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Integrated Green Economy Policy for Fishery Waste Valorization in the Cirebon Coastal Area: A Mixed-Method PLS-SEM Analysis

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Abstract

Background: Cirebon coastal area generates approximately 15,000–20,000 tons of fishery waste annually, with more than 60% remaining unutilized, leading to environmental pollution and missed economic opportunities. Existing waste management policies remain fragmented among Regional Apparatus Organizations and lack an integrated framework that combines local wisdom, green economy principles, and fishery waste valorization.
Objective: This study analyzes the relationships among local wisdom, green economy policy, fishery waste transformation, and waste-based economic products by examining the mediating role of an integrated policy model using Partial Least Squares Structural Equation Modeling (PLS-SEM).
Methods: A convergent mixed-methods design was employed, involving 132 respondents from coastal fishery communities. Quantitative data were collected using stratified random sampling and analyzed using PLS-SEM, while qualitative data were obtained through purposive interviews and integrated through triangulation to enrich the interpretation of the findings.
Results: The direct effects of local wisdom ($\beta = 0.097$; $t = 0.674$), green economy policy ($\beta = 0.018$; $t = 0.280$), and fishery waste transformation ($\beta = 0.059$; $t = 0.698$) on waste-based economic products were statistically insignificant. However, all three variables significantly influenced economic products through integrated policy model ($p < 0.05$), confirming its full mediating role. The findings indicate that institutional support, including quality standards, technical assistance, and market facilitation, is essential for successful waste valorization.
Conclusion: *Integrated green economy policies* are critical for transforming fishery waste into sustainable economic products while reducing coastal pollution. Strengthening collaboration among government, academia, and local communities can accelerate waste valorization and enhance sustainable coastal development.

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INTRODUCTION

Cirebon Regency, as a fisheries center on the North Coast of Java, possesses local wisdom in the form of community beliefs and practices that have been inherited across generations to manage marine resources sustainably through the utilization of traditional fishing gear that does not damage ecosystems. However, fisheries activities in this region also generate substantial amounts of fishery waste, including fish waste, crab shell waste, and shellfish waste (Adriyani et al., 2018; Erna, 2021; Erna et al., 2023). This fishery waste creates environmental problems in coastal areas, ranging from discarded fish bones, scales, and skins to crab shells and mollusk shells, which contribute to unpleasant odors and wastewater pollution from fishery waste processing activities (Sundoko, 2026). Most of this waste has not been optimally utilized and has significant potential to pollute coastal ecosystems (Adinuha et al., 2023; Hadi Sumantri et al., 2025; Sugianto et al., 2025). Data from the Cirebon Regency Environmental Agency (2023) indicate that coastal areas in these sub-districts generate an estimated 40–55 tons of fishery waste per day during peak harvest seasons, contributing to elevated biological oxygen demand (BOD) levels in surrounding waters. Waste materials that could potentially serve as raw materials for economically valuable products have instead become a burden on regional waste management systems (Awino, 2024; Ferronato et al., 2019). Preliminary observations across three coastal sub-districts (Gunungjati, Mundu, and Gebang) indicate a strategic transition condition: the community possesses strong social capital, local wisdom, and awareness of the economic potential of fishery waste; however, further strengthening is required in terms of green economy policies and technical waste transformation capacity.

The coastal communities of Cirebon have a long-standing tradition of processing marine products that has been passed down through generations (Mahardeka et al., 2025) Practices such as the production of shrimp paste, petis rebon, and the utilization of shells for various purposes demonstrate that local wisdom in managing fishery waste already exists (Sari et al., 2024). Conceptually, this accumulated local knowledge serves as foundational social capital within the green economy framework, as it reflects principles of resource efficiency and zero-waste utilization that align with circular economy objectives (Chareonvong et al., 2025). However, the development of local wisdom faces several challenges. The quality of products produced remains inconsistent due to the absence of standardized processing procedures.

Access to broader markets is also limited because these products have not yet fulfilled the requirements for integration into formal trade channels. Furthermore, this traditional knowledge has not been systematically documented, standardized, and developed. Fisheries waste management involves multiple Regional Apparatus Organizations (OPDs) with different responsibilities and functions. The Marine and Fisheries Service manages fisheries-related technical aspects, the Environmental Agency oversees pollution control, the Industry and Trade Service supports processing industries, and the Health Service supervises food safety (Jiang & Sun, 2025). However, coordination among OPDs in fisheries waste management has not yet been implemented in an integrated manner (Mustaruddin et al., 2024). Data regarding waste generation volumes, existing treatment capacities, and environmental impacts have not been effectively integrated. Consequently, programs implemented by each OPD tend to operate independently without achieving optimal synergy.

Based on these conditions, an integrated framework is required to combine coastal local wisdom with green economy principles and sustainable development strategies to empower local communities while creating environmentally sustainable economic opportunities. Unlike previous studies that have examined local wisdom, green economy concepts, or fisheries waste management separately, this study develops and empirically tests an integrated structural model that simultaneously incorporates socio-cultural, environmental, and institutional dimensions to explain the development of waste-based economic products through policy mediation. Specifically, this study aims to examine the effects of coastal local wisdom, green economy policy, and fishery waste transformation on waste-based economic products by investigating the mediating role of an integrated policy model using Partial Least Squares Structural Equation Modeling (PLS-SEM).

