



Unveiling Invisible Stakeholders in Seaweed Supply Chains and Their Strategic Influence on Coastal Economic Resilience

Roni Adi^{1*}, Ratna Koba Susanti², Ilham Yahya³, Jarot Santosa⁴, Aji Suraji⁵

¹Institut Teknologi Batam, Indonesia

²Universitas Abdurachman Saleh Situbondo, Indonesia

³Universitas Bosowa, Indonesia

⁴Universitas Dharma AUB Surakarta, Indonesia

⁵Universitas Widya Gama Malang, Indonesia

Corresponding Author: Roni Adi, roni@iteba.ac.id

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ABSTRACT

Coastal seaweed supply chains are often examined through visible formal actors, overlooking the strategic roles of invisible stakeholders in sustaining local economic resilience. This qualitative case study was conducted in three Indonesian coastal villages with 24 purposively selected informants, including farmers, intermediaries, and community leaders. Data were collected through in-depth interviews, participatory observations, and field documentation, then analyzed using actor and thematic network analysis. Informal actors were found to stabilize distribution flows, reduce farmers' economic risks, and develop adaptive systems rooted in social trust, absent in formal market structures. The study broadens supply chain perspectives and highlights the need for inclusive, socially grounded strategies in sustainable coastal development policy.

INTRODUCTION

Seaweed commodities have long been recognized as one of the economic backbones for coastal communities in Indonesia, not only as a source of income but also as a foundation for sustaining livelihoods and strengthening food security in maritime regions. As the world's second-largest seaweed producer, Indonesia contributes more than 38% of total global production, with major cultivation centers located in eastern regions such as South Sulawesi, Nusa Tenggara, and Maluku (FAO, 2022). This strategic position places seaweed not only as a national economic asset but also as a driver of Indonesia's role in global agro-maritime trade networks. Seaweed is not merely valued as a raw export commodity; it also plays an increasingly significant role in the development of industries related to food, pharmaceuticals, bioenergy, and sustainable packaging, thereby aligning with the global agenda for the development of renewable resources and green economy transitions (Lai, 2024; Msuya et al, 2024).

However, despite its substantial role in both export activities and local economic growth, the Indonesian seaweed supply chain continues to reflect marked imbalances and structural disparities. Existing studies and policy discourses tend to emphasize the roles of formal actors—such as cultivators, large-scale traders, exporters, financial institutions, and government authorities—while giving limited attention to informal participants, including small local intermediaries, women-led household enterprises, and community-based social networks (Jentoft & Eide, 2021; Fabinyi et al., 2020). As a result, the overall structure of the supply chain remains fragmented, with value-added gains distributed unevenly and the bargaining power of marginalized groups, particularly small-scale farmers and informal laborers, remaining significantly constrained.

The exclusion of these informal actors from mainstream analysis is problematic, as they often play a crucial intermediary role in ensuring the circulation of seaweed from production to markets. Local collectors, for example, act as essential connectors between farmers and larger distribution networks, while women in coastal households frequently engage in post-harvest handling, sorting, and drying activities that directly influence product quality and market value. Moreover, these social nodes also embody local knowledge, trust-based transactions, and resilience mechanisms that formal structures often fail to capture. Therefore, understanding the seaweed supply chain from a more inclusive perspective—one that integrates both formal and informal stakeholders—is vital to designing fairer, more sustainable, and more resilient coastal development strategies.

In fact, in practice, this informal network plays a vital role in maintaining supply continuity, regulating the flow of price information, and supporting the resilience of fishermen and seaweed farmers households amid market fluctuations and climate challenges. Research by Amin et al. (2022) confirms that small-scale marine economies in Indonesia are highly dependent on informal relationships based on trust and social capital, especially in the process of distributing marine products and mitigating risks. Similarly, a study by Lau et

al. (2021) shows that the existence of informal actors acts as an adaptive buffer against structural pressures such as the climate crisis, logistics disruptions, and market uncertainty. However, until now, there have not been many studies that explicitly raise the role and strategic dynamics of these invisible stakeholders in the context of the seaweed supply chain in a comprehensive and field-based manner.

Most previous studies, such as Sari et al. (2023) and Utomo & Riani (2022), have only mapped the structure of product flows and economic relationships between actors, but have not highlighted how informal social networks contribute to the economic resilience of coastal communities. In addition, the approach used tends to be linear and technocratic, assuming that logistics optimization and market efficiency will automatically improve the welfare of producers. In fact, this approach risks forgetting the social, cultural, and adaptive dimensions that are the main strengths of coastal communities in surviving disruption. This indicates a research gap in understanding the seaweed supply chain not only as a formal economic system, but also as a complex adaptive social network.

