the understanding of sustainable aquaculture policy transformation at the regional level, while also producing relevant and applicable policy recommendations for strengthening food security in West Aceh Regency. Based on this background, it is necessary to formulate research questions that can serve as a basis for analyzing sustainable aquaculture policy transformation within the framework of the blue economy to promote local food security. Thus, the research questions in this study are as follows:

1. How can aquaculture potential be harnessed to achieve sustainable aquaculture and promote food security in West Aceh Regency?
2. What are the challenges of local aquaculture practices in West Aceh Regency and their implications from a blue economy perspective?
3. What policy transformations can be recommended to promote food security in line with the blue economy perspective?

Based on the formulated research problems, this study employs a policy transformation theory approach within a blue economy perspective to analyze the achievement of the study's objectives. The research objectives are as follows:

1. To analyze the potential of aquaculture development in achieving sustainable aquaculture to enhance food security in West Aceh Regency.
2. To examine the challenges of local aquaculture practices in West Aceh Regency and their implications from a blue economy perspective.
3. To provide policy transformation recommendations to promote food security in line with the blue economy perspective

RESEARCH METHODS

Location and Time of Research

This research was conducted from April to August 2025, covering the stages of observation, data collection, and analysis of results. The research was conducted in West Aceh Regency, which has high aquaculture potential and practices, such as in Johan Pahlawan, Meureubo, Kaway XVI, and Samatiga sub-districts. The research location was selected with reference to regional planning documents developed in accordance with the mandate of Law No. 26 of 2007 on Spatial Planning, which indicate that

the four sub-districts in West Aceh possess spatial characteristics and resource conditions relevant to aquaculture development. Accordingly, this area provides an appropriate context for conducting a detailed analysis of aquaculture potential, examining challenges in local practices, and formulating policy recommendations to support sustainable aquaculture development.

Types and Methods of Data Collection

This study uses a descriptive qualitative approach with a policy-oriented case study design to analyze the transformation of sustainable fisheries cultivation policies based on the blue economy at the district level. This approach is relevant for exploring the dynamics of actors, local contexts, and policy implementation from a blue economy perspective. According to John W. Creswell, qualitative approaches are used to understand social issues through the exploration of meaning and processes in a particular context. The main focus is to gain an in-depth understanding of a phenomenon from the perspective or point of view of the people involved in it. (Creswell & Creswell, 2018).

The types of data used in this study consist of primary data, namely: First) field observations conducted by directly observing the conditions of aquaculture facilities and infrastructure in the field. The results of the observations were recorded in field notes. Second) semi-structured in-depth interviews lasting approximately 1–2 hours per respondent. This technique was chosen to obtain in-depth data related to the experiences, views, and practices of actors in aquaculture management. The entire interview process was recorded and then transcribed in full as material for analysis. Third, research documentation, as well as secondary data obtained from the 2024 and 2025 Aceh Barat Dalam Angka publications, as well as books, theses, and relevant journal articles used as reference materials and to support the research analysis. The data collection method used was purposive sampling.

Purposive sampling was used by establishing criteria for informants who had relevant understanding and experience of aquaculture issues and policy transformation, in order to obtain in-depth data that was relevant to the research objectives. In this study, the informants consisted of 7 people who were selected based on data saturation, while the diversity of perspectives of the informants selected purposively was used to ensure representation of the main issues analyzed. The informants included the West Aceh Fisheries and Marine Service, lecturers from the Aquaculture Study Program at Teuku Umar University, aquaculture business actors, and 4 informants from the West Aceh Regency community.

Analysis Method

The data analysis technique used refers to the interactive model of Miles et al., (2014), which consists of data condensation, data presentation, verification, and drawing conclusions. The analysis process is structured in stages according to the focus of the research. The first stage is aimed at identifying the potential for aquaculture through the grouping of thematic data sourced from interviews, observations, and secondary data. The second stage analyzes the dynamics of aquaculture practices and governance in the field, including interactions between actors and institutional conditions that influence policy implementation.