To achieve this objective, this study adopts the Triple Helix framework, which integrates government, community, and academic/business actors to address the complex and cross-sectoral challenges of fisheries waste management. The Triple Helix approach is particularly relevant because sustainable fisheries waste management requires coordinated regulatory support, technological innovation, community participation, and market development. By integrating these perspectives, this study provides an evidence-based policy framework for strengthening green economy implementation and promoting sustainable fisheries waste valorization in the Cirebon coastal area.

METHOD

This study used a qualitative and quantitative descriptive approach (mixed-method approach), which combined quantitative data analysis and in-depth exploration of qualitative data. Specifically, the study employed a convergent parallel mixed-method design (Creswell & Plano Clark, 2018), in which quantitative survey data analyzed using PLS-SEM and qualitative interview data analyzed through thematic coding were integrated during the interpretation phase to provide complementary insights into the research phenomena. This approach enabled the researchers to describe general patterns statistically while explaining the relationships among local fisheries wisdom, green economy principles, fishery waste transformation, and waste-based economic products within an integrated policy model in the research setting.

The data used in this study consisted of primary and secondary data. Primary data were obtained from surveys and interviews with fishery entrepreneurs and fishing communities, while secondary data were obtained from relevant previous research publications, including official reports from the Cirebon Regency Marine and Fisheries Service, fishery production data from the Badan Pusat Statistik (BPS), environmental impact assessment reports from the Environmental Agency, and Scopus-indexed journal articles on green economy and fisheries waste management published between 2016 and 2025.

The research population included all fishery business actors in three sub-districts, namely Gunungjati District, Mundu District, and Gebang District, consisting of fishermen, fishery product processors, and small and medium enterprises utilizing fishery residues. Based on data from the Cirebon Regency Marine and Fisheries Service (2023), the estimated total population of active fishery business actors across these three sub-districts was approximately 850 individuals.

The sampling method used purposive sampling, which involved selecting respondents considered most relevant to the research objectives. The respondent criteria included: (1) communities directly involved in fisheries activities, including fishing or fishery product processing; (2) business actors who utilized or had the potential to utilize fishery waste; and (3) fishing communities involved in coastal local wisdom practices.

The study involved 132 respondents as a representative sample size. Sampling was conducted using two techniques: purposive sampling for qualitative data collection through interviews to obtain informants with in-depth knowledge of the research topic, and stratified random sampling for quantitative data collection. The sample size of 132 respondents was determined using the Slovin formula ($n = N/(1+Ne^2)$) with a margin of error of 7.5%, applied to the estimated population of 850 fishery business actors, resulting in a minimum required sample size of 130 respondents. This sample size also met the minimum requirement for PLS-SEM analysis, which recommends a sample size of at least ten times the maximum number of structural paths directed toward a latent construct (Hair Jr et al., 2021).

Data collection was conducted through three main stages. First, questionnaire surveys were administered to collect quantitative data related to fishery waste management practices, economic activities, and perceptions of green economy policies. Second, structured and semi-structured interviews were conducted to obtain deeper information from fishing communities regarding local wisdom, waste utilization practices, and policy implementation. Third, documentation studies were conducted by reviewing business records, policy documents, and other supporting materials relevant to fisheries waste management.

Data analysis in this study was conducted through quantitative and qualitative approaches. Quantitative analysis was applied to survey data using descriptive statistics to identify the distribution of characteristics among fishery waste-based entrepreneurs and their contributions to local economic activities. Inferential analysis was performed using Partial Least Squares Structural Equation Modeling (PLS-SEM) through SmartPLS 4.0 software to examine causal relationships among research variables, including direct effects, indirect (mediation) effects, and overall model assessment. Qualitative analysis was conducted on interview data through the stages of data reduction, thematic categorization, and in-depth interpretation to obtain a contextual understanding of green economy policy implementation in fisheries waste management.

The qualitative coding process followed a structured approach: initial open coding was conducted to identify emerging themes from interview transcripts, followed by axial coding to establish relationships among categories, and selective coding to consolidate findings into overarching themes. Inter-coder reliability was ensured through independent coding by two researchers, with a Cohen's kappa coefficient exceeding 0.80.

To ensure data validity and reliability, this study applied triangulation of data sources and data collection techniques by comparing the results of surveys, interviews, and official documents. Discrepancies among data sources were resolved through iterative cross-referencing and member checking with key informants to verify interpretive accuracy. This approach ensured that the research findings were objective, consistent, and scientifically accountable.

RESULTS AND DISCUSSION

Results

Green economy policy is a development paradigm that emphasizes a balance between economic growth, environmental protection, and social equity. In the fisheries sector, this green economy approach is realized through the efficient utilization of fishery resources, the application of economic principles, and waste reduction strategies.

