

An Analysis of the Policy Direction of Korea's Eco-Friendly Marine Product Assorted Feed Direct Payment System Using AHP

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AHP를 이용한 친환경 수산물 배합사료 직불제의 정책 방향 분석

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Abstract

This study examines the policy direction priorities for Korea's Eco-Friendly Marine Product Assorted Feed Direct Payment System and proposes strategic recommendations for its improvement. As environmental sustainability becomes increasingly important in the fisheries sector, promoting eco-friendly aquaculture and supportive policies are crucial. By utilizing expert surveys and the Analytic Hierarchy Process (AHP), this research identifies key policy priorities. The findings provide valuable insights into enhancing the direct payment system's effectiveness and suggest strategies to support the sustainable development of Korea's fisheries industry. This study analyzes Korea's Eco-Friendly Marine Product Assorted Feed Direct Payment System, identifying its priorities through AHP analysis. Key findings highlight the importance of advancing production structures and efficient distribution, emphasizing technology development and education for workforce management. The system's success relies on producers' adherence to eco-friendly practices and government support for resource management and sustainability. However, the study notes survey inconsistencies and the need for further research to enhance fisheries policies and system effectiveness.

Key words : Direct payment system for fisheries, Eco-friendly marine product assorted feed, AHP

I. Introduction

Korea's fishing villages face multiple challenges, including resource depletion, overfishing, supply-demand imbalance, and climate change. Notably, the fishing village population decreased by more than half over 20 years, from 251,000 in 2000 to 97,000 in 2020, while the aging rate surged from 15.9% in 2003 to 36.1% in 2020(Korea Policy Briefing, 2024). To

address these issues, the government has implemented various policies. The Draft of the Special Act on Support for Specialized Development of Fishing Villages was created in 2012 and came into effect in 2015. The government's fisheries policy primarily focuses on enhancing the competitiveness and sustainability of the fisheries industry, with various measures in place to achieve these goals.

In particular, the government has implemented

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the Public-Purpose Direct Payment System for Fisheries in 2021 to support fishers who adhere to obligations aimed at promoting public interest. This system imposes certain obligations on fishers to enhance the public benefits generated by the fisheries industry, providing subsidies to those who comply. The Public-Purpose Direct Payment System for Fisheries seeks to preserve the marine ecosystem, sustain fishing village communities, protect fishery resources, and ensure the supply of safe seafood (MOF 2024). The system includes six types of direct payments, such as the Direct Payment System for Unqualified Regions, the Payment System on Transferred Business, the Payment System to Protect Fishery Resources, the Direct Payment System to Support Product of Eco-Friendly Fishery Products, the Direct Payment System for Small-Scale Fishing, and the Direct Payment System for Fishing Workers. The Ministry of Oceans and Fisheries has been implementing the specific provisions delegated by Act on the Operation of Direct Payment Program for Promoting Public Functions of Fisheries and Fishing Villages since March 1, 2021. Among these, the Direct Payment System to Support Product of Eco-Friendly Fishery Products is divided into the Eco-Friendly Marine Product Assorted Feed Direct Payment System and the Eco-Friendly Marine Product Certification Direct Payment System. This system is designed to promote the aquaculture industry, which contributes to the production of safe food and the preservation of the marine environment.

The Eco-Friendly Marine Product Certification Direct Payment System is a program provides subsidies to aquaculture farms that comply with HACCP standards and have obtained Eco-Friendly Marine Product Certification. The support ranges

from a minimum of KRW 530,000 to a maximum of 2.7 billion KRW per certified hectare. Meanwhile, Eco-Friendly Marine Product Assorted Feed Direct Payment System aims to promote the use of environmentally friendly assorted feeds in aquaculture, thereby protecting fishery resources and preserving the marine environment, with the ultimate goal of establishing a sustainable production system. In 2024, the budget for the Eco-Friendly Marine Product Certification Direct Payment System increased by KRW 6.6 billion compared to the previous year, totaling KRW 34.5 billion.

Several studies have examined aspects of the Public-Purpose Direct Payment System in the fisheries sector. For example, the study titled *A Study on Setting Public Interest Functions of Fisheries and Fishing Villages in Korea* analyzed the public-benefit direct payment system in the fisheries sector. The research aimed to establish directions for the expansion and improvement of the fisheries direct payment system and proposed strategies to achieve these goals (Oh et al., 2020). Additionally, *Mandatory Use of Formulated Feed Through Aquaculture Fisheries Direct Payment System* reviewed the issues, functions, and effects of the assorted feed direct payment system and studied appropriate implementation measures for its enforcement (Kwon et al., 2022).

