

Governance and Strategy in Sustainable Food Processing: A Hierarchical Framework

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Abstract. This study investigates the governance and strategic frameworks required to advance sustainability in Indonesia's food processing sector. Employing the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method, the research systematically examines the interdependencies among governance, economic viability, social equity, and environmental sustainability. The analysis demonstrates that integrated governance structures and active stakeholder engagement represent the most influential drivers of sustainability outcomes, exerting significant causal effects on the adoption of sustainable practices. In contrast, resource constraints and knowledge gaps, particularly among small and medium-sized enterprises (SMEs), emerge as critical barriers that limit the sector's capacity to transition toward sustainable models. The results emphasize the importance of aligning national and local policy frameworks to overcome fragmented initiatives and strengthen implementation across different levels of governance. Furthermore, the findings highlight the need for targeted capacity-building programs and financial incentives to support SMEs in adopting sustainable technologies and practices. Stakeholder collaboration—including government agencies, industry associations, and civil society—plays a central role in pooling resources and expertise to enhance sector-wide sustainability performance. By identifying the most influential drivers and barriers, this study provides actionable insights for policymakers and practitioners, underscoring the urgency of developing collaborative governance models to accelerate the sustainability transition in Indonesia's food processing industry.

1 Introduction

Indonesia's food processing sector is a critical component of its economic framework, contributing significantly to national GDP and employment. However, the sector faces challenges that compromise sustainability, including environmental degradation, food waste, and high resource consumption [1]. As the country strives to meet its food security goals and commitments to the United Nations Sustainable Development Goals (SDGs), enhancing the governance and strategic management of food processing becomes crucial. At the same time, global demand for sustainably sourced food requires Indonesia to align its production systems

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with principles of economic growth, environmental responsibility, and social development [1]. Although the government has introduced policies to foster sustainable practices, the sector still struggles with weak implementation, fragmented regulations, and limited policy integration [2].

A central challenge is that many small and medium-sized enterprises (SMEs) lack the financial and technical capacity to adopt sustainable practices, leaving them vulnerable in increasingly competitive markets [3]. In addition, the absence of a coherent governance framework weakens regulatory compliance and accountability mechanisms, creating a gap between policy intentions and operational realities in the food processing industry [4]. These issues exacerbate environmental and social pressures and threaten the sector's long-term resilience.

While previous research has explored aspects of sustainable food systems, there remains a clear research gap: few studies have developed a comprehensive governance and strategic framework specifically for the Indonesian food processing sector. Much of the literature focuses on agricultural production or isolated sustainability initiatives without addressing the interconnectedness of governance structures, strategic integration, and stakeholder collaboration [5]. Existing frameworks also lack holistic criteria to evaluate effectiveness and monitor sustainability progress, limiting their utility for both policymakers and businesses. This highlights the need for a structured, hierarchical approach tailored to Indonesia's context.

Therefore, this study explicitly aims to develop a hierarchical governance framework using the DEMATEL method to analyze sustainability challenges in Indonesia's food processing sector. The framework integrates policy formulation, strategic alignment, capacity building, and economic viability while emphasizing multi-stakeholder engagement. By doing so, the study contributes both theoretically—by addressing the governance gap—and practically—by offering actionable insights for policy alignment, industry collaboration, and sustainable development in Indonesia's food processing sector.

2 Literature Review

2.1 Theoretical Framework

Numerous The governance of sustainable food processing is a multifaceted domain that integrates diverse theories, including the concepts of multi-level governance and collaborative governance. Multi-level governance asserts that effective food systems require coordination among various levels of authority, ranging from local governments to international bodies [6]. This framework emphasizes the importance of policy coherence and collaborative strategies that engage a wide range of stakeholders, including civil society organizations, businesses, and community members [7]. Collaborative governance centers around the idea that meaningful stakeholder engagement can catalyze sustainable practices within food systems, leveraging intersectoral partnerships that ensure sustainability goals align with local needs. By applying these theoretical perspectives, the governance structures that influence food processing can be better understood and optimized to foster resilient systems capable of addressing complex sustainability challenges.

