

Sustainable Livelihoods of Coastal MSME Communities in the Tomini Bay Area Gorontalo Province, Indonesia

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Abstract

This study aims to analyze the sustainable livelihoods of coastal MSME actors in the Tomini Bay Area, Gorontalo Province, through the Multiaspect Sustainable Analysis (MSA) approach. A mixed-methods approach with an explanatory design was employed, emphasizing quantitative findings subsequently strengthened by qualitative data to generate more comprehensive and reliable conclusions. The research subjects consisted of coastal MSME actors, local government representatives and relevant stakeholders, totalling 30 experts. Data were collected through observation, interviews, questionnaires and documentation and were analyzed using Exsimpro Software by considering both existing conditions and future conditions. The results indicate that the sustainable livelihoods of coastal MSMEs fall within the good (sustainable) category, demonstrating significant strengths in natural and social capital (very sustainable), alongside adequate support in financial, human and physical capital (sustainable), although these aspects have not yet reached optimal levels. This sustainability is reflected in the utilization of local resources grounded in the Blue Economy concept, inherited technical skills and strong social networks. Nevertheless, challenges persist, particularly concerning digital literacy, business management capacity and dependency on seasonal resources. Based on these findings, multi-stakeholder collaboration is recommended among government institutions, higher education institutions, NGOs, MSME actors and the private sector. Such collaboration should encompass regulatory strengthening, infrastructure development, technopreneurship training, applied research, sustainability education, digital literacy enhancement, product innovation and environmentally friendly investment and ecotourism partnerships. These collective efforts are expected to strengthen the adaptive capacity of coastal communities in responding sustainably to economic and environmental dynamics.

Keywords: Coastal Communities, MSME Actors, Multiaspect Sustainable Analysis, Sustainable Livelihoods, Tomini Bay.

Introduction

Coastal communities have a high dependency on marine resources as their primary means of livelihood for economic sustainability (1). Therefore, to optimize the income and welfare of coastal communities, diversification and business innovation must be achieved through MSMEs that utilize the Blue and Green Economy approach as a foundation for regional development. MSMEs must be managed effectively in accordance with the management concept of POAC, which will result in MSMEs with superior performance, driven by management-led innovation (2, 3). In the context of Indonesia's national development agenda, the 2025–2029 National Medium-Term Development Plan (RPJMN), aligned with the President and Vice President's Asta Cita, emphasizes strengthening

research and innovation ecosystems to advance technology and public welfare. This direction is relevant to maritime-based socio-economic development because it integrates human resource development, science and technology, industrial down streaming and sustainable utilization of marine potential. Strengthening coastal MSMEs therefore supports broader goals of equitable growth, poverty reduction and sustainable regional development. MSME performance represents the outcomes of MSME operations in both financial and non-financial aspects, serving as a key indicator in measuring the effectiveness of economic development strategies based on sustainable livelihoods. Factors such as business strategy, technology utilization,

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government policy, stakeholder engagement and entrepreneurial commitment play vital roles in determining MSME success (4-7). Several studies have demonstrated that business sustainability and technology adoption act as mediating variables that can enhance MSME performance (8, 9). Commodities such as agriculture, livestock and fisheries face distinct challenges in marketing, making digitalization an essential requirement for improving business performance (10, 11). The majority of coastal communities in Tomini Bay, Gorontalo, rely on the fisheries, tourism and MSME sectors as their primary sources of income. However, overreliance on natural resources without proper management can threaten sustainability. Therefore, strategies to enhance sustainable livelihoods and support economic growth and food security require the maximization of MSME roles, particularly when these MSMEs are led by fisherwomen or wives of fishermen (12, 13). This condition shows that coastal households must maintain income continuity while preserving the natural resources on which they depend. MSMEs can provide supplementary income, reduce vulnerability to fluctuations in fishing activities and expand women's participation in local economic development. Sustainable livelihoods have increasingly gained attention in economic and development studies, particularly for coastal communities that depend on natural resources for their economic survival (14, 15). These livelihoods consist of human, social, natural, physical and financial capital, which collectively influence technopreneurship-based commitment, where human capital enhances innovation skills, social capital strengthens business networks, natural capital provides resources, physical capital supports infrastructure and financial capital facilitates technological investment (16, 17).

Technopreneurship is one of the approaches that can be adopted by enterprises for socio-economic development (18, 19), particularly for MSMEs in coastal areas. Technopreneurship enables business actors to utilize technological innovations in optimizing the production, distribution and marketing processes of MSMEs (20, 21). Through technology adoption, MSMEs can reach broader markets, improve operational efficiency and strengthen competitiveness amid global competition (22). However, the implementation of technopreneurship among MSMEs still faces

challenges, such as low digital literacy, limited access to capital and inadequate supporting infrastructure (23, 24). In addition to the technological aspect, technopreneurship-based commitment is also a key factor in supporting MSME performance (25, 26). This commitment encompasses motivation and a proactive attitude in adopting technology, the willingness to continuously learn and innovate, as well as adaptability to market dynamics (27). Commitment grounded in technopreneurship with a strong entrepreneurial orientation has a positive impact on competitiveness and growth (28, 29). In coastal livelihood contexts, Blue Economy principles can be implemented through business practices that use marine resources efficiently, reduce waste, increase product value and maintain ecosystem sustainability. For coastal MSMEs, these practices may include fishery product processing, utilization of by-products, environmentally friendly materials and business diversification based on local potential. Such practices are important because they can improve business efficiency, create more stable income sources, reduce pressure on natural resources and support the long-term sustainability and resilience of coastal community livelihoods.