Based on this background, this study aims to uncover the strategic role of informal actors in the seaweed supply chain in Indonesia's coastal regions, focusing on how they contribute to maintaining distribution stability, strengthening community adaptive systems, and creating forms of local economic resilience that are not reflected in formal market structures. Through a qualitative approach and case studies in three coastal villages, this study also intends to map informal social networks as well as analyze how social capital, trust, and informal relationships are used as a mechanism for distribution and risk management.

Theoretically, this research contributes to expanding the perspective of supply chain analysis by integrating circular economy approaches and social networks, which have been under-appreciated in the marine economics and coastal development literature. This research also enriches the discourse on informal governance and local adaptation in the rural commodity supply system. Meanwhile, practically, the findings of this study are expected to be an evidence base in the formulation of coastal development policies that are more inclusive, participatory, and based on local social contexts. Policies that are able to accommodate informal actors will be more sustainable and effective in facing economic, social, and ecological challenges in the future.

THEORETICAL REVIEW

The supply chain of coastal commodities, especially seaweed, has become the focus of attention in the study of rural economic development and sustainable fisheries, especially because of its role in providing livelihoods, creating local jobs, and supporting Indonesia's non-oil and gas exports. However, most academic approaches and public policy still view this system in a limited way, through a market-oriented formalistic lens. Previous studies have generally highlighted the relationship between farmers, large collectors, and exporters as the main node in the supply chain, thus tending to ignore the role of informal

actors that are invisible in the institutional structure, but instead play a vital function in maintaining the stability of distribution systems and local economic adaptation (Fabinyi et al., 2020; Jentoft & Eide, 2021).

In the Indonesian context, the management of seaweed commodities still faces challenges in terms of inequality of market access, price fluctuations, and vulnerability to climate change. Research by Amin et al. (2022) shows that the economic resilience of seaweed farmers in eastern Indonesia is highly dependent on informal local social networks, such as traditional intermediaries and household economic actors. These actors are often not recorded in formal structures, but have a strategic position as guarantors of market information, micro capital providers, and supporters of community trust systems in the distribution and management of crops. However, their role has not been studied in depth in the available literature.

Several studies such as Sari et al. (2023) and Utomo & Riani (2022) have indeed begun to raise the importance of social networks in the seaweed value chain, but the approach used is still descriptive-structural, and has not explored contextually how these informal roles contribute to local adaptation mechanisms and coastal economic sustainability. The study of Lau et al. (2021) also states that the absence of informal actors in the formulation of coastal resource management policies risks creating a mismatch between program interventions and the socio-economic realities of local communities. This reinforces the urgency to understand more deeply the role of invisible actors in the marine economic system.

On the other hand, the dominant methodological approach in seaweed supply chain studies is often quantitative-econometric with a focus on logistics efficiency, production volume, and profit margins between actors (Fabinyi et al., 2020). This approach tends to ignore social aspects such as social capital, trust, and community attachment, even though these aspects serve as informal mechanisms in maintaining the sustainability of distribution amid limited access to formal systems. Studies based on in-depth qualitative approaches, such as those conducted by Jentoft & Eide (2021), suggest a more complex rereading of supply chain governance based on inclusivity and social relations.

By Raising Awareness Following the results of previous studies, this study offers an alternative approach that places informal actors as strategic nodes in the economic adaptation system of coastal communities. Through a network of actors and thematic analysis based on case studies at the local level, this study answers gaps in the literature by mapping the relational dynamics, social roles, and adaptive forces of invisible stakeholders in supporting the sustainability of the seaweed supply chain. The results of this study are expected to make a theoretical contribution to the development of a social network-based supply chain perspective as well as a practical contribution to the formulation of more inclusive and sustainable coastal development policies.

METHODOLOGY

This study uses a qualitative-descriptive approach with an exploratory case study design based on actor and thematic network analysis, in order to

deeply understand the strategic role of informal actors in the seaweed supply chain in coastal areas. The qualitative approach was chosen because it allows researchers to contextually explore the meaning, social relations, and dynamics of the local economy that cannot be quantitatively measured but have a substantial influence on the economic resilience of the community (Jentoft & Eide, 2021). Descriptive design aims to describe socio-economic phenomena systematically without variable manipulation, while case studies allow for an in-depth exploration of the unique local context of each research site (Creswell & Poth, 2018).