This section presents the results of a descriptive analysis of data from fishery and fishing-related entrepreneurs in three locations in Cirebon Regency, involving a total of 132 respondents. The descriptive analysis was conducted to provide an overview of the waste-processing entrepreneurs examined in this study, including the types of processed waste that possess economic value.

Table 1
Description of Respondents

Item	Description	Quantity	Percentage (%)
Gender	Male	65	49.24
	Women	67	50.76
Age	15 - 22	5	3.79
	23 - 30	12	9.09
	31 - 38	32	24.24
	39 - 46	37	28.03
	47 - 54	26	19.70
	55 - 62	16	12.12
	63 - 70	3	2.27
	71 - 78	1	0.76
Long Term of Effort	1 - 5	26	19.70
	6 - 10	36	27.27
	11 - 15	21	15.91
	16 - 20	21	15.91
	21 - 25	16	12.12
	26 - 30	8	6.06
	31 - 35	1	0.76
	36 - 40	3	2.27
Respondent Status	- Society	39	29.55
	- Community	37	28.03
	- Entrepreneur	56	42.42
Type of Business	- Fish Waste Treatment	45	34.09
	- Crab Waste Treatment	65	49.24
	- Shellfish Waste Treatment	22	16.67

Respondent Answer Description

Criteria for the results of the indicator index (Ferdinand, 2013):

Index Value 20 – 46.66 = Low
Index Value 46.67 – 73.33 = Medium
Index Value 73.34 – 100 = Height

Local Wisdom

Local wisdom in the context of fisheries waste management refers to the knowledge, practices, and values that have been developed by coastal communities over generations in utilizing marine resources and processing catches. This knowledge has proven to be sustainable because it considers the balance between economic utilization and environmental conservation. Concrete forms of local wisdom include traditional fish-processing techniques, such as the production of shrimp paste, petis, salted fish, and other processed products that utilize all parts of fish, including those that are usually considered waste. It also includes knowledge of appropriate processing times and methods based on seasonal variations and weather conditions.

Local wisdom also encompasses systems of mutual cooperation and the division of labor within coastal communities, knowledge related to maintaining the quality of the coastal environment, and values that emphasize efficient resource utilization. These aspects represent important social capital for the development of sustainable fishery waste management programs.

Table 2
Value of Coastal Local Wisdom Variable Index

No.	Indicator Items	Frequency Percentage					Index Value
		1	2	3	4	5	
1	KLP1	14.39	10.61	0.00	25.00	50.00	77.12
2	KLP2	10.61	15.15	0.76	14.39	59.09	79.24
3	KLP3	7.58	18.18	0.76	26.52	46.97	77.42
4	KLP4	13.64	12.12	0.76	25.76	47.73	76.36
5	KLP5	13.64	11.36	0.76	31.82	42.42	75.61
6	KLP6	15.15	11.36	0.76	30.30	42.42	74.70
Variable Index Values							76.74

The variable index value of coastal local wisdom obtained from respondents' answers was 76.74%, indicating that the coastal local wisdom variable was categorized as high. Among the six indicators of the coastal local wisdom variable, the second indicator (KLP2) recorded the highest index value of 79.24%, indicating that the validity of local knowledge regarding traditional fisheries practices remains relevant and applicable among coastal communities. Meanwhile, the lowest index value was found in the sixth indicator (KLP6), with a value of 74.70%, indicating that local-based technological innovation remains relatively underdeveloped. The development of new waste management approaches by integrating traditional and modern knowledge demonstrates that traditional waste management practices inherited from ancestors remain relevant and can be adapted to contemporary environmental challenges.

Green Economy

A green economy within the context of this policy is defined as an economic development approach that prioritizes improving community welfare and social equity while reducing environmental degradation and the depletion of natural resources. This approach is particularly relevant to fisheries waste management because it can transform waste-related environmental problems into economic opportunities. The principles of a green economy applied in this context include resource-use efficiency through the utilization of waste as raw materials for value-added products, emission and pollution reduction through appropriate waste treatment technologies, and the creation of green employment opportunities that support environmental sustainability. This approach also emphasizes the adoption of environmentally friendly, accessible, and affordable technologies for coastal communities.

In practice, a green economy involves the development of economic activities that generate benefits for coastal communities while maintaining the sustainability of marine and coastal ecosystems. This concept aligns with the principles of sustainable development, which seek to achieve a balance among economic growth, social well-being, and environmental protection.