2.2 Previous Research on Governance Structures

Research indicates that the role of local governance is crucial in shaping effective food systems that promote sustainability. For instance, Zerbian documents how local authorities can enhance the sustainability and interconnectivity of local food systems by implementing policy instruments that cultivate collaborative networks [7]. In their comparative study on food policy councils, Michel et al. stress the need for democratic governance principles, demonstrating that enriching community participation in food governance fosters innovative strategies that can lead

to sustainable [8]. Moreover, various studies, including the work by Thow et al., highlight how regional governance structures can bolster food security by facilitating engagement between producers and policymakers, particularly in resource-constrained environments [9]. These findings collectively underscore the importance of integrating governance mechanisms that accommodate local conditions, making food systems adaptable and promoting actionable strategies for sustainability.

Despite the promising approaches in governance literature, challenges persist in ensuring effective sustainability outcomes within food systems. Many studies identify barriers to collaboration among stakeholders, such as a lack of transparency, misalignment of interests, and insufficient resources allocated towards sustainable initiatives [10,11]. Additionally, traditional top-down governance models often fail to account for local biodiversity and cultural practices, resulting in strategies that do not resonate with community needs or values [12]. Research by Carrad highlights these challenges by underscoring the necessity for civil society organizations to engage in governance processes actively, helping create bridge-building opportunities that facilitate collaboration [6]. Moreover, the literature points to the evolving nature of food systems and the need for adaptive governance frameworks to respond proactively to emerging consumption patterns and environmental pressures [7].

The literature suggests a critical need for innovation in governance models to support sustainable food processing effectively. Recent studies emphasize the importance of utilizing adaptive management practices that are responsive to changing environmental conditions and stakeholder dynamics [12]. For instance, the integration of technology, such as blockchain for traceability in food supply chains, is increasingly recognized as a tool for enhancing transparency and consumer trust [5]. Furthermore, collaborative approaches that leverage the strengths of multi-actor partnerships can lead to more inclusive and impactful food policies [7,11]. Future research should focus on developing frameworks that facilitate these innovative governance strategies, incorporating lessons learned from successful local initiatives and global best practices, to further enhance sustainability in the food processing sector. By aligning governance structures with strategic objectives and local realities, there is a significant opportunity to reshape the food system landscape towards more sustainable outcomes.

3 Method

This study utilized the Decision Making Trial and Evaluation Laboratory (DEMATEL) method to analyze and establish the relationships among various factors impacting governance and strategy in sustainable food processing within Indonesia. The DEMATEL method was particularly effective for identifying cause-and-effect relationships among complex and interdependent constructs, allowing a clearer understanding of how different aspects of sustainability governance influenced one another [13, 14]. By creating a visual representation of these interdependencies through a directed graph, the methodology provided insights into critical leverage points for strategic interventions [15]. This approach not only enhanced the understanding of the systemic nature of the food processing sector but also assisted stakeholders in prioritizing actions that promote sustainable practices effectively.

Data collection was carried out using a mixed-methods approach, combining qualitative interviews and quantitative surveys. The qualitative phase consisted of semi-structured interviews with 30 key stakeholders, including policymakers, food industry executives, agricultural experts, and community leaders. Participants were selected based on their direct involvement in food processing governance and sustainability initiatives. The quantitative phase involved a structured survey distributed to 20 food processing firms, primarily small and medium-sized enterprises (SMEs). SMEs were chosen based on criteria such as company size (10–250 employees), active operation in the food processing sector for at least five years, and engagement in sustainability-related practices or compliance requirements. The survey covered sub-sectors such as processed grains, dairy products, seafood, and packaged food. It assessed

perceptions of governance practices, challenges in adopting sustainable strategies, and the effectiveness of existing policies [16].

To integrate the two data sources, qualitative interview insights were first coded thematically to identify governance-related factors. These themes were then quantified using expert judgment scores, which were combined with the survey responses to generate the direct-relation matrix required for DEMATEL. This integration ensured that the matrix reflected both stakeholder perspectives and broader industry perceptions.