Despite growing attention to sustainable livelihoods, technology adoption, entrepreneurship and MSME performance, these dimensions are often examined separately. Limited attention has been given to how the five livelihood capitals collectively shape technopreneurship-based commitment and, in turn, MSME performance in coastal communities. This gap is particularly relevant in Tomini Bay, where household resilience depends on the ability to diversify income through productive and technology-enabled enterprises. Therefore, this study positions sustainable livelihood factors as a foundation for strengthening technopreneurship-based commitment and improving coastal MSME performance.

The urgency of this research lies in the fact that fishermen's income remains suboptimal, even though it serves as the main source of household welfare in coastal communities. The presence of MSMEs, many of which are managed by fishermen's wives will contribute positively to the welfare of coastal communities. The fishermen's exchange rate over the past five years has tended

to remain below 100%, indicating that fishermen are relatively less prosperous. Therefore, to maximize fishermen's welfare through the utilization of the blue economy, it is essential to optimize coastal community MSMEs by maintaining entrepreneurial commitment, capitalizing on opportunities in technopreneurship and strengthening sustainable livelihood factors. MSMEs, in this regard, hold significant potential in increasing the income of coastal communities (30). Based on the aforementioned explanation, the research problem formulation can be stated as follows: how sustainable livelihoods of coastal communities' function as MSME actors.

Methodology

Sustainable livelihood refers to community activities encompassing the capabilities, assets and activities required for a means of living that enable people to cope with and recover from pressures arising from existing vulnerability aspects, whether in the form of shocks, trends, or seasonality (31, 32). The indicators of sustainable livelihoods include: (a) human capital, (b) social capital, (c) natural capital, (d) physical capital and (e) financial capital (33, 34).

The coastal area of Tomini Bay in Gorontalo Province was selected because of its high ecological value, its central role in coastal livelihoods and its support for fisheries, seafood processing, trade and local resource-based MSMEs. The area is also institutionally important because coastal management and blue-economy development involve local governments, universities, business actors, communities and other stakeholders. These ecological, socioeconomic and institutional characteristics make Tomini Bay an appropriate setting for examining sustainable coastal livelihoods. Geographically, the study area is located along the Tomini Bay coast, with a representative point at approximately 0.47° N, 123.06° E, within Gorontalo Province, which extends from 0°19'–1°15' N and 121°23'–123°43' E.

An explanatory mixed-methods design was employed because quantitative results alone were insufficient to explain the reasons underlying the identified sustainability patterns. Qualitative evidence was used to deepen, confirm and

contextualize the quantitative findings through respondents' experiences and perspectives. Quantitative instrument validity was examined through item appropriateness assessment, while questionnaire reliability was evaluated using internal consistency testing. Qualitative credibility was ensured through triangulation across interviews, observations, documentation and questionnaire results, together with member checking to confirm the accuracy of interpretations derived from participants' information. In this study, the five livelihood capitals were treated as equally important and assigned equal weights in assessing sustainability at the provincial level.

The subjects of this study consist of coastal communities engaged in business activities, the government and relevant stakeholders, adjusted to the target needs of each subject based on the data analysis to be used. The total of 30 respondents were purposively selected as expert participants based on their knowledge, experience and direct involvement in coastal MSME development and sustainable livelihood issues in the Tomini Bay area, Gorontalo Province. The sample size was considered adequate because the study was designed to obtain informed expert judgments rather than to achieve statistical representativeness of the wider population. Accordingly, respondent selection prioritized expertise, relevance and diversity of stakeholder perspectives. The involvement of experts from coastal MSMEs, local government institutions and other relevant stakeholders, combined with the integration of quantitative and qualitative evidence, enabled cross-validation of information and strengthened the credibility and reliability of the findings.

Data were collected through observation, interviews, questionnaires and documentation. Sustainable livelihood was analyzed using the Multiaspect Sustainability Analysis (MSA) approach. The MSA analysis employs multiple indicators to measure performance in each aspect, generating data on Existing Conditions while also considering Future Conditions. This MSA analysis utilizes the Exsimpro Software (<https://msa.exsimpro.com/>). The sustainability standards applied in this study are presented in Table 1 (35).

Table 1: Sustainability Criteria

Score (%)	Criteria
0.00 – 25.00	Not Sustainable
25.01 – 50.00	Less Sustainable
50.01 – 75.00	Sustainable
75.01 – 100.00	Very Sustainable

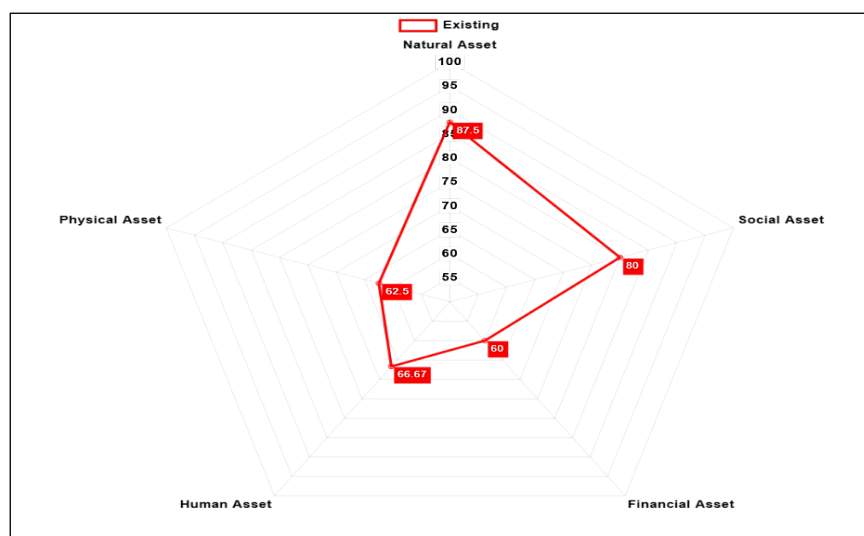
Results

Sustainable livelihood refers to the capacity of individuals or communities to secure adequate living standards without compromising future generations. It integrates economic resilience, social protection and environmental preservation to build adaptive systems (36). Such strategies are

crucial for vulnerable groups, including former migrant workers (37), through participatory, locally resource-based approaches. The results of the sustainable livelihood analysis of coastal MSME communities in the Tomini Bay Area, Gorontalo Province, are presented as in Table 2 and Figure 1.