Table 3
Value of Green Economic Policy Variable Index

No.	Indicator Items	Frequency Percentage					Index Value
		1	2	3	4	5	
1	KEH1	12.12	16.67	0.76	25.76	44.70	74.85
2	KEH2	7.58	19.70	3.79	27.27	41.67	75.15
3	KEH3	7.58	19.70	7.58	28.79	36.36	73.33
4	KEH4	10.61	16.67	0.76	19.70	52.27	77.27
5	KEH5	7.58	21.21	6.06	31.06	34.09	72.58
6	KEH6	12.88	17.42	6.06	34.85	28.79	69.85
Variable Index Values							73.84

The variable index value of the green economy policy obtained from respondents' responses was 73.84 percent. This finding indicates that the index value of the green economy policy variable falls within the high category, demonstrating that the implementation of green economy policy principles is perceived positively by respondents. Among the six indicators of the green economy policy variable, the fourth indicator (KEH4) recorded the highest index value of 77.27 percent. This indicates that the implementation of green principles reflects respondents' environmentally responsible practices in fisheries-related businesses. Meanwhile, the lowest index value was recorded for the sixth indicator (KEH6), with a value of 69.85 percent. This finding indicates that institutional support remains relatively limited, particularly regarding support from relevant institutions for the development of fishery-based businesses and the lack of collaboration among government agencies, academics, and business actors in managing fishery waste.

Waste Transformation

Waste transformation in the context of this policy refers to the process of converting fishery waste from its initial state, which has the potential to cause environmental pollution, into products with economic value that provide benefits to communities. This transformation process involves not only technical treatment aspects but also changes in community perceptions and attitudes toward waste management. Technical transformation includes physical, chemical, or biological processing methods that alter the characteristics of waste into new value-added products. These processes may include drying, fermentation, grinding, or other treatment methods that can be implemented using appropriate and accessible technologies. The quality of the resulting transformation products must comply with minimum standards to ensure their feasibility for commercialization.

Social transformation involves shifting community perceptions from viewing waste as an environmental burden to recognizing it as an economic opportunity. This process requires education, capacity building, mentoring, and the provision of successful examples that can encourage community participation in sustainable waste management programs.

Table 4
Value of Fishery Waste Transformation Variable Index

No.	Indicator Items	Frequency Percentage					Index Value
		1	2	3	4	5	
1	TLP1	11.36	16.67	0.00	22.73	49.24	76.36
2	TLP2	10.61	17.42	1.52	32.58	37.88	73.94
3	TLP3	9.85	18.18	2.27	31.82	37.88	73.94
4	TLP4	10.61	17.42	3.03	25.76	43.18	74.70
5	TLP5	10.61	18.94	5.30	34.85	30.30	71.06
6	TLP6	16.67	11.36	6.82	26.52	38.64	71.82
Variable Index Values							73.64

The value of the fishery waste transformation variable index obtained from the respondents' responses was 73.64 percent. This indicates that the fishery waste transformation variable index is categorized as high, demonstrating that the transformation of fishery waste has been implemented effectively. Among the six indicators of the fishery waste transformation variable, the first indicator (TLP1) showed the highest index value of 76.36 percent, indicating that the indicator of waste potential identification ability demonstrates that respondents have identified types of fishery waste with economic value. Meanwhile, the lowest index value was recorded for the sixth indicator (TLP5) at 71.06 percent, indicating that the market access indicator for processed products remains a challenge, as limited access to markets for selling processed fishery waste products persists. Therefore, it is necessary to develop a sustainable marketing network to strengthen the commercialization of fishery waste-based products.

Integrated Policy Model

An integrated policy model refers to a policy approach that connects various aspects of fisheries waste management within a coherent and mutually supportive framework. This model recognizes that waste management cannot be addressed partially but requires coordination among sectors and stakeholders.

Integration within this model includes regulatory aspects that provide legal certainty for business actors, technical aspects that provide the necessary technologies and assistance, economic aspects that facilitate market access and capital support, and social aspects that consider local wisdom and community participation.

The integrated model also emphasizes synchronization among programs implemented by various Regional Apparatus Organizations, coordination with central and provincial government programs, and harmonization with initiatives from the private sector and civil society. This approach ensures efficient resource utilization and prevents program duplication.

Table 5

Value of Integrated Policy Model Variable Index

No.	Indicator Items	Frequency Percentage					Index Value
		1	2	3	4	5	
1	MKT1	15.91	9.85	0.76	35.61	37.88	73.94
2	MKT2	9.09	17.42	3.79	46.21	23.48	71.52
3	MKT3	14.39	12.88	2.27	36.36	34.09	72.58
4	MKT4	9.09	15.91	3.03	34.09	37.88	75.15
5	MKT5	6.82	21.21	0.76	34.85	36.36	74.55
6	MKT6	12.88	14.39	3.79	30.30	38.64	73.48
Variable Index Values							73.54

The value of the integrated policy model variable index obtained from the respondents' responses was 73.54 percent. This indicates that the integrated policy model variable index is categorized as high, reflecting a strong implementation of integrated policy mechanisms for fishery waste transformation. Among the six indicators of the fishery waste transformation variable, the fourth indicator (MKT4) demonstrated the highest index value at 75.15 percent. This finding indicates that the local system resilience indicator has been well established, suggesting that the local fisheries management system has the capacity to withstand various challenges. Meanwhile, the lowest index value was recorded for the second indicator (MKT2), at 71.52 percent, indicating that synergy among local stakeholders in fisheries management remains suboptimal and that some actors have not yet adapted their waste management practices to current technological and developmental advancements.