The population in this study includes all actors in the seaweed supply chain in three coastal villages in South Sulawesi and East Nusa Tenggara Provinces, which were selected purposively based on the criteria of seaweed production intensity, the existence of informal social networks, and local trade dynamics. A total of 24 key informants were involved in this study, consisting of seaweed farmers, collectors, community leaders, informal intermediaries, and village officials. The selection of informants was carried out using the snowball sampling technique in order to be able to reach invisible actors who play an important but structurally hidden role.

Data were collected through three main techniques, namely semi-structured in-depth interviews, participatory observations, and field documentation. The interviews were directed to explore information related to the socio-economic role of informal actors, seaweed distribution flows, price negotiation mechanisms, and local trust networks. The interview instrument was compiled by adapting indicators from the study of Fabinyi et al. (2020) and Amin et al. (2022), which were previously used to research community-based supply networks in coastal areas of Southeast Asia. Participatory observations were conducted for 12 days at each location to understand the social processes directly, including harvesting activities, informal transactions, and gender roles in household economic activities. Documentation in the form of photographs, field notes, and economic artifacts is used as a complement to strengthen data triangulation.

Validity testing is carried out through triangulation of sources, methods, and theories. The content validity of the interview guide was obtained through input from two marine socio-economic experts and one fisheries policy researcher from a state university. To increase the reliability of data interpretation, a member-checking technique was used to some informants to ensure that the narrative compiled was in accordance with their experiences and perceptions. In addition, peer debriefing was also carried out by involving two peer researchers as discussion partners during the thematic analysis process.

The research procedure begins with the exploration and mapping stage of actors through field observation, followed by in-depth data mining through interviews, and thematic analysis and actor networks. Data were analyzed with a themaculous-inductive approach to identify patterns of meaning from interview transcripts, using the help of NVivo software version 12. The coding is done openly and is categorized into key themes such as "social trust", "informal

mechanisms of distribution", "gender roles in transactions", and "economic risk mitigation".

In addition, data on relationships between actors is constructed in the form of social networks using a relationship matrix, which is then visualized through Gephi to map the strategic positions of invisible stakeholders. Each node and relationship (edge) is analyzed to determine the level of connectivity, influence, and centrality of informal actors in maintaining the stability of the supply chain system. This visualization reinforces the understanding of hidden structures that are not visible in formal value chain maps.

The results of this analysis are then interpreted narratively and contextually by taking into account local social, economic, and cultural conditions. Such qualitative data not only explains "who does what", but also "why and how" informal roles are formed and maintained in the dynamics of coastal economies.

RESEARCH RESULTS

This research resulted in important findings that reveal hidden structures in the seaweed supply chain in three coastal villages in Indonesia. Based on the results of field observations, in-depth interviews with 24 key informants, as well as analysis of actor and thematic networks, data were obtained that informal stakeholders play a strategic role in supporting distribution resilience and the sustainability of local economies.

Categories and Roles of Invisible Actors

The findings of this study indicate that informal actors within the seaweed supply chain in Indonesia can be classified into three dominant categories: (1) local intermediaries, (2) household economic actors – particularly women, and (3) community-based social networks. Each of these categories contributes significantly to ensuring the continuity of the supply chain, not only through direct involvement in distribution and post-harvest processing but also through the provision of adaptive mechanisms for risk management and socio-economic resilience.

First, local intermediaries occupy a pivotal position as connectors between smallholder farmers and larger market actors such as regional collectors and exporters. Their role is not limited to purchasing and aggregating seaweed but also includes providing liquidity through short-term credit, advancing cash payments before harvest, and offering logistical support during distribution bottlenecks. Local intermediaries often operate with a high degree of trust-based reciprocity, where transactions are built on long-standing relationships with farmers rather than formal contracts. This embedded trust allows them to function as flexible buffers, absorbing shocks from sudden price fluctuations or transportation delays. By bridging the gap between grassroots producers and formal markets, these actors serve as the first safety net in maintaining the stability of the local seaweed economy.

Second, household economic actors, particularly women, form an essential yet often invisible pillar of the seaweed supply chain. Women in coastal households typically engage in labor-intensive post-harvest activities such as

drying, sorting, and quality control, which determine the market value of seaweed. Beyond these technical tasks, women also manage household-level financial flows, allocate resources for education and food security, and engage in micro-entrepreneurial ventures such as small-scale trading or producing value-added seaweed products (e.g., snacks, cosmetics, or local crafts). Their contribution ensures not only the economic sustainability of households but also the intergenerational transfer of knowledge and resilience strategies. The centrality of women’s role highlights the gendered dimension of informal economies, where unpaid or underrecognized labor significantly underpins the functioning of global value chains.

