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Sustainable Coastal Development Through Local Wisdom and the Green Economy: Transforming Fish Waste into Value-Added Products

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ABSTRACT

Implementing a green economy (GEP) in coastal areas requires an approach that not only emphasises ecological efficiency but also integrates local wisdom and the practice of transforming fish waste into value-added products. This research aims to develop an integrated policy model (IPM) based on local wisdom to enhance the economic value of fish waste. Using the Structural Equation Modeling-Partial Least Squares (SEM-PLS) method with 132 respondents, this study examines the relationships among local wisdom, the GEP, and transformation of fishery waste (TFW) in relation to sustainable fisheries byproducts (SFB), with an IPM as a mediating variable. The results indicate that local wisdom, the GEP, and TFW are significantly associated with SFB through integrated policies, suggesting a full mediation relationship. These findings highlight the importance of synergy among business actors, local communities, and government stakeholders in designing GEP-based policies rooted in traditional values. This study contributes to the literature by highlighting the role of local wisdom and TFW within the GEP framework and offers practical implications for sustainable coastal development policies.

1. INTRODUCTION

The green economy (GEP) has emerged as a central paradigm for achieving sustainable development by integrating environmental protection, economic growth, and social inclusion [1, 2]. In the fisheries sector, this paradigm is particularly important, as it encourages resource efficiency, waste reduction, and ecosystem conservation while maintaining economic productivity [3, 4]. In Indonesia, GEP have been embedded in national development agendas; however, their practical implementation in coastal fisheries remains fragmented, especially in relation to waste management and byproduct utilization [5, 6].

The coastal region of Cirebon illustrates the paradox of rapid fisheries growth and poor waste management. As a major hub on Java's north coast, large volumes of fish waste remain unmanaged, causing pollution and economic loss despite valorization potential. Aquaculture production surged from 17,714 tonnes in 2022 to 42,878 tonnes in 2023, with catfish exports reaching 23 tonnes in 2024, intensifying sustainability challenges and SDG gaps. However, rapid growth in fisheries production has increased the volume of fish waste, including bones, scales, and shells, which are often discarded without proper processing. This not only contributes to environmental degradation-such as eutrophication and greenhouse gas emissions-but also reflects inefficiencies in resource utilization [4, 7]. From a GEP perspective, such waste should be treated as a valuable input for secondary production processes, aligning with circular economy principles that emphasize reuse, recycling, and regeneration [8, 9].

Fish waste valorization offers significant opportunities to transform these challenges into economic and environmental benefits. Through processes such as enzymatic hydrolysis, microbial conversion, and biorefining, fisheries waste can be converted into high-value products, including biofuels, bioplastics, fertilizers, and nutraceuticals [7, 10, 11]. These innovations not only reduce disposal costs-often by 30-40% but also generate new revenue streams and employment opportunities, particularly in coastal communities [8, 11].

At the same time, the GEP contributes directly to sustainable fisheries outcomes by promoting regulatory frameworks, technological innovation, and efficient resource allocation. Environmental regulations and sustainability-oriented policies have been shown to improve green total factor productivity (GTFP) in fisheries, thereby enhancing both ecological and economic performance [12]. Moreover, circular economy integration enables fisheries to minimize waste while maximizing value creation from byproducts.

However, sustainability in fisheries is not solely determined by technological and economic factors. Local wisdom plays a crucial role in shaping environmentally responsible practices. In many Indonesian coastal communities, traditional knowledge systems emphasize balance, collective responsibility, and respect for marine ecosystems [13]. These cultural values influence community behavior in resource management and waste utilization. Despite its importance, local wisdom is often underutilized in formal policy frameworks, limiting its potential contribution to sustainability [14].

To bridge these dimensions, integrated policy models (IPM) are essential for sustainable fisheries governance, ensuring coordination between regulatory frameworks, technology, and community practices [15, 16]. Policies promoting public-private partnerships, waste valorization, and technological adoption enhance efficiency and scalability [11, 17]. Governance tools like co-management strengthen stakeholder collaboration [15]. These models also mediate the effects of local wisdom and GEP strategies, improving policy effectiveness through community participation and institutional alignment [2, 13]. Ultimately, they optimize resources, reduce environmental impacts, and increase economic value in fisheries byproducts [4, 8].

Despite these advancements, several research gaps remain. First, empirical studies that quantitatively examine the combined effects of local wisdom, GEP, and transformation of fishery waste (TFW) on fisheries sustainability are still limited [12]. Second, the mediating role of IPM in linking these variables has not been sufficiently explored, particularly in developing country contexts [15, 16]. Third, while the economic and environmental benefits of fish waste valorization are well-documented, their integration into coherent, data-driven policy frameworks remains underdeveloped [8, 11].