Economical Products

The economic products referred to in this policy framework are processed fishery waste products that possess market value and can generate additional income for coastal communities. These products must fulfil several practical criteria to provide a tangible contribution to improving community welfare. The criteria for economical products include having an appropriate selling value relative to the production costs and labour inputs, being producible using simple technologies that can be adopted by coastal communities, possessing sufficient durability to support distribution and storage processes, and having market acceptance at the local or regional level.

Examples of economical products derived from fishery waste include fish bone meal for animal feed, handicrafts made from crab shells, organic fertilisers produced from fish processing residues, and processed food products that utilise underutilised fish parts that are typically not consumed. Product development should be adjusted to the capabilities, resources, and interests of business groups in each location to ensure sustainable implementation within the coastal community.

Table 6
Variable Index Value of Waste-Based Economic Products

No.	Indicator Items	Frequency Percentage					Index Value
		1	2	3	4	5	
1	PEL1	12.12	12.88	2.27	18.94	53.79	77.88
2	PEL2	13.64	11.36	2.27	30.30	42.42	75.30
3	PEL3	12.12	14.39	2.27	28.79	42.42	75.00
4	PEL4	12.12	13.64	1.52	32.58	40.15	75.00
5	PEL5	6.82	17.42	5.30	38.64	31.82	74.24
6	PEL6	5.30	18.94	0.00	24.24	51.52	79.55
7	PEL7	9.09	15.15	0.76	29.55	45.45	77.42
8	PEL8	11.36	13.64	7.58	26.52	40.91	74.39
9	PEL9	9.85	14.39	3.79	10.61	61.36	79.85
10	PEL10	15.91	8.33	4.55	10.61	60.61	78.33
Variable Index Values							76.70

The transformation of fishery waste into economic products is one of the main discussions in this study. Fishery waste, including shells, fish bones, and unsold catches, can be processed into value-added products such as organic fertilizers and handicrafts with aesthetic value. Structural model analysis shows that waste transformation has a significant effect on the development of economic products, both directly and through the mediation of integrated policies. This result is consistent with the findings of Agustina et al. (2020), who stated that innovations in fishery waste utilization can increase community income while reducing environmental pollution. Therefore, the integration of waste transformation not only provides economic benefits but also strengthens the social and ecological pillars of sustainable development.

Discussion

Evaluation of Measurement Models (Outer Model)

Validity Test for Reflective Indicators

Table 7
Convergent Validity Test - Loading Factor

No.	Statement Item Code	*Loading Factor*	Remarks
1	KLP1	0.9509	Valid
2	KLP2	0.9631	Valid
3	KLP3	0.9555	Valid
4	KLP4	0.9466	Valid
5	KLP5	0.9548	Valid
6	KLP6	0.9390	Valid
7	KEH1	0.9383	Valid
8	KEH2	0.9415	Valid
9	KEH3	0.9388	Valid
10	KEH4	0.9630	Valid
11	KEH5	0.9137	Valid
12	KEH6	0.9113	Valid
13	TLP1	0.9335	Valid
14	TLP2	0.9460	Valid
15	TLP3	0.9392	Valid
16	TLP4	0.9457	Valid

No.	Statement Item Code	*Loading Factor*	Remarks
17	TLP5	0.9160	Valid
18	TLP6	0.9218	Valid
19	MKT1	0.9333	Valid
20	MKT2	0.9255	Valid
21	MKT3	0.9488	Valid
22	MKT4	0.9387	Valid
23	MKT5	0.9348	Valid
24	MKT6	0.9520	Valid
25	PEL1	0.9428	Valid
26	PEL2	0.9429	Valid
27	PEL3	0.9233	Valid
28	PEL4	0.9195	Valid
29	PEL5	0.9324	Valid
30	PEL6	0.9409	Valid
31	PEL7	0.9387	Valid
32	PEL8	0.9122	Valid
33	PEL9	0.9518	Valid
34	PEL10	0.9576	Valid

The result of the outer *loadings table,* if the result is > 0.7, then it is a valid category.

Table 8
Convergent Validity Test – Average Variance Extracted (AVE)

Variable	AVE Value	*Rule of Thumb*	Conclusion
KEH	0.873	> 0.5	Valid
KLP	0.906	> 0.5	Valid
MKT	0.882	> 0.5	Valid
PEBL	0.877	> 0.5	Valid
TLP	0.872	> 0.5	Valid

Table 9
Discriminant Validity Test via Fornell Larcker – Communality

Variable	Fornell-Larcker *Values*	Conclusion
KEH	0.935	Valid
KLP	0.952	Valid
MKT	0.939	Valid
PEBL	0.936	Valid
TLP	0.934	Valid