Third, community social networks play an indispensable role in risk management and collective action. These networks, rooted in local cultural norms of solidarity, mutual assistance, and cooperation, are activated especially during times of crisis such as extreme weather events, transportation breakdowns, or delays in seaweed pick-up by exporters. For instance, when formal logistics systems fail due to stormy seas, community members often mobilize collectively to rent vehicles or share storage spaces, thereby preventing product spoilage and loss of income. Beyond practical functions, these networks also serve as information hubs where knowledge on market prices, seasonal forecasts, and new cultivation techniques is exchanged informally. Such horizontal flows of information reduce uncertainty and enable farmers and small-scale actors to adapt quickly to external shocks.

Taken together, these three categories of informal actors illustrate that the resilience of the seaweed supply chain is not merely a function of formal market mechanisms but is deeply rooted in localized social structures. Their interdependent roles—ranging from market intermediation and household financial management to collective coping strategies—constitute a complementary system that sustains both the economic and social fabric of coastal communities. This underscores the importance of acknowledging informal actors not as peripheral participants but as central pillars of coastal economic resilience, whose contributions warrant recognition in policy design, academic research, and development interventions.

Table 1. Categories of Informal Actors and Their Role in the Supply Chain

Category: Actor	Main Functions	Social Capital	Forms of Interaction
Local intermediaries	Bridging farmers and collectors	Trust and experience	Informal daily transactions
Domestic actors	Seaweed drying and packing	Family workforce	Economic domestic activity
Community network	Logistics support during market disruptions	Social solidarity	Arisan, gotong royong

Adaptive Response to External Disturbances

Informal mechanisms within the seaweed supply chain have shown remarkable resilience in responding to systemic disruptions such as delays in transportation fleets, fluctuations in international and domestic prices, or the impact of extreme weather events. Unlike formal structures that often depend on rigid schedules, bureaucratic procedures, or external capital flows, informal community-based networks tend to operate with a higher degree of flexibility and adaptability. For instance, in situations where exporters are unable to collect harvested seaweed due to storms or prolonged rainfall that hinder access to coastal villages, local social networks often step in by mobilizing emergency solutions. One common strategy is the collective rental of small-scale vehicles or boats, financed through mutual contributions from community members. This allows the harvested seaweed to be transported on time to local collectors or drying facilities, thereby reducing the risk of product spoilage and mitigating potential income losses.

More importantly, these informal responses are not only ad-hoc solutions but also reflect embedded social capital that underpins trust, reciprocity, and solidarity among community members. Such practices demonstrate that the resilience of coastal economies does not rest solely on formal institutional arrangements, but also on the capacity of local actors to generate adaptive responses through shared resources and cooperative norms. In this sense, informal mechanisms function as safety nets that buffer small-scale farmers from external shocks, while simultaneously reinforcing social cohesion and local autonomy within the broader seaweed supply chain.

Table 2. Community Adaptation Strategy to External Risks

External Risks	Adaptive Strategy	Economic Impacts Avoided
Extreme rain	Drying in people's homes	Deterioration of crop quality
Prices plummeted	Sales to fixed intermediaries (at the social base price)	Total loss of revenue
Export fleet late	Collective truck rental through social gatherings or community bailouts	Failed to ship to primary market

These responses suggest that informal networks serve not only as a complement to formal systems, but as the main backbone of local resilience. This pattern is in stark contrast to conventional market approaches that are inflexible in responding to unexpected dynamics.

In addition, interviews found that 87.5% of informants considered the presence of local intermediaries to be more helpful than official cooperatives in maintaining smooth distribution. This is due to the flexibility of payments and long-term social relationships that do not depend on written contracts.

Thus, this part of the results suggests that the existence of informal actors cannot be considered as an obstacle to modernization, but rather as a highly functional and relevant social infrastructure, especially in the context of coastal regions that face the limitations of formal institutions and logistical infrastructure.

DISCUSSION

The findings of this study demonstrate the strategic contribution of informal actors in sustaining the resilience of coastal economies, particularly within the seaweed supply chain. The results reveal that the functioning of this supply chain ecosystem does not rely solely on formal actors such as farmers, large-scale collectors, exporters, and state institutions, but equally depends on the often-overlooked role of informal actors. These include small-scale local collectors, women-led household enterprises, neighborhood-based intermediaries, and community social networks that operate with a high degree of flexibility and responsiveness. Their role as adaptive connectors within the system is vital for ensuring the continuity of distribution channels, maintaining the stability of household economies, and mitigating systemic risks that arise from structural inequalities and external shocks (Utomo & Riani, 2022).