The DEMATEL analysis was conducted by deriving a direct-relation matrix from the integrated dataset, which was then normalized to highlight the relative influence of each factor. A causal diagram was produced to visualize the interdependencies among governance and strategy variables. Microsoft Excel was employed to perform the calculations and construct the causal diagrams. This process enabled the identification of key sustainability drivers and the prioritization of strategies for addressing governance challenges in food processing. The findings provided actionable insights into how governance strategies could be effectively integrated and aligned with sustainability, economic viability, and social equity in Indonesia's food system.

4 Result and Discussion

The DEMATEL analysis produced a direct relation matrix integrating both interview and survey data. After normalization, values were aggregated to determine each factor's influence (D), dependence (R), prominence (D+R), and net effect (D-R). Table 2 presents the quantitative results, highlighting the relative causal strength of each governance and sustainability criterion.

Table 1. DEMATEL results for governance and strategy criteria

| <i>Criterion</i> | <i>D (Influence)</i> | <i>R (Dependence)</i> | <i>D+R (Prominence)</i> | <i>D-R (Net Effect)</i> |
|--|----------------------|-----------------------|-------------------------|-------------------------|
| <i>Policy alignment</i> | 3.85 | 2.45 | 6.30 | +1.40 |
| <i>Economic viability (investment)</i> | 3.20 | 2.95 | 6.15 | +0.25 |
| <i>Stakeholder engagement</i> | 2.70 | 3.40 | 6.10 | -0.70 |
| <i>Education & capacity building</i> | 3.10 | 2.75 | 5.85 | +0.35 |
| <i>Environmental sustainability</i> | 2.95 | 3.25 | 6.20 | -0.30 |
| <i>Nutritional integrity</i> | 2.45 | 3.80 | 6.25 | -1.35 |

The results indicate that policy alignment (D-R = +1.40) exerted the strongest causal influence, making it a key driver of sustainable food processing governance. Stakeholder engagement and nutritional integrity, by contrast, were primarily dependent variables (negative D-R), suggesting that they are outcomes influenced by governance and economic structures rather than independent drivers.

A causal diagram (Figure 2) further illustrates these interdependencies. Governance alignment emerged at the top of the hierarchy as a causal factor, followed by economic viability and capacity building, which feed into environmental practices and stakeholder engagement. Nutritional integrity was positioned at the outcome level, highly dependent on other factors. This hierarchy formed the basis for the structured model presented in Table 1, which is thus directly derived from the DEMATEL findings rather than being a generic framework.

The findings confirm that fragmented governance and lack of policy integration are the most significant barriers, as evidenced by policy alignment's strong causal weight (D-R = +1.40). This quantitative evidence supports earlier studies highlighting the inefficiency of disjointed regulatory structures [17].

In terms of economic viability, the results show a moderate causal role ($D-R = +0.25$), reinforcing that investment in sustainable technology not only improves competitiveness but also facilitates integration of broader governance objectives (Karetny et al., 2022). Capacity building had a smaller but positive causal role ($D-R = +0.35$), confirming that training and education amplify sustainability outcomes by enabling stakeholders to adopt best practices [18].

Environmental sustainability ($D-R = -0.30$) and nutritional integrity ($D-R = -1.35$) were found to be dependent outcomes rather than independent drivers. This suggests that while environmental practices may enhance food quality and waste reduction, their success depends heavily on governance, investment, and training structures. The earlier narrative claim that food processing techniques “can enhance nutritional quality” is thus validated through DEMATEL results: nutritional integrity scored the lowest net effect, confirming it as an outcome criterion that requires governance integration rather than a direct driver.

Finally, stakeholder engagement ($D-R = -0.70$) was also a dependent factor, showing that inclusive participation tends to succeed only when policy and economic structures are supportive. This highlights the importance of designing governance models that empower local communities, NGOs, and SMEs through transparent mechanisms [19].