Table 2: Results of the MSA

Aspect	Existing
Natural Asset	87.50
Social Asset	80.00
Financial Asset	60.00
Human Asset	66.67
Physical Asset	62.50
Total Average	71.33
Status Sustainability	Sustainable

**Figure 1:** Results of the MSA

Based on the Table 2 and Figure 1, it can be seen that the sustainable livelihoods of coastal MSME communities in the Tomini Bay Area, Gorontalo Province, fall within the Sustainable category (indicating a good level of sustainability) with an average score of 71.33%. This demonstrates that the livelihoods of coastal MSME actors in the Tomini Bay Area are in a good condition and can be categorized as sustainable, as reflected in their ability to maintain business continuity as well as social, economic and environmental well-being. This achievement is inseparable from the richness

of coastal natural resources, strong social interconnectedness and the presence of local institutional support. However, this score also indicates that several dimensions still need to be strategically strengthened, particularly those related to limited access to business infrastructure, skills training and financial resources. In practice, MSME actors often remain dependent on seasonal marine-based enterprises and have not yet fully adopted digital or production technology innovations. Therefore, although the current condition is categorized as sustainable, future

development approaches need to be holistic in nature to enhance the economic resilience and long-term competitiveness of MSMEs. The results of the sustainable livelihood analysis of coastal MSME communities in the Tomini Bay Area,

Gorontalo Province, for each aspect are presented as follows:

The results of the MSA for the natural asset (natural capital) dimension of sustainable livelihoods among coastal MSME communities are presented in the Figure 2.

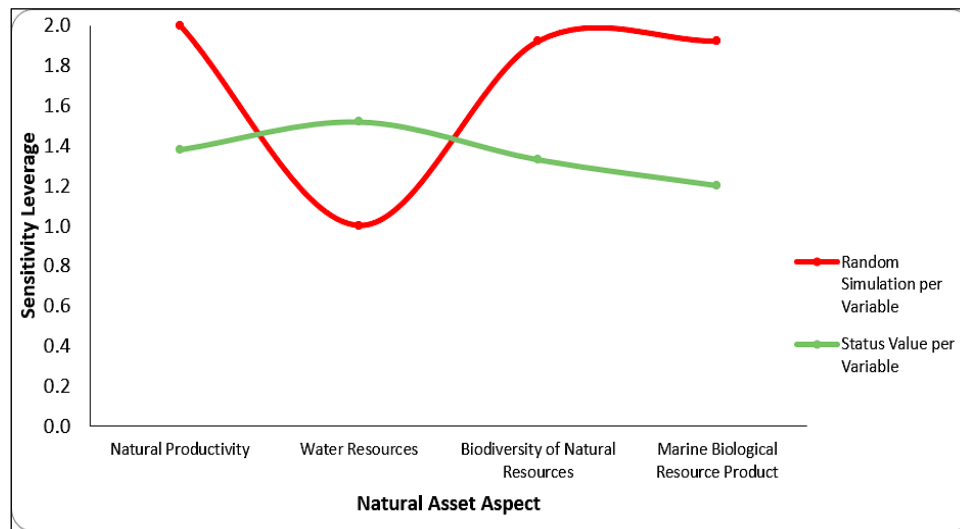


Figure 2: Results of Natural Asset

Based on Figure 2, it can be seen that the natural asset (natural capital) dimension of sustainable livelihoods among coastal MSME communities scores 87.50%, which falls under the Very Sustainable category (indicating a very high level of sustainability). This demonstrates that the coastal environmental conditions of Tomini Bay remain highly supportive of community economic activities. Marine biological resources, including fish, seaweed and shrimp, together with relatively well-preserved mangrove ecosystems, constitute

key strengths for MSME flagship products. However, heavy dependence on natural resources poses degradation risks without conservation-based and participatory management. Therefore, environmentally data-driven and sustainable resource management planning is essential to ensure long-term ecological resilience.

The results of the sensitivity analysis for the natural asset (natural capital) dimension of sustainable livelihoods among coastal MSME communities are presented in the Figure 3.