Similarly, *A Study on the Comparative Analysis of Business Performance of Raw Feed and Formula Feed in Fish Aquaculture* conducted a comparative analysis of aquaculture operations using raw feed versus assorted feed, highlighting the superiority of assorted feed. However, the research also explored the reasons why the use of assorted feed has made little progress in aquaculture practices (Song, 2011). Moreover, *A Decomposition Analysis of Fisheries*

Household Income Inequality with and without Public Subsidies examined the public benefit direct payment system as a policy tool for income redistribution, using the Gini coefficient. Based on the results, it was analyzed that this system could alleviate inequality in fishing villages while also reducing income inequality between fishing villages and urban households (Jeong et al., 2023). The Ministry of Oceans and Fisheries (MOF) is continuing to set sustainable development goals for the fisheries industry and is preparing and implementing policies related to these objectives. In line with this plan, continuous development efforts are being made to address necessary tasks beyond the maintenance and reinforcement of production facilities, such as fishing grounds and their management (MOF, 2021). Other research also emphasizes stable seafood production as the key goal for Korean fisheries. Experts prioritize resource management, seafood safety, and training while recommending advanced technologies and broader policy inclusion for sustainable development (Lee et al., 2018).

However, there are several issues that need to be addressed while implementing these systems. First, to provide substantial benefits, the Public-Purpose Direct Payment System for fisheries requires clear performance indicators; however, there is a lack of such indicators due to the relatively short period since the system was established. Second, if the effectiveness of the system is low, the Public-Purpose Direct Payment System for fisheries may only provide financial support, making it difficult to achieve its original goal of enhancing the sustainability of the fisheries industry.

In particular, the Eco-Friendly Marine Product Assorted Feed Direct Payment System seeks to promote the use of assorted feed instead of raw

feed. However, as of 2022, the usage rate for 19 fish species remained low at 20.6% (Korean School Meal Newspaper, 2024). Therefore, to enhance the effectiveness of this system, it is crucial to relax certification requirements and establish more realistic criteria. This study aims to prioritize the most suitable elements among the details of the Eco-Friendly Marine Product Assorted Feed Direct Payment System through AHP analysis and to propose directions for system development based on these findings.

II . Research method

1. The Eco-Friendly Marine Product Assorted Feed Direct Payment System

According to the Food and Agriculture Organization (FAO), global aquaculture production increased by 527% between 1990 and 2018, while the consumption of edible fish rose by 122%. Fish continues to be a vital source of nutrition for many populations, with approximately 3.3 billion people obtaining 20% of their average animal protein intake from fish. As of 2018, aquaculture fish production had reached 114.5 million tons, and the total trade value of farmed fish amounted to \$263.6 billion (FAO, 2024). However, the aquaculture industry faces significant challenges due to the widespread use of raw feed, which contributes to marine pollution and the depletion of fishery resources. Addressing these issues has become crucial for the sustainable growth of the sector.

In response, the National Institute of Fisheries Science is prioritizing research and development of eco-friendly marine product assorted feed as a sustainable alternative to raw feed. Meanwhile, the government is actively implementing a mandatory

use system for eco-friendly marine product assorted feed to improve the environmental conditions of fishing grounds and reduce feed costs. Another reason for the necessity of eco-friendly marine product assorted feed is its role in disease prevention and seafood safety. The main ingredients of raw feed are often difficult to trace regarding their origin, and they frequently do not maintain adequate freshness during storage and transportation. In contrast, eco-friendly marine product assorted feed can inhibit microbial proliferation and maintain a moisture content of less than 10%, effectively preventing spoilage (NFRDI, 2024). Additionally, assorted feeds undergo nutritional component and harmful substance testing according to feed management regulations even after product production, ensuring their safety.

The target beneficiaries of the Eco-Friendly

Marine Product Assorted Feed Direct Payment System are fishers and corporations that utilize assorted feed meeting the minimum quality standards set by the Minister of Oceans and Fisheries. Applications for the program are processed through local city and provincial districts, and the announcement dates may vary depending on the administering organization.