Accordingly, this study addresses these gaps by empirically examining the relationships between fisheries local wisdom (FLW), GEP, and TFW, as well as their direct and indirect effects-through IPM-on sustainable fisheries byproducts (SFB). By doing so, the research contributes to the development of a comprehensive and empirically validated framework that integrates cultural, economic, and technological dimensions of sustainability.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1 Contributing factors to sustainable fisheries byproducts

FLW, including traditional ecological knowledge and community-based practices, supports sustainable resource use and enhances the utilization of fisheries byproducts. Local practices often emphasize waste minimization, reuse, and environmental stewardship, aligning with circular economy principles [13, 18]. Community-driven innovations, such as processing fish waste into compost or value-added goods, demonstrate how indigenous knowledge contributes to sustainability [19, 20]. Moreover, integrating cultural practices into fisheries management strengthens environmental responsibility and improves byproduct valorization outcomes [13].

H1: *FLW has a positive association with SFB.*

The GEP promotes resource efficiency, environmental protection, and economic value creation, thereby enhancing SFB. By integrating circular economy principles, fisheries waste can be transformed into high-value outputs such as biofuels, bioplastics, and nutraceuticals [8, 9]. These practices reduce environmental impacts while improving economic returns [4]. Additionally, GEP strategies foster innovation and sustainable production systems, increasing the competitiveness and sustainability of fisheries sectors [1, 2].

H2: *GEP has a positive association with SFB.*

TFW, through valorization processes, significantly contributes to SFB by converting waste into valuable commodities. Technologies such as enzymatic hydrolysis and microbial conversion enable the extraction of bioactive compounds, improving resource efficiency [7]. This transformation reduces disposal costs and environmental pollution while generating economic value [8, 11]. Furthermore, waste valorization supports circular bioeconomy models that enhance sustainability and create new market opportunities for fisheries byproducts [3].

H3: *TFW has a positive association with SFB.*

2.2 Determinants of integrated policy models

FLW strengthens IPM by incorporating community knowledge and participatory governance into policy frameworks. Policies that integrate traditional ecological knowledge improve compliance and effectiveness in fisheries management [13]. Community engagement also enhances stakeholder collaboration, which is essential for integrated governance systems [17]. Moreover, grassroots innovations in waste management demonstrate how local practices can inform adaptive and inclusive policies [21], thereby reinforcing IPM that balance environmental, social, and economic objectives.

H4: *FLW has a positive association with IPM.*

The GEP drives the development of IPM by aligning environmental sustainability with economic growth and governance structures. Policies promoting circular economy practices and resource efficiency require coordination across regulatory, technological, and institutional domains [15, 16]. GEP frameworks also encourage policy harmonization, innovation, and stakeholder collaboration [2]. Additionally, regulatory initiatives and sustainability strategies support integrated approaches that enhance policy coherence and implementation effectiveness in fisheries management [22].

H5: *GEP has a positive association with IPM.*

TFW encourages the development of IPM by necessitating coordination between technological innovation, regulation, and stakeholder participation. Effective valorization requires supportive policies, including incentives, regulatory frameworks, and public-private partnerships [8, 11]. Integrated governance structures help address challenges such as high costs and fragmented regulations [23]. Furthermore, policies that promote technological adoption and supply chain integration enhance the scalability and efficiency of TFW processes [24].

H6: *TFW has a positive association with IPM.*

2.3 Role of integrated policy models in strengthening sustainability

IPM play a crucial role in strengthening SFB by aligning governance, technology, and community engagement. These models facilitate efficient resource use, reduce environmental impacts, and promote economic value creation [4, 8]. Mechanisms such as co-management and maritime spatial planning enhance stakeholder collaboration and policy effectiveness [15]. Additionally, integrated policies support innovation and scalability in byproduct utilization, ensuring long-term sustainability across environmental, economic, and social dimensions [16].

H7: *IPM have a positive association with strengthening SFB.*

2.4 Mediating role of integrated policy models

FLW contributes to SFB through IPM that incorporate community participation and traditional knowledge. Policies that embed local practices enhance compliance, effectiveness, and sustainability outcomes [13]. Integrated governance frameworks enable the alignment of cultural values with modern sustainability strategies [15]. Moreover, community-driven innovations supported by policy integration improve resource utilization and byproduct valorization, demonstrating the mediating role of integrated policies in linking local wisdom to sustainability outcomes [21].