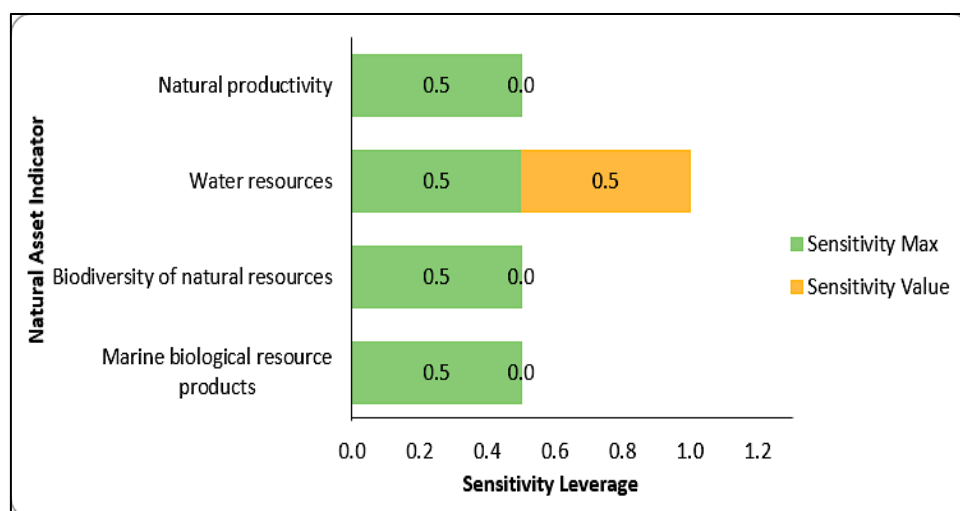


Figure 3: Sensitivity Analysis of Natural Asset

The analysis of the natural asset dimension presented in Figure 3 indicates that most indicators are in good condition, although several challenges require immediate attention. Natural productivity remains relatively optimal through aquaculture and high-value marine product processing, yet it faces risks from land-use conversion and overfishing. Biodiversity is generally preserved but remains vulnerable to

pollution and seasonal variability. Water resource conditions are less favorable due to limited availability and uneven distribution, making water resilience strengthening the primary strategic priority. The results of the MSA for the social asset (social capital) dimension of sustainable livelihoods among coastal MSME communities, are presented in the Figure 4.

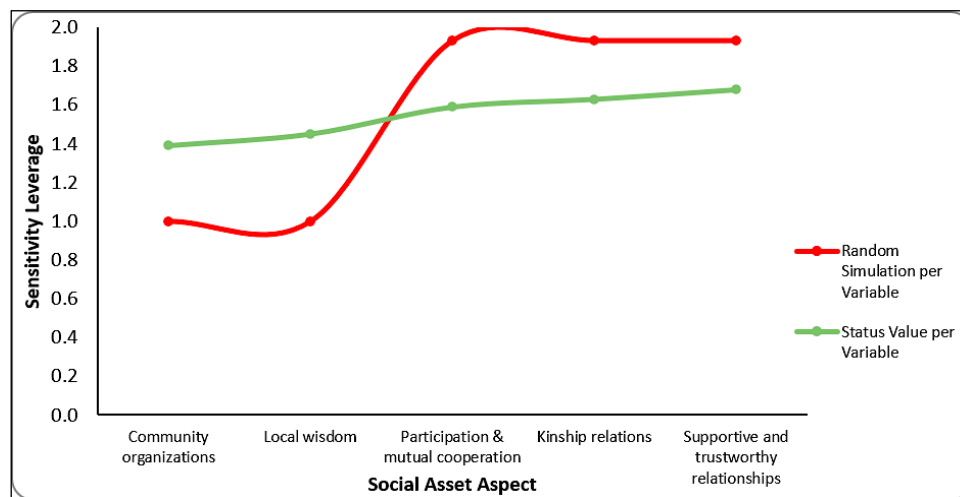


Figure 4: Results of Social Asset

Based on Figure 4, it can be seen that the social asset (social capital) dimension of sustainable livelihoods among coastal MSME communities scores 80.00%, which falls into the Very Sustainable category (indicating a very high level of sustainability). This finding indicate that coastal communities possess strong social networks and high cohesion in supporting MSMEs. Mutual cooperation, trust and kinship form the foundation of economic resilience. Business groups, cooperatives and community forums facilitate

information exchange and collective promotion. However, local institutional structures remain weak and the integration of local wisdom into modern economic activities is limited, requiring institutional capacity strengthening and closer collaboration with local governments.

The results of the sensitivity analysis for the social asset (social capital) dimension of sustainable livelihoods among coastal MSME communities are presented in the Figure 5.

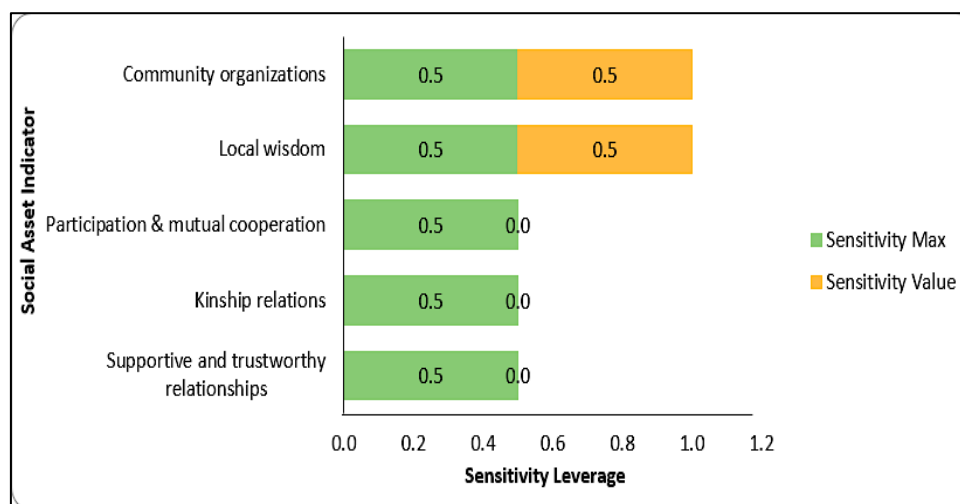


Figure 5: Sensitivity Analysis of Social Asset

The social asset dimension analysis presented in Figure 5 reveals variation across indicators. Community organizations and local wisdom remain relatively weak due to limited institutional capacity and formal recognition. In contrast, participation, mutual cooperation, kinship ties and trust are in good condition, reflecting strong social solidarity and collective networks supporting microeconomic activities. However, these

strengths may erode amid modernization. Therefore, priority should focus on strengthening organizational capacity, revitalizing local wisdom and preserving social values to sustain coastal MSMEs.