The final stage focused on analyzing policy transformation by examining the gap between existing policies and actual practices in the field. All findings are analyzed thematically and linked to blue economy principles to formulate implications for sustainable aquaculture development and food security. Next is the data verification process, which aims to interpret the meaning behind the series of data presented. This stage is supported by two types of notes, namely descriptive and reflective, which contain the researcher's thoughts. Drawing conclusions is the process of formulating the meaning and findings of the research in short, concise, and clear sentences. This stage takes place continuously throughout the entire research process.

RESULTS AND DISCUSSION

Potential for Fisheries Cultivation in West Aceh Regency

In addition to capturing fisheries, West Aceh Regency also has promising potential for developing sustainable aquaculture. Its strategic geographical location on the west coast of Sumatra, supported by the availability of vast cultivation areas and adequate water quality, is an important asset for increasing production. Based on data, aquaculture production in West Aceh has increased yearly, indicating consistent growth in this sector. This is also supported by high market demand for aquaculture products. The following graph shows the increase in aquaculture production in West Aceh, as shown in Figure 1.

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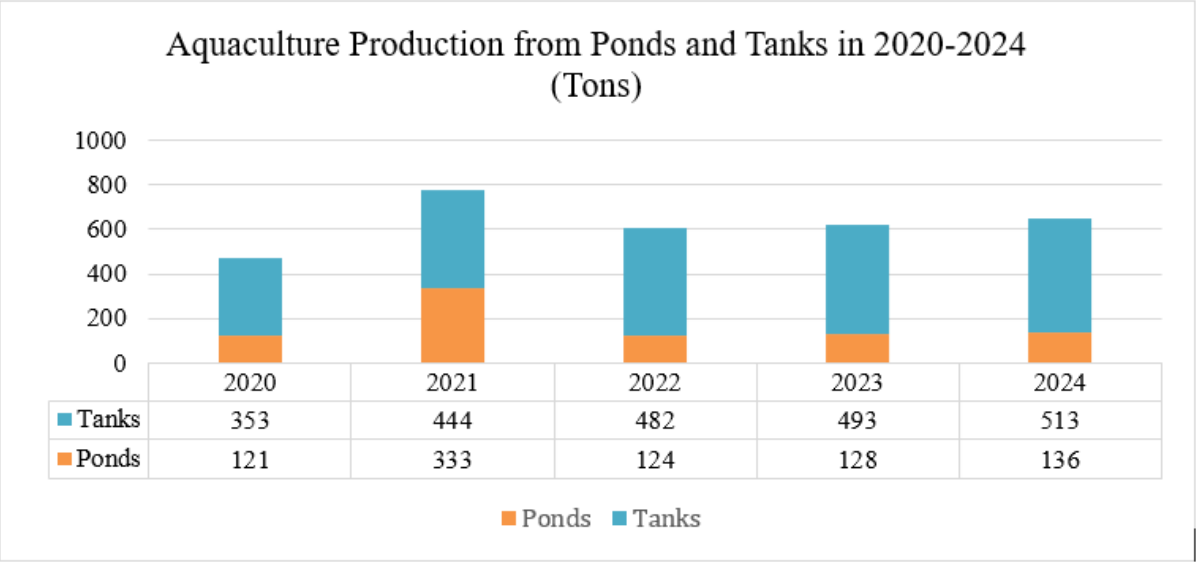

Figure 1. Aquaculture Production Trends in West Aceh Regency (2020–2024).
Source: Bappeda Aceh Barat (Aceh Barat, 2025).

Despite increases in production, land expansion, and the addition of aquaculture business units in West Aceh Regency, these developments have not been accompanied by increases in productivity per unit or overall sector growth sustainability. This predominantly extensive expansion has not been supported by business efficiency and production stability, leaving the aquaculture system vulnerable to external disturbances and input constraints. The decline in production in the 2021–2022 period indicates structural vulnerabilities in the aquaculture system related to production input constraints, environmental pressures, and weak governance and institutional support.

These conditions have limited the contribution of aquaculture in maintaining the stability of local food supply and distribution, while emphasizing the urgency of shifting governance from a quantitative orientation towards strengthening productivity, system resilience, and aquaculture sustainability. Although production will increase again in the 2022–2024 period, this recovery does not necessarily guarantee long-term growth or a stable contribution to local food security. Without increased productivity per business unit, improvements to the distribution system, and stronger aquaculture governance, the increase in production risks being only temporary and unevenly distributed among the community.