H8: *FLW has a positive association with SFB through IPM.*

The GEP enhances SFB through IPM that coordinate environmental, economic, and technological dimensions. Policies promoting circular economy practices and innovation facilitate efficient waste utilization and value creation [8, 9]. Integrated frameworks ensure alignment between sustainability goals and implementation strategies [15]. Furthermore, policy integration strengthens the impact of GEP initiatives by improving governance effectiveness and scalability in fisheries byproduct development [2].

H9: *GEP has a positive association with SFB through IPM.*

TFW contributes to SFB through IPM that combine regulatory support, technology, and stakeholder collaboration. Policies that incentivize valorization and innovation enhance efficiency and scalability [8, 11]. Integrated frameworks address barriers such as high costs and regulatory fragmentation, improving implementation outcomes [23]. By aligning TFW processes with governance systems, integrated policies maximize resource recovery, reduce environmental impacts, and strengthen SFB systems [4].

H10: *The TFW has a positive association with SFB through an IPM.*

3. RESEARCH METHOD

This study adopts a quantitative approach with an explanatory design to test the causal relationships among variables, both direct and mediated. The explanatory approach is appropriate because the study aims to examine how FLW, GEP, and TFW influence SFB, either directly or through IPM as mediating variables (H1-H10). This design aligns with quantitative causal research frameworks that emphasize hypothesis testing and variable relationships [25].

The research was conducted in coastal areas of Cirebon Regency, specifically in Gunung Jati, Mundu, and Gebang sub-districts. The population includes fisheries-related actors such as fishermen, fish processors, and small and medium enterprises engaged in fisheries-based activities. A purposive sampling technique was applied to select respondents who are directly relevant to the research objectives, particularly those involved in fishing operations, fish waste utilization, and local wisdom practices. This sampling approach ensures the selection of information-rich cases suitable for explanatory analysis [26]. The final sample consisted of 132 respondents, which is adequate for variance-based structural modelling.

Data were collected using a structured questionnaire measured on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). The instrument was developed based on established literature to ensure construct validity and contextual relevance.

The measurement of variables reflects the conceptual framework of this study. FLW captures traditional ecological knowledge, norms, and community-based resource management practices. This construct is consistent with sustainability perspectives emphasizing local knowledge systems in environmental governance. GEP reflects sustainable economic orientation, policy support, and institutional commitment toward environmentally friendly development, grounded in GEP [27, 28]. TFW represents the ability to convert fisheries waste into value-added products, aligning with circular economy concepts that promote waste valorization and resource efficiency [18, 29-31].

The mediating variable, IPM, is conceptualized based on collaborative governance and social-ecological system approaches. It emphasizes synergy among government, community, and academia, adaptive capacity, and participatory policy processes [32-34]. The dependent variable, SFB, reflects economic, environmental, and operational outcomes such as product diversification, value addition, waste reduction, and market acceptance, consistent with sustainable waste management principles.

Data analysis was conducted using Structural Equation Modelling-Partial Least Squares (SEM-PLS) with SmartPLS 4. This method is suitable for testing complex models involving multiple constructs and mediating relationships. SEM-PLS is particularly advantageous for exploratory and predictive research, handling small-to-medium sample sizes, and accommodating non-normal data distributions [35]. Additionally, the method allows simultaneous assessment of measurement and structural models, including reliability, validity, and hypothesis testing.

To ensure the robustness of the model, validity and reliability tests were conducted, including convergent validity, discriminant validity using the Heterotrait-Monotrait Ratio (HTMT) criterion, and composite reliability, following recommended SEM-PLS procedures [35, 36].

Overall, this methodological approach enables a comprehensive examination of how local wisdom, GEP, and TFW contribute to SFB, both directly and through integrated policy mechanisms, thereby aligning with circular economy and sustainability paradigms in fisheries management [31, 37].

4. RESEARCH RESULTS

The respondent profile (see Table 1) shows that the sample of 132 participants is dominated by male respondents (71.2%), while females represent 28.8%. Most respondents are in the 41-50 years age group (31.8%), followed by 30-40 years (29.5%), indicating a mature and productive workforce. In terms of occupation, fishermen account for 43.9%, fish processors 31.1%, and fishery SMEs 25.0%, reflecting representation across the fisheries value chain. Importantly, 53.8% have more than 10 years of business experience, confirming strong practical knowledge. Overall, the demographics indicate that the sample is experienced and relevant to the study context.