The results of the MSA for the financial asset (financial capital) dimension of sustainable livelihoods among coastal MSME communities, are presented in the Figure 6.

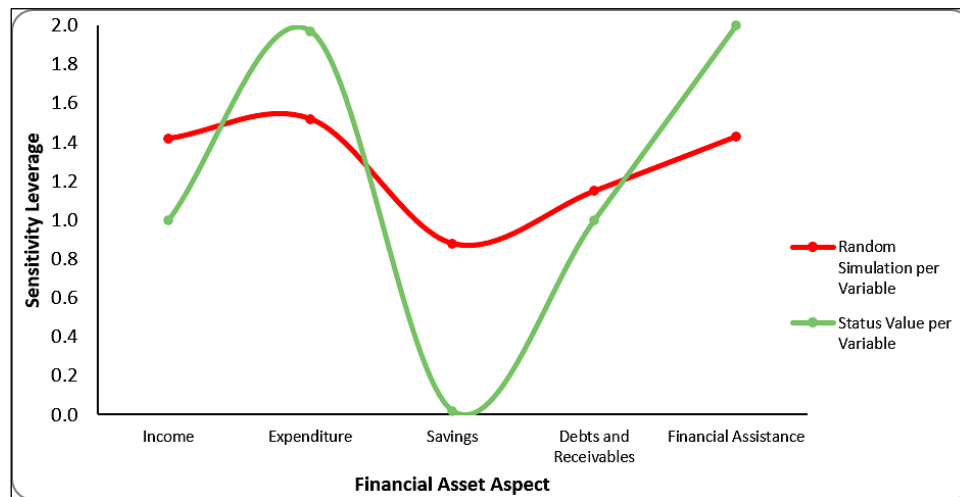


Figure 6: Results of Financial Asset

Based on Figure 6, it can be seen that the financial asset (financial capital) dimension of sustainable livelihoods among coastal MSME communities scored 60.00%, which falls into the Sustainable category (indicating a good level of sustainability). This shows that the financial dimension moderately supports sustainable livelihoods, as some MSME actors have received government and donor assistance. However, savings, income and debt management remain problematic due to inadequate bookkeeping and the mixing of

household and business finances. Targeted interventions, including financial literacy programs, basic accounting training and improved access to formal financial institutions and cooperatives, are necessary to strengthen long-term financial independence sustainably.

The results of the sensitivity analysis for the financial asset (financial capital) dimension of sustainable livelihoods among coastal MSME communities are presented in the Figure 7.

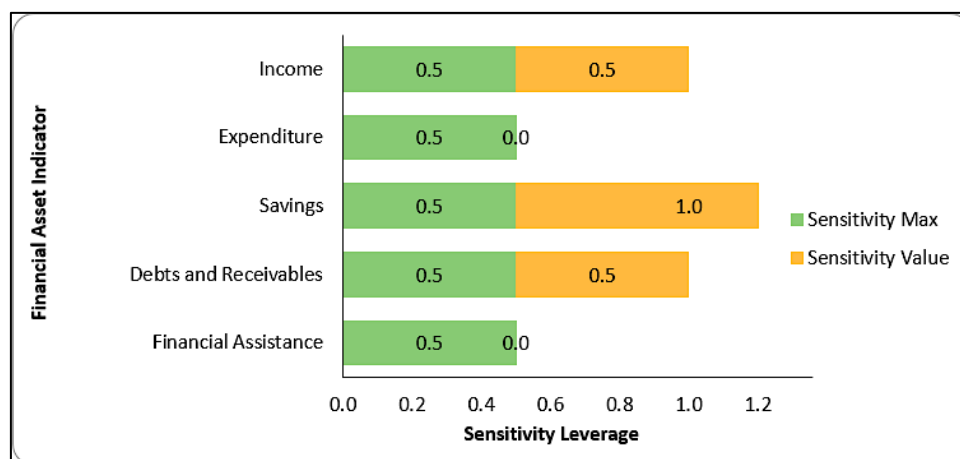


Figure 7: Sensitivity Analysis of Financial Asset

The financial asset dimension in Figure 7 reveals varied conditions with several critical challenges. Savings remain low due to limited income, unplanned expenditures and restricted access to formal financial services. Income is seasonal and insufficiently supported by business diversification. Debt management is weak, characterized by poor administration and informal lending practices. Expenditures are relatively efficient and

financial assistance provides support, though it risks dependency. Key priorities include strengthening financial literacy, promoting business diversification and expanding access to savings and responsible credit mechanisms.

The results of the MSA for the human asset (human capital) dimension of sustainable livelihoods among coastal MSME communities, are presented in the Figure 8.