In the context of food security, such fluctuations in production can lead to instability in the supply and access to fish-based food at the local level. Thus, aquaculture production data in West Aceh not only shows the potential for development but also emphasizes the importance of transforming fisheries management. Strengthening policies oriented towards increasing sustainable productivity, the resilience of production systems to climate shocks, and distribution efficiency are prerequisites for the aquaculture sector to function optimally as a pillar of food security and the regional economy (Aceh Barat, 2025).

One of the potentials that contributes to strengthening the development of sustainable aquaculture to promote local food security in West Aceh Regency is the role and support of regulations or programs from the local government, because realizing food security through sustainable aquaculture in a region requires full support from the government as the main party that has a role in formulating policies (Schøning et al., 2023). So far, the central and local governments have begun to focus their policies and programs on promoting the advancement of the aquaculture sector, ranging from providing facilities and infrastructure, training for farmers, to opening up market access (Darajati, 2025). Based on interviews with the West Aceh Regency Marine and Fisheries Service, it is known that the programs formulated are indeed directed at developing aquaculture, in line with the local government's understanding of the high productivity potential of this sector in West Aceh Regency (08/06/2025).

In line with this, the local government has developed various programs outlined in annual planning documents, including the empowerment of small-scale fish farmers, the management of aquaculture businesses, and the provision of

facilities, infrastructure, and capital support to ensure the sustainability of aquaculture activities (DKP Aceh Barat, 2022). This is an important factor in increasing the competitiveness of this sector. The synergy between natural resource wealth, human resource quality, and appropriate policy support provides a great opportunity for West Aceh to develop sustainable aquaculture in line with the principles of the blue economy.

However, existing aquaculture practices are not yet fully sustainable and do not yet lead to the application of the principles of the blue economy. This situation has given rise to various challenges, such as limited eco-friendly innovation, low implementation of green technology, and suboptimal collaboration between stakeholders, which need to be addressed immediately so that this potential can be utilized optimally and sustainably. In addition to government support, West Aceh Regency also has great potential for developing sustainable aquaculture due to the existence of non-governmental sectors that can facilitate the development of science and innovation in supporting sustainable aquaculture development, namely academics.

One of the universities that focuses on the fisheries and aquaculture sector is Teuku Umar University. As a higher education institution in western Aceh, Teuku Umar University can become an institution capable of preparing skilled and competent human resources in the field of sustainable fisheries and aquaculture. Through relevant study programs, research activities, and community service, this university supports developing eco-friendly, sustainable aquaculture (Feoh, 2024). Sustainable aquaculture also has the potential to support food security through the availability of land resources and the increasing number of private aquaculture businesses that have begun to spread throughout West Aceh Regency. In fact, in 2024, the number of aquaculture households increased to 661 units, divided into several land areas with a total area of 185.48 ha for aquaculture ponds, 75.90 ha for pond cultivation, and 2.28 ha for net cage cultivation.

Thus, the potential for sustainable aquaculture in West Aceh shows great potential as part of local food security, because with high production levels, support from local and non-local governments, academics, and the private sector, as well as extensive land resources, it has become the main modality in the transformation of sustainable aquaculture policies to promote local food security in West Aceh Regency.

Local Practice Challenges and Implications in the Blue Economy Perspective

Behind the potential of West Aceh Regency in realizing sustainable aquaculture as part of achieving food security, several major challenges affect the implementation process of sustainable aquaculture in promoting local food security, including:

a. Limitations of Eco-Friendly Technology

- The adoption of eco-friendly aquaculture technology in West Aceh Regency is still facing significant obstacles. This is supported by interviews with aquaculture businesses in West Aceh Regency, which show that the use of aquaculture technology tends to be conventional due to considerations of more affordable capital costs compared to the use of eco-friendly technology, which is more expensive and limited (27/05/2025). This condition is reinforced by the low literacy and understanding of the community regarding the availability, benefits, and application of more modern and sustainable cultivation technology. These challenges are not unique to West Aceh Regency.
- Previous studies highlight that the development of sustainable aquaculture within a blue economy framework is often constrained by insufficient initial investment in essential infrastructure, including hatcheries, processing facilities, and irrigation systems (Moazzam, 2022), such as hatcheries, processing facilities, and irrigation systems. There are also limited technologies, which hinder the achievement of sustainable aquaculture development based on the blue economy (March et al., 2023).