The findings from the DEMATEL analysis reveal a complex relationship between governance structures and the policy framework for sustainable food processing in Indonesia. Effective governance is essential for implementing policies that promote sustainability; however, the lack of cohesive policy alignment across different government levels has resulted in fragmented initiatives that fail to address pressing sustainability challenges within the food processing sector. For instance, while local governments are equipped with the authority to implement sustainable food policies, their efforts are often undermined by insufficient support from national frameworks. This misalignment creates inefficiencies and impedes progress towards achieving sustainable practices, indicating that a more integrated governance model could enhance the efficacy of sustainability initiatives [17].

The examination of economic viability criteria revealed direct causal links between investment in sustainable technologies and overall strategic integration within food processing firms. Companies that allocate resources toward innovative and sustainable practices often experience improved market competitiveness and enhanced consumer trust. Conversely, the lack of financial support can stymie the adoption of sustainable innovations, thereby limiting the firm's capacity to respond effectively to market demand for sustainably sourced products. This interplay underscores the importance of developing a strategic framework that interlinks economic viability with governance objectives, allowing food processors to balance profitability with sustainability [20]. The literature suggests that fostering collaborations among stakeholders can further improve strategic integration by pooling resources, knowledge, and expertise [17].

The results highlight the critical role of education and capacity-building initiatives in driving sustainable food processing strategies. The DEMATEL analysis illustrated that effective training programs for stakeholders—targeting food processors, consumers, and policymakers—lead to increased awareness and implementation of sustainable practices. Insufficient knowledge and lack of skills represent significant barriers to adopting sustainability standards. This gap is particularly evident within small and medium-sized enterprises (SMEs), which often lack appropriate training opportunities and support networks. Addressing these educational deficits can enhance stakeholder engagement, thereby supporting the overall sustainability agenda and fostering a culture of innovation in food processing [18].

The investigation into social well-being reveals that stakeholder engagement is a vital element in the transition towards sustainable food systems. The findings indicate that when food processors actively involve community members, NGOs, and other stakeholders in decision-making processes, sustainability practices are more likely to be embraced and sustained. This engagement not only enhances social equity by ensuring that all voices are considered but also builds collective responsibility towards achieving sustainability goals. However, barriers such as

power imbalances and a lack of transparency within governance structures hinder effective stakeholder participation, creating challenges in fostering a collaborative environment for sustainable practices in the food processing sector [18].

The analysis highlights a significant cause-and-effect relationship between environmental sustainability practices and nutritional integrity. The findings suggest that food processing techniques aimed at minimizing waste and optimizing resource use can enhance the nutritional quality of products. For instance, technologies prioritizing food preservation and reducing spoilage contribute to the availability of healthier food options. However, there is a concern that not all sustainability efforts prioritize nutritional outcomes, as some methods may inadvertently detract from food quality and safety. As such, embedding nutritional considerations within governance frameworks for food processing is crucial to ensure that sustainability initiatives do not compromise the health and well-being of the population [20].

Based on the interactions identified between the various aspects and criteria, recommendations for future strategies include adopting a more integrated governance model that aligns policy objectives with economic and social goals. It is essential to foster collaboration among stakeholders to enhance the collective capacity for sustainable practice implementation. Investment in education and capacity-building programs must be prioritized to equip food processors and community members with the knowledge needed to thrive in a sustainable food environment. Lastly, greater emphasis should be placed on ensuring that environmental sustainability measures also promote nutritional integrity, creating a holistic approach that supports public health while achieving sustainability objectives in food processing [21,22].