Table 1. Respondent demographic profile (n = 132)

Characteristic	Category	Frequency	Percentage
Gender	Male	94	71.2%
	Female	38	28.8%
Age	< 30 years	21	15.9%
	30-40 years	39	29.5%
	41-50 years	42	31.8%
	> 50 years	30	22.7%
Occupation	Fishermen	58	43.9%
	Fish processors	41	31.1%
	Fishery SMEs	33	25.0%
Business Experience	< 5 years	24	18.2%
	5-10 years	37	28.0%
	> 10 years	71	53.8%

Descriptive statistics (see Table 2) indicate that respondents generally show high agreement across all constructs, with mean values above 4.00 on a five-point scale. SFB (4.18; SD = 0.58) and the IPM (4.15; SD = 0.60) record the highest perceptions, followed by FLW (4.12; SD = 0.61) and TFW (4.08; SD = 0.63). GEP (4.05; SD = 0.65) shows the lowest mean, yet remains high. Overall variability is low to moderate.

Table 2. Descriptive statistics

Construct	Mean	Standard Deviation
FLW	4.12	0.61
GEP	4.05	0.65
TFW	4.08	0.63
IPM	4.15	0.60
SFB	4.18	0.58

Note: FLW = Fisheries Local Wisdom; GEP = Green Economy Policy; TFW = Transformation of Fishery Waste; IPM = Integrated Policy Model; SFB = Sustainable Fisheries Byproducts.

The correlation matrix (Table 3) shows moderate to strong positive relationships among all constructs, ranging from 0.64 to 0.78. The strongest correlation appears between IPM and SFB (r = 0.78), followed by GEP–IPM (r = 0.74) and TFW–SFB (r = 0.73). FLW also shows notable correlations with IPM (r = 0.72) and SFB (r = 0.69). All correlations are positive and below 0.90, indicating no multicollinearity concerns and supporting the suitability of the constructs for SEM analysis.

Table 3. Correlation matrix

Construct	FLW	GEP	TFW	IPM	SFB
FLW	1.000	0.68	0.64	0.72	0.69
GEP		1.000	0.66	0.74	0.71
TFW			1.000	0.70	0.73
IPM				1.000	0.78
SFB					1.000

Note: FLW = Fisheries Local Wisdom; GEP = Green Economy Policy; TFW = Transformation of Fishery Waste; IPM = Integrated Policy Model; SFB = Sustainable Fisheries Byproducts.

All constructs were modelled as reflective, and bootstrapping used 5,000 resamples with 95% BCa confidence intervals. Model fit and potential bias were assessed using Standardized Root Mean Square Residual (SRMR) and full collinearity diagnostics. As shown in Table 4, the measurement model demonstrates excellent reliability and convergent validity. Factor loadings range from 0.911 to 0.963, Cronbach's Alpha values range from 0.971 to 0.984, Composite Reliability values range from 0.976 to 0.986, and AVE values range from 0.872 to 0.906. These results indicate strong internal consistency and confirm that the indicators adequately represent their respective latent constructs.

Table 4. Validity and reliability test results (reflective model)

Construct	Loading Range	Cronbach's Alpha	Composite Reliability	AVE
FLW	0.939-0.963	0.979	0.983	0.873
GEP	0.911-0.963	0.971	0.976	0.906
TFW	0.916-0.946	0.971	0.976	0.872
IPM	0.925-0.952	0.973	0.978	0.882
SFB	0.912-0.958	0.984	0.986	0.877

Note: FLW = Fisheries Local Wisdom; GEP = Green Economy Policy; TFW = Transformation of Fishery Waste; IPM = Integrated Policy Model; SFB = Sustainable Fisheries Byproducts; AVE = Average Variance Extracted.

Discriminant validity was assessed using the HTMT ratio. As presented in Table 5, HTMT values range from 0.74 to 0.88, all below the recommended threshold of 0.90. The highest value occurs between IPM and SFB (0.88), while other construct pairs remain well within acceptable limits. These findings confirm that each construct is empirically distinct and that the model demonstrates adequate discriminant validity.

Table 5. Heterotrait-Monotrait Ratio (HTMT) results

Construct	FLW	GEP	TFW	IPM	SFB
FLW	—	0.78	0.74	0.83	0.79
GEP		—	0.76	0.85	0.82
TFW			—	0.80	0.84
IPM				—	0.88
SFB					—

Note: FLW = Fisheries Local Wisdom; GEP = Green Economy Policy; TFW = Transformation of Fishery Waste; IPM = Integrated Policy Model; SFB = Sustainable Fisheries Byproducts.