This makes it difficult to realize sustainable aquaculture in West Aceh Regency as part of local food security. From a blue economy perspective, the realization of sustainable aquaculture development to achieve food security requires synergy that is in line with environmental sustainability based on innovation and adaptation, including the use of eco-friendly technologies and facilities. The implications of the low utilization of eco-friendly facilities and technology in aquaculture result in damage to the aquaculture ecosystem, such as an increase in the spread of parasites and diseases in fish (Harvey et al., 2024), limited water exchange (Fitridge et al., 2012), and irregular waste management.

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b. Knowledge Capacity on Sustainable Aquaculture Remains Low

The study shows that the community still has limited knowledge about the concept of sustainable aquaculture. This limited understanding has resulted in a gap between traditional aquaculture methods practiced at the local level and the blue economy strategy outlined by the government. The low level of public understanding and participation in sustainable aquaculture shows that social aspects remain a major challenge in the implementation of sustainable aquaculture. These findings are in line with (Budhathoki et al., 2024), who emphasize that limited public knowledge affects the low level of support for sustainable initiatives. From a blue economy perspective, this condition has implications for the optimization of economic potential and sustainable fisheries production, and has the potential to disrupt long-term fisheries resource conservation efforts (Varshanidze & Popluga, 2023).

Therefore, increasing public understanding of sustainable aquaculture policies and practices is an important factor in promoting regional food security (Arshad et al., 2024). From the perspective of the blue economy concept, this condition has implications for opportunities for economic development and production in supporting food security (Varshanidze & Popluga, 2023), the preservation of fishery resource diversity will also be disrupted due to supervision and management that does not comply with environmental quality standards (Ali & Sulistiyono, 2025) and will hamper the management and expansion of aquatic food systems (Hasselberg et al., 2024). Therefore, there is a need to increase public awareness and understanding to support economic development through food security within the framework of the blue economy (Ahmed, 2025).

c. Waste and Environmental Degradation

Waste management in aquaculture activities remains a major challenge in achieving sustainable aquaculture that contributes to local food security. Based on the results of the study, the environmental impact that arises is not obtained through direct ecological measurements, but is identified through an analysis of ongoing aquaculture practices and stakeholder perceptions, which were gathered through interviews and a review of regional planning documents. The findings show that aquaculture practices in West Aceh Regency have not been optimally and integrally implemented in waste management, as reflected in the low utilization of waste and the lack of an adequate treatment system. This condition has the potential to cause waste accumulation and reduce the sustainability of aquaculture businesses. From a blue economy perspective, these practices are not in line with the zero-waste principle.

The potential environmental impact of these conditions is reinforced by previous research findings, including pond or pond pollution (Chiquito-Contreras et al., 2022), an increase in the population of pathogenic bacteria, low harvest quality standards (Lam et al., 2015), and disturbances to public health (Topić Popović et al., 2019) and aquatic ecosystems (Yusoff et al., 2020). Continuing local practices under the same conditions will result in hampered contributions to achieving local food security (Maharani, 2024).

Transformation of Sustainable Aquaculture Policy in Blue Economy-Based Food Security

The transformation of sustainable aquaculture policies is a strategic step to strengthen local food security while preserving the environment. Within the framework of the blue economy, the development of this sector not only emphasizes increased production, but also the implementation of eco-friendly inclusive, and comprehensive practices. Therefore, the recommendations for sustainable aquaculture policy transformation in this study were compiled with reference to the findings on the potential and challenges of local practices, as well as considering the blue economy framework as a guideline for achieving local food security. Thus, the recommendations for aquaculture transformation in this study include Zero Waste-Based Waste Management, Strengthening and Application of eco-friendly technology, inclusive empowerment, and multi-sector collaboration.

a. Zero Waste-Based Aquaculture Waste Management

From a blue economy perspective, the global view on aquaculture waste has fundamentally shifted. Waste is no longer regarded as a by-product that must be discarded, but as a valuable secondary resource with significant potential, reflecting the blue economy's emphasis on resource efficiency and circularity. One prominent example is the utilization of fish waste, which was previously disposed of, for the production of highly nutritious feed. This approach not only reduces environmental pollution but also contributes to lowering greenhouse gas emissions, thereby supporting more sustainable aquaculture systems (Sahar et al., 2024).