Required documentation includes proof of aquaculture licenses and permits. Additionally, evidence of assorted feed usage, as stipulated in the Enforcement Decree of the Act on the Operation of the Direct Payment System for Enhancing the Public Functions of Fisheries and Fishing Villages, must be provided.

Records of annual production quantities and sales by species are also required. Table 1 shows the payment amount.

<Table 1> Payment Amount

Criteria	Quality Standards				Normal Assorted Feed	High-quality Assorted Feed	Insect Powder Assorted Feed
	Crude Protein	Crude Fat	Crude Fiber	Carbohydrates			
Flatfish	More than 52%	More than 5%			KRW 5,420	-	-
	More than 54% or 8%		Below 5%	Below 25%	-	KRW 8,900	-
	More than 52% (More than 7% for Insect powder)	More than 5%			-	-	KRW 12,390
Sole	More than 50%	More than 5%			KRW 5,420	-	-
	More than 52% or 8%		Below 5%	Below 25%	-	KRW 8,900	-
	More than 52% (More than 7% for Insect powder)	More than 5%			-	-	KRW 12,390
Rockfish, Bream	Assorted feed registered in the National Institute of Fisheries Science				5,420 KRW	-	-

Source: Korea Ministry of Oceans and Fisheries: Fisheries Education Portal, 2024(accessed on April 20, 2024).

2. The Framework and Methodology of AHP Model

Determining the priority for the Eco-Friendly Marine Product Assorted Feed Direct Payment System is crucial for the efficient execution of policy funds and the success of the project. To achieve this, priorities are derived using the Analytic Hierarchy Process (AHP) analysis techniques. AHP is a structured method for organizing and analyzing complex decisions, designed to integrate both rational and intuitive aspects to select the best alternative from several options based on multiple criteria. This analytical method is effective in supporting decision-making

across various fields, including business decision-making, project prioritization, resource allocation, risk management, health management, and environmental management (Michele et al., 2010). This study creates a pairwise comparison matrix based on the collected data, which displays the results of mutual comparisons of the items compared in the survey. The relative importance of each criterion and alternative is organized in a matrix with values ranging from 1 to 9. Table 2 shows the fundamental scale of Saaty absolute number for pairwise comparisons. (Saaty, 1982)

The most fundamental component of AHP is the pairwise comparison matrix. This matrix compares decision criteria or alternatives to evaluate the

<Table 2> Fundamental Scale

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
2	Weak or Slight	
3	Moderate importance	Experience and judgment slightly favor one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgment strongly favor one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
Reciprocals of above	If activity i has one of the above nonzero numbers assigned to it when compared with activity j , then j has the reciprocal value when compared with i	A reasonable assumption
Rationals	Rations arising from the scale	If consistency were to be forced by obtaining n numerical values to span the matrix

relative importance of each element. This can be expressed as eq. (1) (Chen, 2006).

$$A = \begin{bmatrix} \alpha_{11} & \alpha_{12} & \cdots & \alpha_{1n} \\ \alpha_{21} & \alpha_{22} & \cdots & \alpha_{2n} \\ \alpha_{31} & \alpha_{32} & \cdots & \alpha_{3n} \\ \vdots & \vdots & & \vdots \\ \alpha_{n1} & \alpha_{n2} & \cdots & \alpha_{nn} \end{bmatrix} \dots\dots\dots (1)$$

In this context, indicates how much more important criterion is compared to criterion is compared to criterion, and its value is determined by Saaty scale of 1 to 9. Additionally, the relationship holds true. If the two criteria are considered equally important, then.

To determine the importance of each criterion in the pairwise comparison matrix, the eigenvalue problem is solved. In AHP, the maximum eigenvalue and its corresponding eigenvector are used to calculate the weights of each criterion. This can be expressed as eq. (2) (Chen, 2006).

$$A \cdot \omega = \lambda_{\max} \cdot \omega \dots\dots\dots (2)$$

Here, A represents the pairwise comparison matrix is the eigenvector corresponding to and is the maximum eigenvalue.

In AHP, it is essential to verify whether the pairwise comparison matrix exhibits consistency. To achieve this, the Consistency Index (CI) is calculated. The equation for CI is shown in eq. (3) (Chen, 2006).

$$CI = \frac{\lambda_{\max} - n}{n - 1} \dots\dots\dots (3)$$

Here, is the maximum eigenvalue of the pairwise comparison matrix, and is the number of criteria

being compared.