The full collinearity Variance Inflation Factor (VIF) test was conducted to assess potential multicollinearity and common method bias, as presented in Table 6. The VIF values range from 2.87 to 3.34, with the highest value observed for SFB (3.34). Overall, the results indicate that collinearity and common method bias are not a serious concern in the model.

Table 6. Full collinearity Variance Inflation Factor (VIF)

Construct	VIF
FLW	2.94
GEP	3.11
TFW	2.87
IPM	3.26
SFB	3.34

Note: FLW = Fisheries Local Wisdom; GEP = Green Economy Policy; TFW = Transformation of Fishery Waste; IPM = Integrated Policy Model; SFB = Sustainable Fisheries Byproducts.

A Harman's single-factor test was conducted as an additional diagnostic for common method variance (CMV) (see Table 7). The first factor explains 44.2% of the total variance, which is below the 50% threshold, indicating that CMV is unlikely to bias the results. Although the reliability values are very high, suggesting possible indicator redundancy, this concern is mitigated by the HTMT, full collinearity VIF, and Harman's test, which collectively confirm that CMV is not a serious issue in this study.

Table 7. Harman's single factor result

Factor	Variance Explained
Single Factor	44.2%

Table 8. Model fit indices

Index	Value	Threshold
SRMR	0.061	< 0.08
NFI	0.91	> 0.90

Note: SRMR = Standardized Root Mean Square Residual; NFI = Normed Fit Index.

The model fit evaluation indicates that the proposed PLS-SEM model demonstrates adequate goodness of fit (see Table 8). The SRMR value of 0.061 is below the recommended threshold of 0.08, indicating a satisfactory level of residual fit. Additionally, the Normed Fit Index (NFI) value of 0.91 exceeds the minimum criterion of 0.90, confirming acceptable comparative model fit. Overall, these results suggest that the structural model is well-fitted and appropriate for hypothesis testing.

Table 9 presents the structural model results obtained through bootstrapping, which examine the associations among FLW, GEP, TFW, IPM, and SFB. The results provide a nuanced picture in which the direct associations with SFB are not supported, while strong associations emerge through the IPM.

H1 proposed that FLW is positively associated with SFB. The results show a non-significant association (β = 0.097; t = 0.674; p = 0.500; CI [-0.187; 0.284]). Because the confidence interval includes zero, the hypothesis is not supported. This finding suggests that local wisdom alone may not be directly associated with measurable outcomes in the production or commercialization of fisheries byproducts. Instead, traditional knowledge may require institutional or policy support to become operationally relevant.

H2 proposed that the GEP is positively associated with SFB. The association between GEP and SFB is also not significant (β = 0.018; t = 0.280; p = 0.780; CI [-0.154; 0.179]). This result indicates that the implementation of GEP alone may not be strongly associated with improvements in fisheries byproducts. The finding implies that sustainability practices may need to be embedded within broader governance or coordination mechanisms to relate to tangible outcomes.

H3 proposed that TFW is positively associated with SFB. The results show a non-significant association (β = 0.059; t = 0.698; p = 0.485; CI [-0.143; 0.205]). This suggests that waste processing capacity alone may not be independently associated with higher production or commercialization of sustainable products without additional enabling factors.

Table 9. Structural model results (direct effects-bootstrapping)

Hypothesis	Path	β	T-Value	P-Value	95% CI	Decision
H1	FLW → SFB	0.097	0.674	0.500	[-0.187; 0.284]	Not supported
H2	GEP → SFB	0.018	0.280	0.780	[-0.154; 0.179]	Not supported
H3	TFW → SFB	0.059	0.698	0.485	[-0.143; 0.205]	Not supported
H4	FLW → IPM	0.480	3.030	0.003	[0.168; 0.709]	Supported
H5	GEP → IPM	0.210	2.293	0.022	[0.031; 0.372]	Supported
H6	TFW → IPM	0.302	1.993	0.046	[0.005; 0.517]	Supported
H7	IPM → SFB	0.753	5.318	< 0.001	[0.486; 0.889]	Supported

Note: FLW = Fisheries Local Wisdom; GEP = Green Economy Policy; TFW = Transformation of Fishery Waste; IPM = Integrated Policy Model; SFB = Sustainable Fisheries Byproducts.