The recycling concepts currently being developed by various regions is the IMTA (integrated multi-trophic aquaculture) and aquaponics systems, which utilize nutrient-rich water from fish waste to fertilize other organisms and create new biomass (Setyawan et al., 2023). Sediments from organic sludge at the bottom of the pond can also be used as high-quality compost for agriculture, thereby increasing productivity while reducing operational costs (Nenciu et al., 2022).

From a technological perspective, there is a breakthrough called Bio-Floc Technology (BFT) that creates a mini ecosystem in the pond, eliminating the need for water changes. In this system, a group of beneficial microbes is deliberately grown to "eat" fish waste, often referred to as floc. These microbes are rich in protein and can be eaten again by fish, thus functioning as free natural feed (Rj et al., 2020). Thus, this represents a truly sustainable resource management approach in the aquaculture and fisheries sectors (Meena et al., 2024).

b. Strengthening and Implementation of Eco-Friendly Technology

The strengthening of eco-friendly technology in aquaculture has not been optimally realized in West Aceh Regency, not solely due to limited availability of technology, but also due to a number of structural and institutional factors. The results of the study show that the low adoption of eco-friendly technology is influenced by the limited technical capacity of farmers, the lack of sustainable assistance, and the weak integration between government programs, farmers' needs, and the local ecological context. In addition, farmers' perceptions of high initial costs and uncertainty about short-term benefits are also obstacles to the application of innovative technology. Within the framework of the blue economy, these conditions indicate that the transformation of sustainable aquaculture depends not only on the availability of technology, but also on the social, institutional, and economic readiness of the local community to adopt it.

Therefore, the recommendations for strengthening eco-friendly technologies in this study are based on empirical findings that increasing technology adoption requires capacity building, consistent technical assistance, and policy implementation mechanisms that are more contextual and responsive to the needs of farmers. Referring to various previous literature, various technologies have been developed that are considered capable of improving the efficiency and sustainability of aquaculture.

Such as in the development of integrated cultivation areas (Ermawati, 2020), the use of bio-floc for waste processing into feed (Manan et al., 2023), aquaponics (a combined aquaculture and hydroponics cultivation system) (Sumartono et al., 2024), Integrated Multi Trophic Aquaculture (IMTA), which is an integrated farming system of various organisms from different trophic levels so that the waste of one species is utilized by another species (Insani et al., 2018), and Recirculating Aquaculture Systems (RAS), which is a closed aquaculture system with water circulation and filtration that can be reused (Lal et al., 2024).

c. Inclusive Empowerment

Considering the substantial aquaculture potential and the large number of aquaculture households in West Aceh Regency, inclusive efforts are required to strengthen food security in the aquaculture sector. However, these efforts are constrained by limited understanding of the blue economy framework and low public awareness, which hinders the adoption of efficient, environmentally responsible, and economically resilient aquaculture practices. The blue economy provides a strategic framework for sustainable aquaculture by integrating resource efficiency, ecosystem protection, and socio-economic inclusiveness, all of which are essential for long-term food security. Therefore, inclusive empowerment becomes a key instrument for translating the blue economy concept into practical actions at the local level.

This empowerment can be implemented through knowledge strengthening (Hafizhah Sekarwangi et al., 2021), cultivation guidance and training (Ayuzar et al., 2022), technology introduction (Hikmah et al., 2023), and opportunities with comprehensive equality in the inclusive aquaculture sector (Kelling & Lawan, 2023). This is because local communities need new knowledge and skills in the blue economy-based fisheries sector, such as resource management and fishery product processing (Choudhary et al., 2021).