The Consistency Ratio (CR) is calculated by comparing the Consistency Index (CI) to the Random Index (RI). The equation for CI is shown in eq. (4) (Chen, 2006).

$$CR = \frac{CI}{RI} \dots\dots\dots (4)$$

Generally, a CR value of 0.1 or less indicates that the consistency of the pairwise comparison matrix is acceptable. Table 3 shows the random index values for matrices from order 1 to order 15.

<Table 3> Random Index for N=15

N	RI
1	0
2	0
3	0.58
4	0.9
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49
11	1.51
12	1.48
13	1.56
14	1.57
15	1.58

Source: Saaty, 1982.

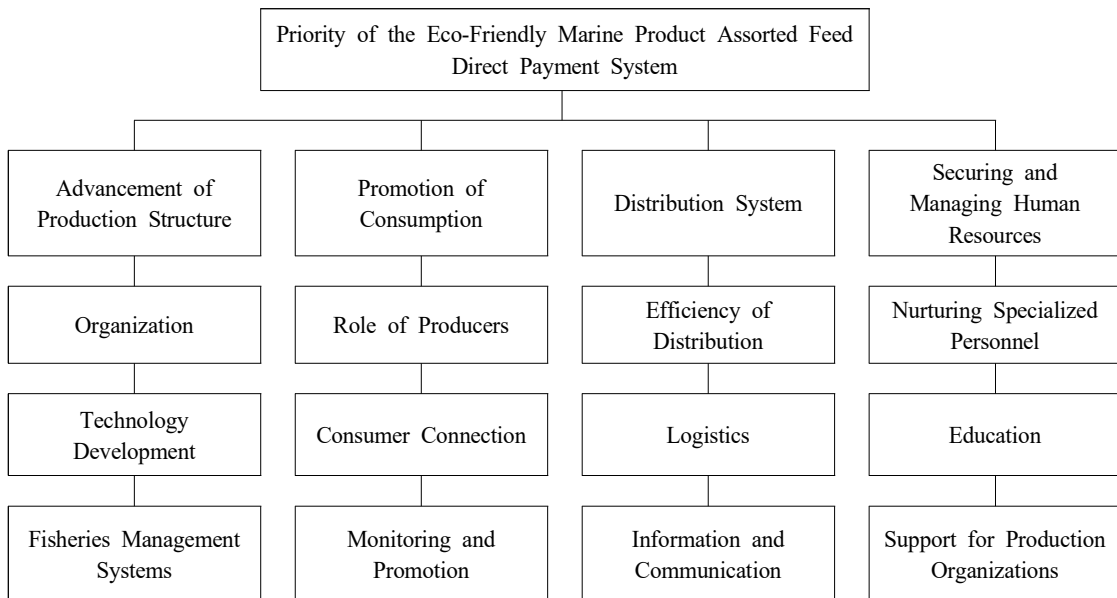
3. Procedure and Data Collection of AHP

The AHP hierarchical structure, as illustrated in Figure 1, which serves as the foundation of this study, is organized as follows. The evaluation items are divided into four principal domains: the advancement of production structure, the promotion

of consumption, the distribution system, and the securing and managing human resources. The sub-areas of advancement of production structure include organization, technology development, and fisheries management systems. The of promotion of consumption is analyzed through the role of producers, consumer connection, as well as monitoring and promotion. The distribution system, is evaluated in terms of efficiency of distribution, logistics, and information and communication. Lastly, the domain of securing and managing human resources is subdivided in nurturing specializ-ed personnel, education, and support for production organizations. For establishing the AHP structure, we referred to Saaty foundational papers on the AHP model. This approach acknowledges that some degree of subjectivity from the researcher is inevitable when establishing a hierarchical structure. To minimize this subjectivity and enhance reliability, we developed our questions with input

from researchers at the Fisheries Research Institute and stakeholders in the fisheries sector. As a result, a limitation of this paper is that the structure has been somewhat subjectively set up. Future research will address these issues and explore alternative structures.