Table 10
Discriminant Validity Test - Cross Loading

No.	Statement Item Code	*Loading Factor*	Remarks
1	KLP1	0.951	Valid
2	KLP2	0.963	Valid
3	KLP3	0.955	Valid
4	KLP4	0.947	Valid
5	KLP5	0.955	Valid
6	KLP6	0.939	Valid
7	KEH1	0.938	Valid
8	KEH2	0.941	Valid
9	KEH3	0.939	Valid
10	KEH4	0.963	Valid
11	KEH5	0.914	Valid
12	KEH6	0.911	Valid
13	TLP1	0.934	Valid

No.	Statement Item Code	*Loading Factor*	Remarks
14	TLP2	0.946	Valid
15	TLP3	0.939	Valid
16	TLP4	0.946	Valid
17	TLP5	0.916	Valid
18	TLP6	0.922	Valid
19	PEL1	0.943	Valid
20	PEL2	0.958	Valid
21	PEL3	0.943	Valid
22	PEL4	0.923	Valid
23	PEL5	0.919	Valid
24	PEL6	0.932	Valid
25	PEL7	0.941	Valid
26	PEL8	0.939	Valid
27	PEL9	0.912	Valid
28	PEL10	0.952	Valid

Validity Test for Formative Indicators

Table 11
Evaluation of Formative Indicator Measurement Models through Significant Weight

Indicator	*T Statistics*	*Rule of Thumb*	Conclusion
MKT1 <- MKT	41.333	> 1.96	Valid
MKT2 <- MKT	59.957	> 1.96	Valid
MKT3 <- MKT	61.953	> 1.96	Valid
MKT4 <- MKT	50.389	> 1.96	Valid
MKT5 <- MKT	56.873	> 1.96	Valid
MKT6 <- MKT	57.555	> 1.96	Valid

Table 12
Evaluation of Formative Indicator Measurement Models through Multicollinearity

Indicator	VIF Value	Categories
MKT1	5.563	Valid
MKT2	5.402	Valid
MKT3	7.508	Valid
MKT4	6.355	Valid
MKT5	5.832	Valid
MKT6	7.904	Valid

Reliability Test

Table 13
Reliability Test through *Cronbach Alpha's* and *Composite Reliability scores*

Variable	*Cronbach's Alpha*	*Composite Reliability*	*Rule of Thumb*	Conclusion
KLP	0.979	0.983	> 0.7	Reliable
KEH	0.971	0.976	> 0.7	Reliable
MKT	0.973	0.978	> 0.7	Reliable
TLP	0.971	0.976	> 0.7	Reliable
PEBL	0.984	0.986	> 0.7	Reliable

Evaluation of Structural Models (Inner Model)

Table 14
Goodness of Fit *Assessment* through *R-Square Value*

Variable	R Square *Value*	Conclusion
MKT	0.884	Strong
PEBL	0.828	Strong

Table 15
Effect Size *Test Results (*f 2*)*

	Value f^2	The Magnitude of Influence
KEH -> MKT	0.022	Medium
KEH -> PEBL	0.110	Medium
KLP -> MKT	0.003	Small
KLP -> PEBL	0.015	Small
MKT -> PEBL	0.000	Small
TLP -> MKT	0.047	Medium
TLP -> PEBL	0.084	Medium

Table 16
Goodness of Fit *Assessment* through Q2 *predictive relevance*

Variable	*SSO*	*SSE*	*Q^2 (=1-SSE/SSO)*	Conclusion
MKT	792	180.505	0.772	Strong
PEBL	1320	375.226	0.716	Strong

Table 17
Significance of Influence Between Variables

Variable Influence Relationships	*Original Sample (O)*	*T Statistics*	Hypothesis Test Conclusion
KLP -> PEBL	0.097	0.674	Insignificant (H_1 Rejected)
KEH -> PEBL	0.018	0.280	Insignificant (H_2 Rejected)
TLP -> PEBL	0.059	0.698	Insignificant (H_3 Rejected)
KLP -> MKT	0.480	3.030	Significant (H_4 Accepted)
KEH -> MKT	0.210	2.293	Significant (H_5 Accepted)
TLP -> MKT	0.302	1.993	Significant (H_6 Accepted)
MKT -> PEBL	0.753	5.318	Significant (H_7 Accepted)
KEH -> MKT -> PEBL	0.158	1.962	Significant (H_8 Accepted)
KLP -> MKT -> PEBL	0.361	3.205	Significant (H_9 Accepted)
TLP -> MKT -> PEBL	0.228	2.038	Significant (H_{10} Accepted)

Description :
KLP : Coastal Local Wisdom
KEH : Green Economy Policy
TLP : Transformation of Fishery Waste
MKT : Integrated Policy Model
PEBL : Economical Waste-Based Products

Table 18
Convergent Reliability & Validity

Construct	Number of Indicators	Cronbach's Alpha	Composite Reliability	AVE
Coastal Local Wisdom	6	0.979	0.983	0.873
Green Economy Policy	6	0.971	0.976	0.90

Construct	Number of Indicators	Cronbach's Alpha	Composite Reliability	AVE
				6
Fisheries Waste Transformation	6	0.971	0.976	0.872
Integrated Policy Model	6	0.973	0.978	0.882
Economical Waste-Based Products	10	0.984	0.986	0.877

The results of the loading factor analysis met the required criteria, namely, values above 0.7, indicating that all construct indicators were valid. This means that, overall, each variable was able to explain the variance of its respective indicators, allowing the analysis to proceed with the assessment of convergent validity using the Average Variance Extracted (AVE). The recommended AVE value should be greater than 0.5, indicating that 50% or more of the indicator variance can be explained by the construct. Furthermore, the Cronbach's Alpha and Composite Reliability values were greater than 0.7, indicating that all construct indicators were reliable and had satisfied the reliability test criteria.