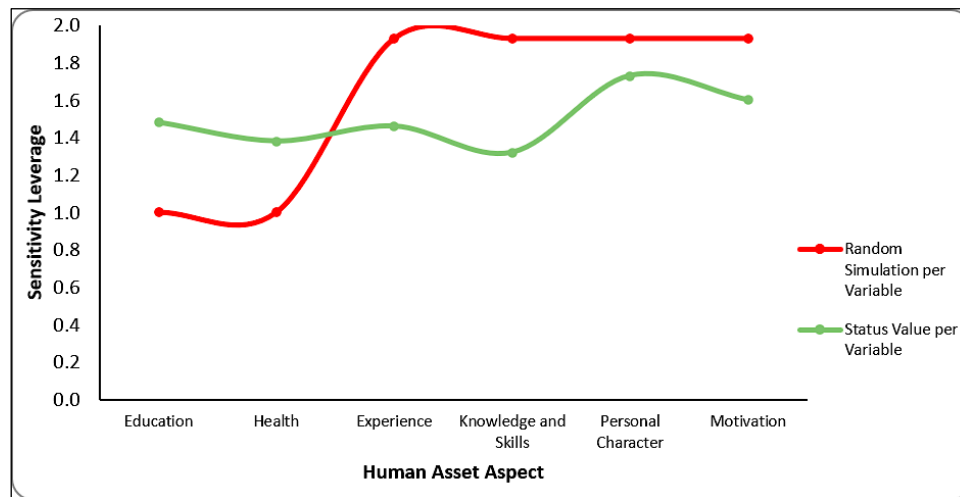


Figure 8: Results of Human Asset

Based on Figure 8, it can be seen that the human asset (human capital) dimension of sustainable livelihoods among coastal MSME communities scored 66.67%, which falls into the Sustainable category (indicating a good level of sustainability). This shows that MSME actors demonstrate strong human resource potential, yet it remains underutilized. High motivation and work ethic are constrained by low formal education, limited technical skills and insufficient business experience. Many still rely on inefficient traditional

practices. Restricted access to training further limits capacity development. Strengthening this dimension requires locally based technical training, village-level business incubators and collaboration with universities to enhance productivity, innovation and competitiveness.

The results of the sensitivity analysis for the human asset (human capital) dimension of sustainable livelihoods among coastal MSME communities are presented in the Figure 9.

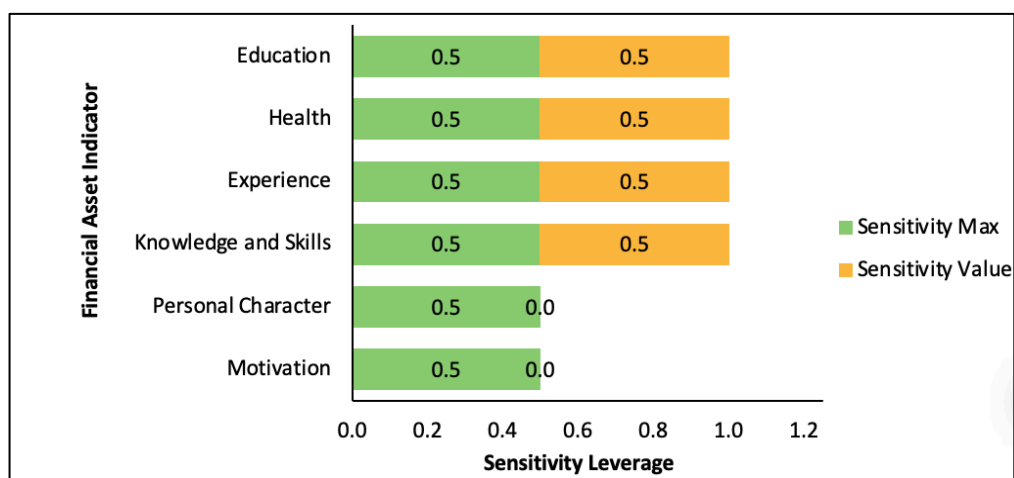


Figure 9: Sensitivity Analysis of Human Asset

The human asset dimension presented in Figure 9 indicates that most indicators remain weak, particularly education, health, experience and technical skills. Low formal education, limited healthcare access and insufficient business competencies constrain adaptability to market and technological change. In contrast, personal character and motivation are strong, reflected in diligence and mutual cooperation. Improvement

priorities should therefore emphasize education and health enhancement, supported by entrepreneurship training, mentoring and facilitated access to finance and markets to strengthen coastal human capital.

The results of the MSA for the physical asset (physical capital) dimension of sustainable livelihoods among coastal MSME communities, are presented in the Figure 10.

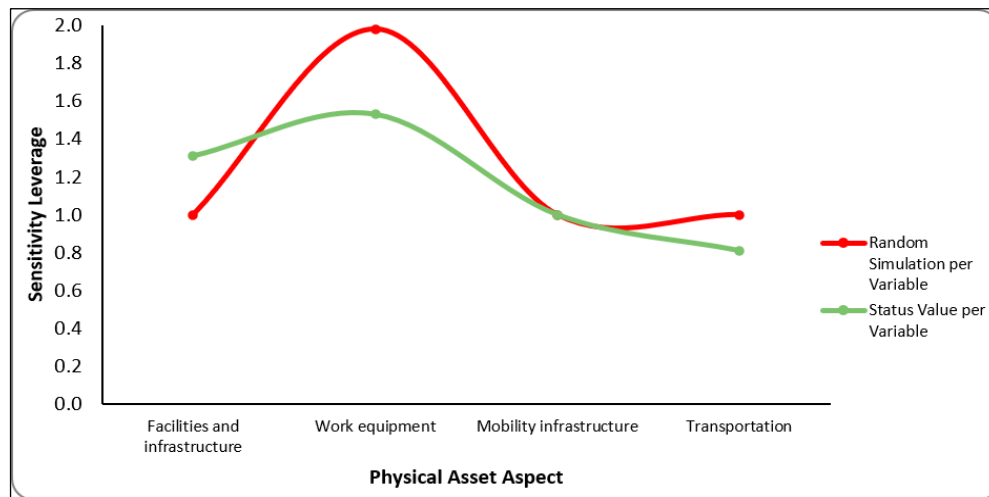


Figure 10: Results of Physical Asset

Based on Figure 10, it can be seen that the physical asset (physical capital) dimension of sustainable livelihoods among coastal MSME communities scored 62.50%, which falls into the Sustainable category (indicating a good level of sustainability). This shows that the physical infrastructure supporting MSMEs is generally available at a basic level but remains uneven and insufficient. Production roads, equipment and distribution channels serve some areas, while others face limited access, storage and transport facilities.