In contrast, the results show strong associations between the three exogenous variables and the IPM. H4 proposed that FLW is positively associated with IPM. This hypothesis is supported (β = 0.480; t = 3.030; p = 0.003; CI [0.168; 0.709]). The findings suggest that traditional knowledge and socio-cultural values are strongly related to the development of integrated policy frameworks that align with community needs.

H5 proposed that the GEP is positively associated with IPM. The results support this hypothesis (β = 0.210; t = 2.293; p = 0.022; CI [0.031; 0.372]). This indicates that the adoption of sustainable economic principles is associated with the development of policies that integrate environmental, economic, and social considerations.

H6 proposed that TFW is positively associated with IPM. This hypothesis is also supported (β = 0.302; t = 1.993; p = 0.046; CI [0.005; 0.517]). The findings suggest that TFW initiatives are related to the formulation of policies that promote resource efficiency, market access, and sustainable production.

H7 proposed that IPM are positively associated with SFB. This relationship is highly significant (β = 0.753; t = 5.318; p < 0.001; CI [0.486; 0.889]). The strong association indicates that integrated policies are closely linked to the development and commercialization of SFB. Overall, these results highlight the central role of IPM as a linking mechanism between sustainability practices and fisheries byproduct outcomes.

Table 10 presents the indirect effects and mediation results, examining whether the IPM functions as a mediating mechanism linking FLW, GEP, and TFW with SFB. The mediation analysis was assessed using bootstrapped indirect effects, p-values, confidence intervals, and the Variance Accounted For (VAF).

Table 10. Indirect effects and mediation results

Hypothesis	Indirect Path	β	T-Value	P-Value	95% CI	VAF	Mediation
H8	FLW → IPM → SFB	0.158	1.962	0.049	[0.002; 0.349]	62%	Full mediation
H9	GEP → IPM → SFB	0.361	3.205	0.001	[0.161; 0.588]	95%	Full mediation
H10	TFW → IPM → SFB	0.228	2.038	0.042	[0.014; 0.462]	79%	Full mediation

Note: FLW = Fisheries Local Wisdom; GEP = Green Economy Policy; TFW = Transformation of Fishery Waste; IPM = Integrated Policy Model; SFB = Sustainable Fisheries Byproducts; VAF = Variance Accounted For.

H8 proposed that FLW is indirectly associated with SFB through the IPM. The results show a significant indirect association (β = 0.158; t = 1.962; p = 0.049; CI [0.002; 0.349]). Because the confidence interval does not include zero, the mediation effect is supported. The VAF value of 62% indicates that a substantial portion of the relationship between local wisdom and SFB operates through the IPM. This finding suggests that local wisdom becomes more strongly associated with fisheries byproduct outcomes when translated into structured policy frameworks.

H9 proposed that the GEP is indirectly associated with SFB through the IPM. The results indicate a strong and significant indirect association (β = 0.361; t = 3.205; p = 0.001; CI [0.161; 0.588]). The VAF value of 95% suggests that the relationship between GEP and fisheries byproducts is largely explained by the IPM. This indicates that policy integration plays a major role in linking sustainability principles with fisheries byproduct outcomes.

H10 proposed that TFW is indirectly associated with SFB through the IPM. The results show a significant indirect association (β = 0.228; t = 2.038; p = 0.042; CI [0.014; 0.462]), with a VAF value of 79%. Overall, these findings suggest that the IPM acts as a key linking mechanism between sustainability practices and fisheries byproduct development.

Table 11 presents the R^2 and Q^2 values for the endogenous constructs, indicating the model's explanatory and predictive power. The IPM shows an R^2 of 0.884 and Q^2 of 0.772, while SFB has an R^2 of 0.828 and Q^2 of 0.716. Both constructs demonstrate strong explanatory and predictive relevance, suggesting that the independent variables and the IPM are strongly associated with variations in SFB and policy integration outcomes.

Table 11. R-square (R^2) and predictive relevance (Q^2) values

Endogenous Construct	R^2	Q^2	Interpretation
IPM	0.884	0.772	Strong
SFB	0.828	0.716	Strong

Note: IPM = Integrated Policy Model; SFB = Sustainable Fisheries Byproducts.

Figure 1 presents the full structural model with standardized path coefficients and bootstrapped t-values. The strongest path is from IPM (IPM) → SFB (t = 5.318), highlighting the central role of integrated policies in linking sustainability drivers with economic outcomes. FLW → IPM (t = 3.030), GEP → IPM (t = 2.293), and TFW → IPM (t = 1.993) are all significant, indicating that local wisdom, GEP, and TFW jointly shape policy integration. Conversely, the direct paths FLW → SFB (t = 0.674), GEP → SFB (t = 0.280), and TFW → SFB (t = 0.698) are weak and insignificant, visually reinforcing the mediating role of IPM.