In various countries, inclusive empowerment to promote food security and improve the quality of aquaculture has become a concrete recommendation in solving problems, especially those related to the lack of knowledge and the level of community awareness and participation. Examples include Zambia, which has adapted industrial aquaculture training for women to increase household income (Maulu, 2019), sustainable aquaculture technology

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interventions in Odisha, India (Dubey et al., 2024; Jayasankar et al., 2022; Shah et al., 2019), and youth participation in fisheries empowerment in Nigeria (Nigussie et al., 2024).

d. Multi-Sector Collaboration

In promoting food security in the sustainable aquaculture sector, it is important to collaborate with stakeholders who are able to work together to develop the potential of aquaculture and overcome challenges in local practices that occur in a region. This collaboration is a synergy of several parties that have their respective roles in the fisheries sector, including local government, academics, industry, and the community itself (Omalia & Marefanda, 2025). Each stakeholder is a key factor in the success of implementation. This collaboration must be supported by effective and efficient communication mechanisms so that the goals of sustainable development based on the blue economy can be realized (Lee et al., 2020). This is because each stakeholder has a different perspective and responsibility in efforts to promote food security through sustainable aquaculture.

These differences in perspective should be facilitated through multi-sector collaboration mechanisms, thereby becoming a source of policy innovation and strengthening the transformation towards a more inclusive and sustainable blue economy governance (Pace et al., 2023). Some of the successes of the marine aquaculture industry include collaboration with the marine biotechnology sector, such as vaccine manufacturers, fish feed development companies, marine management operations, and fish breeding units in the development of products that are useful for promoting human and animal health (Ninawe & Hameed, 2019).

CONCLUSIONS AND POLICY RECOMMENDATION

Conclusions

This study concludes that the substantial aquaculture potential in West Aceh Regency has not yet been optimally harnessed to strengthen local food security. The findings indicate that this condition is not primarily driven by limitations in natural resources, but rather by weaknesses in governance and institutional readiness, as reflected in the limited adoption of sustainable practices, insufficient capacity among aquaculture producers, and the lack of integration of blue economy principles into aquaculture management.

In line with the research objectives, the study highlights the need for policy transformation that prioritizes the strengthening of local institutions to enhance the contribution of aquaculture to food security. Policy reforms should focus on improving producers capacities, establishing continuous extension and support systems, and fostering cross-sectoral coordination to ensure more effective and sustainability-oriented policy implementation. Based on these findings, this study recommends that local governments prioritize integrated aquaculture policies grounded in a blue economy perspective.

Such policies should move beyond technical production measures and emphasize institutional strengthening, appropriate incentive mechanisms, and environmentally responsible governance. These recommendations may also serve as a reference for other coastal regions with similar characteristics seeking to advance sustainable aquaculture and regional food security.

Policy Recommendation

Based on the findings of this study, local governments should strengthen the aquaculture policy framework by developing regulatory and technical instruments that integrate zero-waste principles throughout the entire production cycle. These instruments should be operationalized through enforceable technical guidelines for waste management, supported by economic policy tools such as targeted subsidies, tax incentives, or preferential access to green financing for aquaculture producers who adopt environmentally sustainable practices. Such measures are essential to align aquaculture development with blue economy principles and local food security objectives.

Furthermore, advancing sustainable aquaculture requires institutional reforms that support continuous capacity building and technology adoption among aquaculture producers. This includes the strengthening of structured extension services and the establishment of formal mechanisms for knowledge transfer. Regulatory support is needed to ensure that capacity-building programs are implemented consistently and linked to sustainability standards, certification schemes, and long-term incentive structures. Finally, effective implementation of sustainable aquaculture policies depends on the institutionalization of cross-sectoral collaboration.

Local governments should act as policy coordinators and regulators, academic institutions should provide technical assistance and innovation

support, and the private sector should supply environmentally friendly inputs and production facilities. Formalizing these collaborative arrangements through local regulations or cooperation agreements is crucial to ensuring policy coherence, accountability, and the long-term contribution of aquaculture to blue economy–based food security.

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AUTHORS CONTRIBUTION STATEMENT

We hereby declare that the contributions of each author to the writing of this paper are: Noka Omalia as the main contributor responsible for data collection, data analysis, writing, and translation, and Nellis Mardhiah as a contributing member responsible for data collection, data verification, editing, and supervision. The authors declare that the Author Contribution Letter has been attached.

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