To determine the policy priorities for the Eco-Friendly Marine Product Assorted Feed Direct Payment System, an AHP survey was conducted. The survey employed a 9-point scale for pairwise comparisons and was administered over period of approximately one month, beginning in February 2024. The survey sample consisted of 50 fisheries officials and subject-matter experts. If the consistency ratio (CR) is $CR \leq 0.1$, the answer's consistency is considered reasonable and acceptable up to $CR \leq 0.2$ (Chen, 2006). For the analysis, data from 20 respondents were utilized, after excluding the questionnaires that did not satisfy the CR threshold.



[Fig. 1] The AHP Hierarchy Structure.

III. Results

The first-level priority results of the Eco-Friendly Marine Product Assorted Feed Direct Payment System are shown in Table 4. Among the top ranking factors, the advancement of production structure holds the highest weight (0.441), indicating that improving production efficiency and establishing a systematic management system through the this payment system is highly prioritized. The second priority is the distribution system (0.415), which signifies the need for a systematic and efficient distribution system to ensure the smooth delivery of eco-friendly marine product assorted feed from producers to consumers. The third priority is secure workforce acquisition and management (0.108), and the fourth is promotion of consumption (0.037). Although the promotion of consumption accounts for the lowest proportion of the overall weight, it still plays an important role in improving consumer awareness and connection. This implies that producers should

actively contribute to increasing the value of eco-friendly aquaculture by building trust with consumers to promote consumption.

The results of the sub-classification priority for the advancement of the production structure showed that technology development (0.515) was identified as the top ranked priority factor. It was evaluated as an absolutely critical element for improving productivity and ensuring environmentally-friendly operations. This suggests that the introduction of new technologies in the eco-friendly aquaculture production process can maximize efficiency, reduce production costs, and positively impact the entire system.

The fisheries management systems (0.388) ranked second, while organization (0.097) was analyzed as having relatively lower importance compared to the other factors. The results of the sub-classification priority for the promotion of consumption showed that the role of producer (0.559) was identified as the top priority factor. This indicates that producers should contribute to enhancing the value of

<Table 4> Analysis Results of the Priority for the Eco-Friendly Marine Product Assorted Feed Direct Payment System

Upper Classification	Weight	Sub-Classification	Weight	Total Weight	Ranking
Advancement of Production Structure	0.441	Organization	0.097	0.043	6
		Technology Development	0.515	0.227	1
		Fisheries Management Systems	0.388	0.171	4
Promotion of Consumption	0.037	Role of Producer	0.559	0.021	9
		Consumer Connection	0.089	0.003	12
		Monitoring and Promotion	0.352	0.013	10
Distribution System	0.415	Logistics	0.078	0.032	7
		Efficiency of Distribution	0.487	0.202	2
		Information and Communication	0.435	0.181	3
Secure Workforce Acquisition and management	0.108	Nurturing Specialized Personnel	0.082	0.009	11
		Education	0.682	0.074	5
		Support for Production Organization	0.236	0.025	8

eco-friendly aquaculture by stabling trust with consumers. The monitoring and promotion (0.352) ranked second, and consumer connection (0.089) was analyzed as having relatively lower importance compared to the other priorities. The results of the sub-classification priority for the distribution system showed that efficiency of distribution (0.487) was identified as the top priority factor. Efficient distribution management plays a crucial role in ensuring the supply of fresh products, reducing costs, and enhancing the stability of the supply chain. This is particularly significant for eco-friendly products, where timely logistics are essential for preserving product freshness, further emphasizing the critical role of distribution efficiency. The information and communication (0.435) ranked second, while logistics (0.079) was analyzed as having relatively lower importance compared to the other factors.

Finally, the priority results of the sub-categories under securing and managing human resources were analyzed in the following order: education (0.682) holds the highest weight, followed by support for production organization (0.236), and nurturing specialized personnel (0.082) is ranked the lowest.

IV. Conclusion

This study examines the Eco-Friendly Marine Product Assorted Feed Direct Payment System, a component of Korea's Public-Purpose Direct Payment System for fisheries. While this system has only been in place for a few years, its policy significance is gradually increasing, leading to various institutional improvements. However, research on this system remains limited, and it has yet to reach the stage of quantitative evaluation or

further development. Thus, the objective of this study is to outline the structure of the Eco-Friendly Marine Product Assorted Feed Direct Payment System, aiming to enhance the competitiveness of Korea's fisheries industry while establishing a sustainable development framework for various support and regulatory policies through AHP analysis. The significance of each factor was determined through a review of previous studies, literature, and expert opinions, followed by AHP analysis.