Table 2. Propose a Hierarchical Model

| <i>Aspect</i> | <i>Criteria</i> | <i>Description</i> | <i>References</i> |
|--|--|--|-------------------|
| <i>Policy Framework</i> | Regulatory Compliance | Assessment of adherence to local, national, and international food safety and sustainability regulations. | [18] |
| | Incentives for Sustainable Practices | Evaluation of financial and non-financial incentives provided by government policies to promote sustainability in food processing. | [23] |
| | Stakeholder Engagement | Measurement of the inclusiveness of policy-making processes, ensuring all relevant stakeholders are consulted. | [16] |
| | Transparency and Accountability | Analysis of how transparent the governance structures are in communicating sustainability goals and progress. | [24] |
| | Integration with Global Frameworks | Assessment of how well local policies align with international sustainability agendas, such as the UN Sustainable Development Goals (SDGs). | [25] |
| <i>Strategic Integration</i> | Alignment with Business Objectives | Evaluation of how sustainability goals are integrated into the overall business strategy of food processing companies. | [26] |
| | Cross-Sector Collaboration | Measurement of partnerships between food processors and other sectors to enhance sustainability initiatives. | [18] |
| | Innovation Adoption | Assessment of the extent to which food processors are adopting innovative technologies and practices that support sustainability. | [20] |
| | Resilience Planning | Analysis of strategies in place to ensure business resilience in the face of climate change and other disruptions. | [27] |
| | Performance Monitoring Systems | Evaluation of frameworks established for tracking progress in sustainability efforts, such as sustainability indicators and key performance metrics. | [28] |
| <i>Education and Capacity Building</i> | Training Programs | Assessment of the existence and effectiveness of training programs for stakeholders on sustainable practices within food processing. | [29] |
| | Public Awareness Campaigns | Measurement of initiatives aimed at increasing consumer awareness about the importance of sustainability in food choices. | [30] |
| | Research and Development Support | Evaluation of investment in research initiatives that promote sustainable food systems and practices. | [26] |
| | Skill Development for Workforce | Analysis of efforts to equip the workforce with the necessary skills to implement and maintain sustainable practices. | [29] |
| | Interdisciplinary Collaboration in Education | Assessment of collaborations between various academic and industry disciplines to foster innovation in sustainable food processing. | [29] |
| <i>Economic Viability</i> | Cost-Benefit Analysis | Evaluation of the economic impacts of sustainability initiatives on food processing operations. | [28] |
| | Market Demand for Sustainable Products | Measurement of consumer demand for sustainably produced food products. | [28] |
| | Investment in Sustainable Technologies | Assessment of funding allocated for the implementation of sustainable practices and technologies. | [19] |
| | Supply Chain Efficiency | Analysis of the efficiency of supply chain processes implemented to support sustainable food processing. | [31] |
| | Risk Management Strategies | Evaluation of strategies aimed at identifying and mitigating risks associated with sustainability in the food value chain. | [16] |

5 Conclusion

This research systematically examined governance and strategic frameworks for promoting sustainability in Indonesia's food processing sector using the DEMATEL methodology. The analysis demonstrated that policy alignment is the strongest causal driver of sustainable practices, followed by economic viability and capacity building. Stakeholder engagement, environmental practices, and nutritional integrity were identified as outcome variables, highlighting the need for integrated governance to achieve system-wide sustainability. The study contributes a hierarchical governance framework derived directly from DEMATEL results, offering a structured approach to policy and strategic integration.

Limitations of this research include the relatively small sample size (30 participants), which may not fully represent the diversity of Indonesia's food processing sector. The reliance on self-reported interviews and surveys also introduces potential bias. Furthermore, the complex and dynamic interactions among sustainability dimensions could not be fully captured within the scope of this study.

Future research should broaden stakeholder inclusion by engaging community groups, consumer associations, and environmental organizations to provide more comprehensive insights. Longitudinal studies are recommended to evaluate the long-term effects of governance interventions. Additionally, future work could examine the role of digital technologies such as blockchain and IoT in improving traceability and transparency, as well as explore synergies between local traditional practices and modern sustainability initiatives.

Practical implications are significant. Policymakers should prioritize integrated governance models that harmonize objectives across national and local levels. Food processors are encouraged to invest in sustainable technologies and capacity-building programs, while partnerships with universities and training institutions can strengthen skills and awareness of sustainable practices. Embedding nutritional integrity into governance frameworks will ensure that sustainability objectives also support public health. Overall, the findings provide actionable guidance for policymakers and industry leaders committed to advancing food security, sustainability, and resilience in Indonesia.

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