Inadequate shared facilities contribute to productivity disparities. Strengthening strategies should prioritize village-based integrated business centers, improved local logistics networks and shared production equipment facilitated through cooperatives or small enterprise groups.

The results of the sensitivity analysis for the physical asset (physical capital) dimension of sustainable livelihoods among coastal MSME communities are presented in the Figure 11.

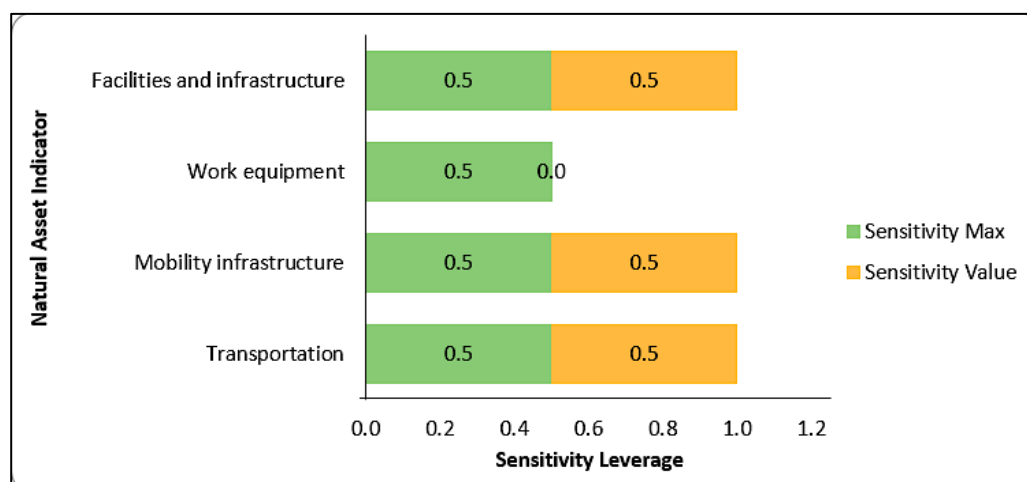


Figure 11: Sensitivity Analysis of Physical Asset

The physical asset dimension presented in Figure 11 indicates that most indicators face substantial challenges. Facilities and infrastructure remain weak, as many MSMEs operate from homes with limited production capacity. Mobility infrastructure is inadequate due to poor road conditions and low connectivity. Transportation is moderately sufficient but relies heavily on private vehicles with high costs. Although work equipment benefits from assistance programs, technological upgrading and maintenance training are needed. Priority actions include developing production centers and strengthening village-based infrastructure to enhance sustainability.

Discussion

The MSA results, with an average score of 71.33%, confirm that the sustainable livelihoods of coastal MSME communities in Tomini Bay have reached a good category, although not yet optimal. This condition indicates that the community has been able to maintain economic sustainability based on coastal natural resources, supported by strong social capital such as community networks and local wisdom. However, there remain gaps in access to training, production technology and formal financing, which limit the competitiveness of MSMEs in broader markets. The sustainability of small-scale fishers in Indonesia has been found to be strongly influenced by the combination of institutional support and the adaptive capacity of local communities (38). Similarly, the digital transformation of coastal MSMEs has been identified as a key factor in promoting sustainable marine tourism-based economic growth (39).

In addition, another emerging challenge is the dependency of MSME actors on seasonal, marine-based businesses that are highly vulnerable to climate change and market fluctuations. This highlights the need for business diversification and product innovation to strengthen economic resilience. More equitable improvements in community welfare can be achieved by empowering coastal MSMEs through the development of collective production centers (40). Meanwhile, the blue economy approach has been shown not only to increase the added value of coastal products but also to support the sustainability of marine ecosystems (41). Therefore, future development strategies should focus on strengthening human capacity,

digitalizing business activities and promoting multi-stakeholder partnerships to make coastal communities more adaptive to global and local dynamics.

The natural asset dimension, scoring 87.50%, indicates that coastal communities in Tomini Bay maintain a strong resource base, including fish, seaweed and mangrove ecosystems as economic and ecological foundations. However, exploitation without conservation risks long-term environmental degradation. Therefore, community-based participatory governance and a Blue Economy approach integrating socio-economic and conservation dimensions are essential to ensure sustainability (38, 41). Priority actions, such as improving clean water access, enhancing productivity and protecting biodiversity, require cross-sector policy support. Integrating natural capital with MSME diversification strategies will strengthen competitiveness and coastal economic resilience amid climate and global market changes (39, 42).

The finding that social capital among coastal communities in Tomini Bay is categorized as very sustainable (80.00%) underscores the critical role of social networks, trust and gotong royong in strengthening MSME resilience. This cohesion supports adaptation to market and resource dynamics; however, it remains insufficiently institutionalized within formal economic governance structures. Social capital enhances MSME performance when embedded in formal institutions (43) and strengthened through a Blue Economy framework to promote diversification and resilience (42). Limited transformation of local wisdom into modern economic instruments risks weakening competitiveness (40). Cooperative development and multi-stakeholder collaboration have proven effective in integrating social capital into sustainable livelihood strategies (44).