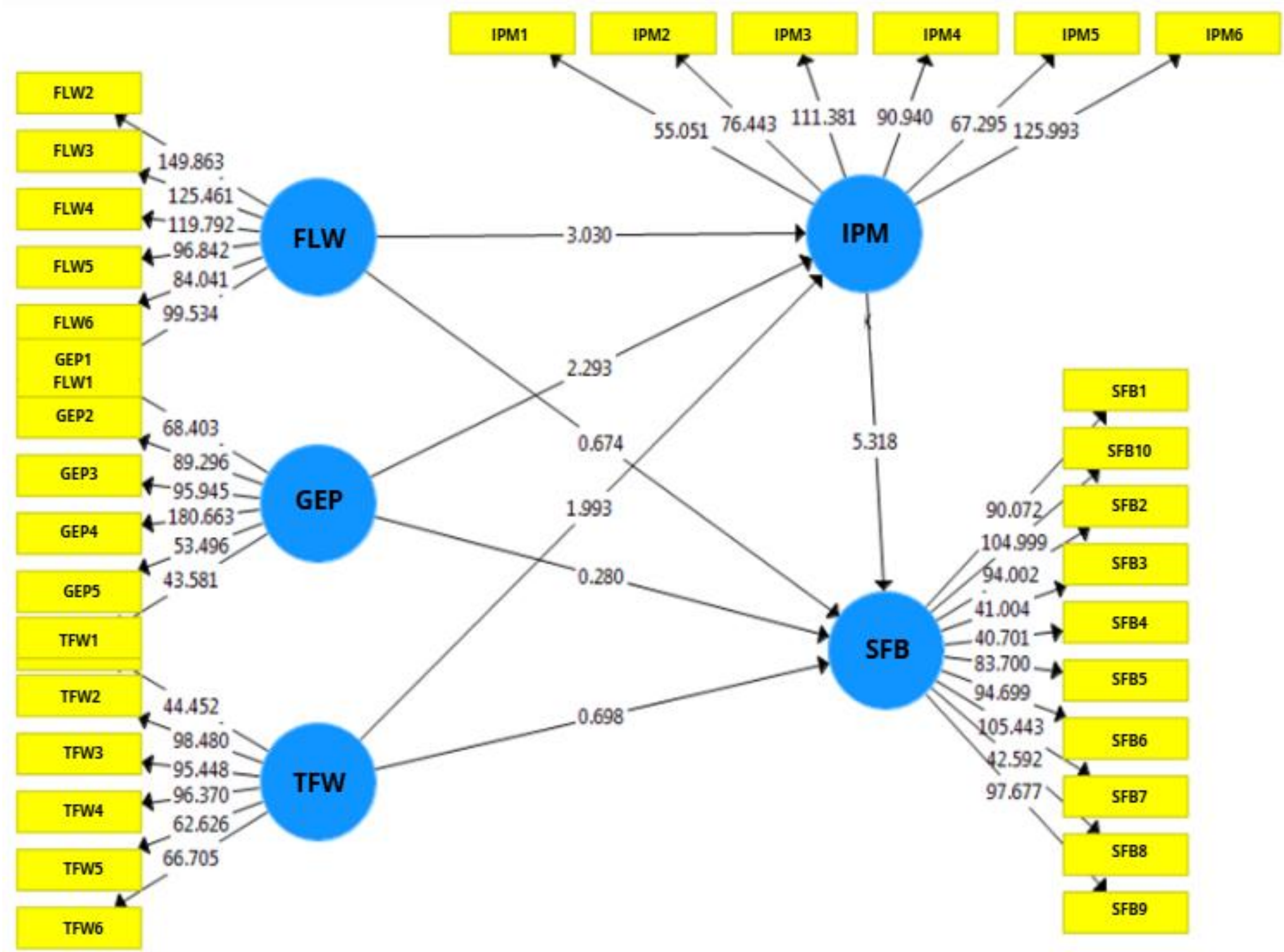

Figure 1. Full model

Note: FLW = Fisheries Local Wisdom; GEP = Green Economy Policy; TFW = Transformation of Fishery Waste; IPM = Integrated Policy Model; SFB = Sustainable Fisheries Byproducts.