Table 19
Structural Model Test Results

Variable Influence Relationships	*Original Sample (O)*	*T Statistics*	Hypothesis Test Conclusion
KLP -> PEBL	0.097	0.674	Insignificant (H_1 Rejected)
KEH -> PEBL	0.018	0.280	Insignificant (H_2 Rejected)
TLP -> PEBL	0.059	0.698	Insignificant (H_3 Rejected)
KLP -> MKT	0.480	3.030	Significant (H_4 Accepted)
KEH -> MKT	0.210	2.293	Significant (H_5 Accepted)
TLP -> MKT	0.302	1.993	Significant (H_6 Accepted)
MKT -> PEBL	0.753	5.318	Significant (H_7 Accepted)
KEH -> MKT -> PEBL	0.158	1.962	Significant (H_8 Accepted)
KLP -> MKT -> PEBL	0.361	3.205	Significant (H_9 Accepted)
TLP -> MKT -> PEBL	0.228	2.038	Significant (H_{10} Accepted)

Table 20
Goodness of Fit *Assessment* through *R-Square* (R2) and *predictive relevance* (Q2)

Endogenous constructs	R^2	Q^2	Interpretation
Integrated Policy Model	0.884	0.772	Strong
Economical Waste-Based Products	0.828	0.716	Strong

Discussion

The strength of coastal local wisdom, green economy policies, and fishery waste transformation in shaping integrated policies was found to be significant, demonstrating that cultural values, green economy principles, and waste management technology/innovation readiness synergistically contribute to the development of an integrated policy model. This finding is consistent with the literature emphasizing the importance of socio-cultural foundations Hadid & Surtikanti (2024) and green paradigms in formulating effective coastal policies, as well as with empirical evidence indicating that waste transformation requires regulatory support and incentives (Sun et al., 2023; Yusheng et al., 2024).

The central role of the integrated policy model in promoting waste-based economic products emphasizes that policy serves as the primary driver for strengthening such products through regulatory certainty, technical assistance, financing and market access, as well as multi-stakeholder coordination. The direct implication for the Cirebon coastal area is the need to establish a collaborative framework at the sub-district level (Gunung Jati, Mundu, and Gebang) involving local governments, relevant agencies, business actors, and customary/business communities to accelerate the downstream utilization of fishery waste.

Coastal local wisdom, green economy policies, and fishery waste transformation do not directly influence waste-based economic products; rather, their effects occur through an integrated policy model (Puspaningtyas, 2026). This indicates that cultural values, green practices, and technical capacities can only generate economic value when supported by policy mechanisms, including quality standards, training programs, incubation initiatives, and supply chain development.

The power of prediction and practical implications

The substantial R^2 and Q^2 values indicate that the model demonstrates adequate explanatory power and predictive relevance for the Cirebon coastal context. Based on effect size measures, the most effective interventions involve strengthening integrated policies through joint programs among marine agencies, cooperatives, and research institutions that establish waste raw material standards, encourage the adoption of appropriate processing technologies (such as drying, collagen hydrolysis, and chitosan extraction), and expand market channels through green labeling, e-commerce platforms, and craft-based tourism. From a social perspective, the involvement of customary institutions and fishermen's community forums enhances policy legitimacy and program sustainability, aligning with empirical evidence regarding the role of local organizations (Marlianingrum et al., 2025; Mustaruddin et al., 2024).

Endurance test (brief)

Sensitivity analysis (removing indicators with the lowest factor loadings, blindfolding procedures, and PLSpredict assessment) did not alter the direction or significance of the structural paths, while the SRMR value remained below 0.08. These results strengthen the reliability and robustness of the research conclusions.

Critical Findings from Research

The quantitative analysis reveals an important finding: local wisdom, green economy principles, and fishery waste transformation cannot independently generate economic products without an integrated policy model functioning as a mediator. This finding confirms that coordination and integration are essential factors in the successful implementation of fishery waste management programs. The respondent profile demonstrates favorable conditions for implementing the policy model, with 42.42% of respondents being entrepreneurs, 49.24% specifically focusing on crab waste utilization, and most respondents belonging to the productive age group with 1–10 years of business experience. This composition provides a strong foundation for developing sustainable waste-based economic programs.

Fishery Waste

Within the framework of this policy, fishery waste is defined as residual materials or by-products generated from fishery activities that retain potential economic value but have not yet been optimally utilized. This waste includes biological materials commonly discarded during fishing, aquaculture, or fish processing activities.