This study reinforces the theoretical proposition of “embeddedness” (Granovetter, 1985), which asserts that economic activities cannot be separated from their social structures. The interactions among informal actors in coastal communities are not merely transactional or profit-oriented, but are deeply embedded within local cultural values of solidarity, reciprocity, and mutual trust. These socio-economic linkages facilitate the smooth flow of goods, credit, and information, even in circumstances when formal market systems and institutional infrastructures fail to function effectively. In contrast to the logic of modern market systems that emphasize efficiency, standardization, and scale, informal mechanisms highlight the importance of trust-based relationships, cooperation, and adaptive problem-solving. Such dynamics illustrate that resilience in coastal economies is as much a product of social capital as it is of economic capital (Wardono et al., 2020).

The implications of these findings are significant for coastal development policy. State-led development efforts have historically been focused on modernization, large-scale infrastructure, and market integration, with an emphasis on formal financial institutions and export-oriented growth. However, this narrow orientation risks sidelining the contribution of informal actors who provide adaptive capacity at the grassroots level. If development frameworks continue to undervalue or marginalize these actors, there is a risk of eroding the very resilience that sustains coastal livelihoods. For this reason, development approaches need to be reformulated in ways that are more inclusive and rooted in local social contexts. Policies that acknowledge, integrate, and empower informal networks—rather than displacing them—are more likely to enhance both social sustainability and economic resilience. Intervention models that are participatory, co-designed with local communities, and respectful of indigenous

social structures will create more durable and contextually relevant outcomes compared to top-down modernization efforts.

From a practical perspective, the study suggests that the integration of informal mechanisms into supply chain governance frameworks can function as a safety net to reduce vulnerabilities during times of crisis, such as sudden price volatility or logistical disruptions caused by climate events. Strengthening local cooperative arrangements, women's economic groups, and neighborhood-level collector associations could enhance the distribution of value-added benefits along the supply chain. Furthermore, recognizing the role of social norms and local trust networks provides an opportunity to design hybrid governance systems that bridge formal and informal structures, thereby improving both equity and efficiency in coastal economic development.

Despite its contributions, this study also acknowledges certain limitations. The spatial scope was restricted to selected localities, and the qualitative approach, while rich in contextual depth, does not allow for a quantitative mapping of network strength or actor centrality across wider regions. Moreover, seasonal variations in seaweed production and global price fluctuations were not fully captured during the study's observation period, which may constrain the generalizability of the findings. To address these gaps, future research should integrate software-based Social Network Analysis (SNA) tools such as Gephi or UCINET to quantitatively identify actor positions, interdependencies, and network robustness within the seaweed supply chain. Expanding the analysis to include temporal dimensions—capturing seasonal cycles, inter-annual variations, and price volatility—as well as household-level microeconomic data will provide a more holistic understanding of the resilience dynamics. Comparative studies across different regions of Indonesia, or even across major seaweed-producing countries, could further enrich the global discourse on coastal economic resilience and the role of informal networks.

Overall, this study contributes to both theory and practice by empirically substantiating the central role of informal actors as the hidden yet indispensable scaffolding of Indonesia's seaweed supply chain. By situating these findings within broader debates on embeddedness, resilience, and inclusive development, it calls for a shift in policy and governance paradigms that place local social capacities at the core of sustainable coastal development strategies.

CONCLUSION AND RECOMMENDATION

This research shows that informal actors have an important contribution in maintaining the stability of the seaweed supply chain in coastal areas. Although not formally recognized, they play a role in distribution, post-harvest risk management, and adaptation to external disturbances. The economic activities they carry out depend heavily on social trust and local community networks.

These findings show that informal systems have the capacity to survive and function effectively, especially when formal systems experience bottlenecks. Collective-based adaptive strategies have been proven to be able to reduce economic losses due to risks such as fleet delays or market price fluctuations. The

presence of social networks strengthens the economic resilience of households and communities.

Therefore, it is important for coastal development policies to recognise and empower informal actors as part of the local economic system. An inclusive and social-context-based approach is considered more relevant in strengthening the sustainability of the seaweed sector and the economic resilience of coastal communities in general.

FURTHER STUDY

Future research should explore in greater depth the mechanisms by which informal actors coordinate and adapt within the seaweed supply chain, particularly under varying environmental and market pressures. Comparative studies across different coastal regions could reveal how cultural, social, and institutional contexts influence the effectiveness of informal networks. In addition, longitudinal research would help capture changes in these roles over time, especially in response to policy interventions, climate variability, and global market dynamics. Such studies could provide stronger evidence for designing inclusive coastal development strategies that integrate both formal and informal economic systems.

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