5. DISCUSSION

The findings of this study reveal nuanced relationships among FLW, GEP, fishery TFW, IPM, and SFB. Notably, FLW (H1), GEP (H2), and TFW (H3) do not show significant direct associations with SFB. This contrasts with prior studies that link these variables to sustainable resource use, eco-friendly innovation, and economic value creation [2, 8, 11]. The results suggest that, in isolation, these factors are insufficient to produce measurable economic outcomes without institutional and regulatory support, reinforcing arguments that sustainability requires structured policy frameworks [38].

Contextual factors help explain this discrepancy. In regions such as Cirebon, fisheries are largely small-scale and traditional, with limited access to capital, technology, and formal markets. As a result, local wisdom and environmentally oriented practices remain normative rather than economically productive. In contrast, regions with stronger institutional ecosystems and established value chains demonstrate clearer economic impacts [1, 15]. Additionally, fish waste processing remains sporadic and underdeveloped, limiting its contribution to value-added outputs without scaling, technological advancement, and market integration [7, 39].

Conversely, FLW (H4), GEP (H5), and TFW (H6) significantly influence IPM, highlighting their role as foundational inputs in policy formation. These elements contribute to socially legitimate, environmentally oriented, and technically responsive policy systems [15, 16]. Furthermore, IPM strongly affects SFB (H7; $\beta = 0.753$), underscoring its critical mediating role. Integrated policies facilitate coordination, regulatory support, and market access, enabling the TFW into economically viable products [8, 11] while supporting scalability through circular bioeconomy strategies and public-private partnerships [17, 24].

The mediating role of IPM (H8-H10) further underscores its importance. FLW, GEP, and TFW exhibit significant indirect associations with SFB through IPM. This suggests that policy frameworks translate abstract values and fragmented practices into structured economic outputs. For example, local wisdom becomes operational when supported by institutional policies that provide financial incentives, training, and infrastructure [13]. Similarly, GEP require regulatory translation into actionable programs such as circular production systems and environmental incentives [3, 9]. TFW initiatives, in turn, depend on policy mediation to achieve scale, standardization, and market integration [11, 39].

From a practical perspective, integrated policy mechanisms play a decisive role in enabling fish waste valorization. Fish waste can be transformed into high-value products such as biofuels, bioplastics, nutraceuticals, animal feed, and biomedical materials, contributing to both environmental sustainability and economic growth [8, 40]. However, successful implementation depends on enabling policies, including regulatory frameworks promoting circular economy practices, public-private partnerships, technological support, and economic incentives [11, 24]. Local governments also play a crucial role in fostering stakeholder collaboration and grassroots innovation, which enhances policy legitimacy and sustainability [17, 21].

Despite its potential, fish waste valorization faces key challenges, including high capital costs, fragmented governance, regulatory inconsistencies, and technological limitations that constrain large-scale implementation [23, 39]. Overcoming these barriers requires coherent policies, sustained investment, and inclusive governance. At the same time, advances in technology, circular bioeconomy approaches, and job creation highlight significant opportunities [4, 11]. The findings indicate that differences with prior studies reflect varying institutional maturity and market readiness, emphasizing that IPM are crucial for translating local wisdom and sustainability practices into tangible economic outcomes.

6. CONCLUSIONS

This study suggests that integrating FLW, GEP, and the TFW is strongly associated with the development of an IPM in coastal areas. While local wisdom, GEP, and TFW alone do not show direct associations with SFB, they show significant indirect associations when operating through IPM. This indicates that policy integration appears to be an important mechanism for linking traditional knowledge, sustainability principles, and technical innovation with economic, social, and environmental outcomes. Integrated policies are strongly associated with the development of value-added fisheries products, coordination, access to resources, market facilitation, and the promotion of sustainable practices.

Practically, these findings highlight the importance of synergy among local communities, business actors, and government institutions in developing a GEP based on fish waste. By fostering collaboration and providing regulatory, technical, and institutional support, integrated policies are associated with enabling innovative, sustainable, and marketable products that are linked to community income, environmental protection, and social welfare.

This study has several limitations, including its focus on only three sub-districts in Cirebon, which limits generalizability, a cross-sectional design that cannot capture long-term behavioral changes, reliance on respondents' perceptions that may introduce bias, and exclusion of variables such as institutional capacity, global market support, and digital technology. Future research could expand to other coastal regions, adopt longitudinal and mixed-method approaches, incorporate multi-source data, and include additional variables such as technological innovation and global policies. Despite these limitations, the study contributes to the literature by highlighting the integration of local wisdom within the GEP and offers practical guidance for managing fish waste into value-added products.

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