The analysis results are as follows. The first-level priority results of the Eco-Friendly Marine Product Assorted Feed Direct Payment System indicate that the advancement of production structure has a weight of 0.441, showing a difference of approximately 0.026 from the second priority, the distribution system which has a weight of 0.415. This indicates that both factors are of near-equal importance. By meeting the nutritional requirements of aquaculture products through assorted feed, consistent quality can be maintained. Additionally, this promotes resource conservation and reduces environmental pollution during the production process, enabling sustainable production. The distribution system is essential for providing consumers with fresh and safe seafood. When eco-friendly certified seafood is delivered to consumers quickly and efficiently through an appropriate distribution network, consumer trust is enhanced, and market demand can increase. "Secure Workforce Acquisition and Management" and "Promotion of Consumption" were analyzed as the third and fourth priorities, respectively. By training specialized personnel, the quality of assorted feed can be consistently maintained, ensuring stable production and efficiency. Furthermore, promoting consumption can motivate consumers to actively

choose eco-friendly seafood, which can provide significant economic benefits to those engaged in the fisheries industry.

The analysis results of the advancement of production structure indicated that technology development has the highest total weight of 0.227 among the sub-categories. This result suggests that improving production efficiency, minimizing environmental pollution, enhancing sustainability, improving feed components, providing differentiated products, and strengthening price competitiveness are the most necessary actions. Therefore, it can be concluded that the implementation of the Eco-Friendly Marine Product Assorted Feed Direct Payment System requires the greatest effort and support related to technology development. This includes developing smarter feed formulations, optimizing production processes, and integrating more sustainable practices in aquaculture systems.

Additionally, the fisheries management systems were also analyzed with a high total weight of 0.171, indicating that effective production process management, environmental pollution prevention, transparent information provision, and improving management efficiency require various forms of government support for aspects that fishermen cannot address independently. Government involvement in providing subsidies, grants, and tax incentives to encourage technological advancements and sustainable practices in aquaculture is also crucial. This can help alleviate the financial burden on small producers and facilitate industry-wide adoption of green technologies.

The analysis results of the promotion of consumption category indicated that the role of producers showed the highest weight. As the actual agents of eco-friendly seafood production, producers must appropriately use assorted feed and implement

environmentally friendly aquaculture practices. If producers do not adhere to these principles, the objectives of the system cannot be achieved. Therefore, it can be asserted that the direct implementation of environmental protection, resource management, and sustainable production methods by producers is essential for the success of the Eco-Friendly Marine Product Assorted Feed Direct Payment System. Encourage the development of unique products that appeal to environmentally-conscious consumers, such as those labeled with eco-certifications. This can increase market competitiveness and consumer trust.

The analysis results for the distribution system item revealed that efficiency of distribution had the highest weight. Efficient distribution can lead to cost savings. When the distribution system operates efficiently, producers can reduce their costs and secure better price competitiveness. This contributes to providing eco-friendly marine products to consumers at more reasonable prices. A robust system ensures that seafood reaches consumers quickly and efficiently, which helps increase consumer trust and demand. Cold chain logistics and traceability technologies can be implemented to maintain the quality and safety of the products from the point of production to the consumer.

The analysis results for the secure workforce acquisition and management item indicated that education had the highest weight. Through education, producers can acquire skills in the appropriate use of feed, water quality management, and disease prevention, enabling them to implement environmentally friendly aquaculture practices. By enhancing understanding of the system through education, it becomes easier to achieve the goals of subsidies that comprehensively support the sustainability of the fisheries industry and fishing communities.

In conclusion, this study sought to determine the priorities of the Eco-Friendly Marine Product Assorted Feed Direct Payment System through AHP analysis, providing a constructive direction for improving the current Public-Purpose Direct Payment System for fisheries. However, a limitation of this study is the presence of numerous inconsistent data from the survey results, which could not be fully utilized, indicating that more in-depth research is needed in the setting of the items. Furthermore, given that research on the Public-Purpose Direct Payment System for fisheries is still lacking, it is anticipated that if various studies are supported, the results of this research will serve as an important foundational resource for future fisheries policy decision-making.

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- Received : 08 November, 2024
 - Revised : 30 December, 2024
 - Accepted : 08 January, 2025