Specifically, fishery waste includes crab shells, fish skin and scales, fish bones, fish heads and tails, as well as mollusk shells and other marine-derived residues. This category also includes wastewater generated from fish processing activities (*air limbah pengolahan ikan*) and by-products such as *petis ikan*, which contain proteins and minerals but are frequently discharged without further utilization.

This definition differentiates fishery waste from materials that have no economic value or possess limited potential for recovery. The focus of this policy is on waste streams that can still be transformed into valuable products through simple, accessible technologies suitable for coastal communities.

Economic Limitations

From an economic perspective, this policy model faces limitations regarding market access, which remains dependent on the capacity of existing marketing networks. Not all processed products can immediately enter broader markets without adequate promotional strategies, branding, and distribution support.

The working capital available to business groups is generally limited; therefore, business development must be implemented gradually and cannot be accelerated without considering financial capacity. Fluctuations in raw material prices and processed product demand may also influence business sustainability.

The profit margins of processed fishery waste products may not be comparable to those of primary fishery commodities; however, these products can provide meaningful additional income for fishermen and fish processors. Revenue projections should therefore remain realistic and aligned with prevailing market conditions.

This fishery waste management policy model based on local wisdom aims to establish a sustainable management system by integrating coastal communities' traditional knowledge with green economy principles. The overarching vision of this program is to transform the community's perspective from perceiving fishery waste as an environmental burden into recognizing it as an economic opportunity that can improve livelihoods while maintaining environmental sustainability.

The program is designed not only to address pollution problems associated with fishery waste but also to empower coastal communities by developing alternative income sources that are more diversified and resilient to external changes. An approach integrating local wisdom ensures that the program can be socially accepted and developed organically by communities rather than functioning merely as a top-down initiative with limited long-term sustainability.

Policy Model Flowchart

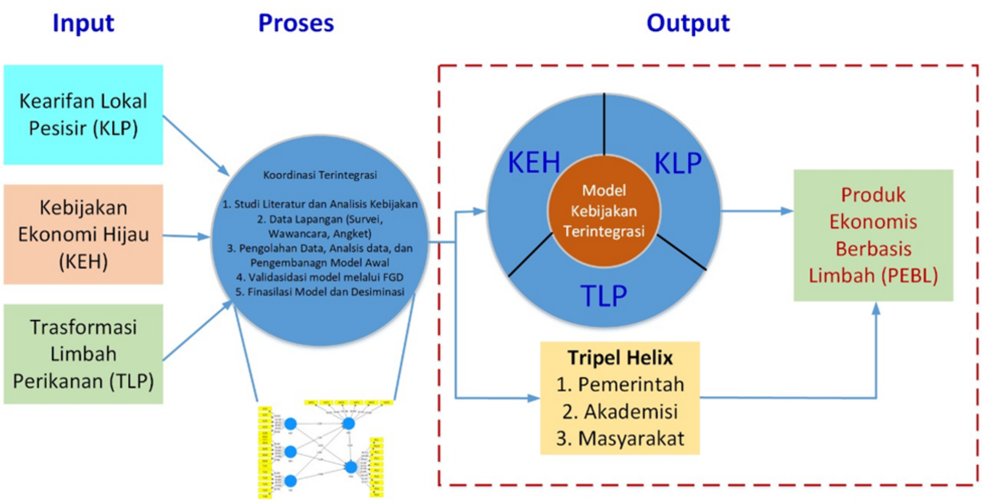

Figure 1. Policy Model Flowchart

Figure 1 shows that integrated coordination is the key mediator based on the research findings

CONCLUSION

This study demonstrates that coastal local wisdom, green economy policies, and fishery waste transformation do not directly generate economically valuable waste-based products but significantly influence their development through an integrated policy model. The findings confirm that institutional coordination plays a decisive mediating role in transforming the socio-cultural and environmental potential of fishery waste into sustainable economic value. The integrated policy framework strengthens collaboration among government agencies, local communities, academia, and business actors, thereby supporting environmentally sustainable fishery waste management while creating new economic opportunities for coastal communities. These findings contribute to the development of an integrated policy framework that combines socio-cultural, environmental, and institutional perspectives to support sustainable coastal development.

The study implies that local governments should prioritize integrated policies through institutional coordination, quality certification, technical assistance, technology transfer, financing support, and market facilitation to accelerate fishery waste valorization. Although the proposed framework demonstrates strong explanatory and predictive capabilities within the

Cirebon coastal area, its findings are limited by the study's geographical coverage and sample characteristics. Future studies are encouraged to validate the proposed model in other coastal regions, incorporate additional institutional and market-related variables, and evaluate the long-term environmental, social, and economic impacts of integrated fisheries waste management policies.

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AUTHOR CONTRIBUTION STATEMENT

All authors jointly contributed to the conception and design of the study, data collection, data analysis, interpretation of the findings, manuscript preparation, critical revision of the manuscript, and approval of the final version of the manuscript. All authors have read and approved the final manuscript.

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