The financial asset dimension of coastal MSMEs in Tomini Bay remains sustainable (60.00%), supported by government and donor assistance but not yet accompanied by improved financial literacy and asset management. Many actors still mix household and business finances. Similar patterns occur elsewhere, where access to formal financial institutions is limited and savings mechanisms remain informal (45). Strengthening financial literacy and local cooperatives is essential to ensure capital enhances productivity.

Community-based micro-savings programs, business diversification and digital platform utilization can stabilize income (46, 47). Inclusive policy support will further improve financial resilience and competitiveness of coastal MSMEs. Human capital in Tomini Bay is categorized as sustainable (66.67%), characterized by strong motivation and work ethic but limited formal education and technical skills. Investment in human resource capacity and the need for high-quality human resources in the implementation of the Blue Economy are essential for ensuring the sustainable livelihoods of coastal communities. Dependence on traditional practices constrains productivity and diversification. Digital-based empowerment can enhance managerial capacity and market access (48), while long-term mentoring strengthens collective learning (40). Therefore, strengthening human capital should prioritize technical training, non-formal education and collaboration with universities and training institutions to foster adaptive and innovative coastal entrepreneurs.

The physical capital dimension of sustainable livelihoods among coastal MSMEs scored 62.50% (sustainable category). Although basic infrastructure exists in parts of Tomini Bay, unequal access to roads, logistics and shared production facilities constrains productivity and generates spatial disparities. Evidence from Java indicates that infrastructure gaps hinder MSME performance despite abundant resources. Blue Economy-based physical development enhances competitiveness and strengthens local economies. Integrating transport, storage and efficient production technologies supports diversification and sustainability (49). Integrated business centers reduce vulnerability to infrastructural constraints. Therefore, community-based collective infrastructure investment should be prioritized to drive long-term regional competitiveness.

The differences in sustainability levels among livelihood capitals indicate that coastal community assets develop unevenly according to resource characteristics and accessibility. Natural and social capital achieved a very sustainable status because coastal MSME livelihoods depend directly on marine resources, local knowledge, kinship ties, trust and community networks established across generations. In contrast, financial, human and

physical capital remained sustainable because their improvement depends more heavily on access to financing, education and skills, technology, infrastructure and institutional support. From the Sustainable Livelihoods Framework perspective, this pattern indicates that livelihood sustainability is determined not only by asset availability, but also by the community's ability to access, combine and transform different forms of capital to strengthen adaptive capacity. Moreover, heavy dependence on seasonal marine resources may increase income instability and exposure to ecological fluctuations, whereas livelihood diversification through value-added processing, complementary enterprises and alternative income sources can reduce vulnerability and strengthen long-term livelihood resilience and sustainability.

Conclusion

This study analyzed the sustainable livelihoods of coastal MSME actors in the Tomini Bay Area, Gorontalo Province, using the Multiaspect Sustainable Analysis (MSA) approach with research subjects consisted of coastal MSME actors, local government representatives and relevant stakeholders and research found that livelihood sustainability is categorized as sustainable, with the strongest performance observed in natural and social capital, while financial, human and physical capital provide adequate but not yet optimal support. These findings indicate that the utilization of local resources aligned with Blue Economy principles, inherited technical skills and strong social networks constitute key foundations for sustaining coastal economic activities. Nevertheless, limitations related to digital literacy, business management capacity and dependence on seasonal resources highlight the need to strengthen the adaptive capacity of coastal MSMEs in responding to market dynamics and environmental change. The study therefore underscores the importance of integrated capacity development, particularly through improvements in digital literacy, business innovation and Blue Economy-based diversification, to enhance the long-term resilience of coastal economic systems. These results also suggest the need for further research to explore how adaptive strategies, digital transformation and multi-stakeholder collaboration can more

effectively support sustainable livelihoods among coastal communities in different coastal regions. Limited digital literacy and business management capacity can weaken the adaptive capacity of coastal MSMEs by restricting access to market information, digital marketing, financial recordkeeping, innovation and timely decision-making when facing economic and environmental change. These constraints can be addressed through applied digital training, business mentoring, improved technology access and collaboration with government, universities and the private sector. The proposed sustainable livelihood model may also be applicable to other coastal areas, but its transferability requires adjustment to local socioeconomic conditions, natural resource quality, infrastructure, institutions and vulnerability levels. Therefore, the model should be treated as an adaptive framework that can be contextualized rather than applied uniformly across different coastal settings.

Abbreviations

Exsimpro: Exsimpro Software for sustainability analysis, MSA: Multiaspect Sustainable Analysis, MSME: Micro, Small and Medium Enterprises), NGO: Non-Governmental Organization, POAC: Planning, Organizing, Actuating, Controlling (Management Concept).

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Authors Contributions

Radia Hafid: Conceptualization, Investigation, Methodology, Resources, Research Management, Supervision, Writing - Original Draft Preparation, Review, Editing, Frahmawati Bumulo: Methodology, Supervision, Writing - Original Draft Preparation, Review, Editing, Siti Rahmatia Machieu: Data Collection, Project Administration, Resources Research Management, Visualization, Mohammad Zubair Hippy: Conceptualization, Formal Analysis, Methodology, Software, Data Formal Analysis, Muhammad Akram Mursalim: Validation, Data Collection, Data Analysis, Siti

Mayasari Pakaya: Project Administration, Methodology, Visualization.

Conflict of Interest

The author(s) declares that this study contains no conflicts of interest, whether horizontal or vertical in nature.

Data Availability

The data used in this study are available at the following link:

https://s.ung.ac.id/researchdata_RH

Declaration of Artificial Intelligence (AI) Assistance

The author used ChatGPT (OpenAI) as an AI-assisted tool while editing this manuscript. The tool was used solely to support grammar correction. No AI tool was used to generate, analyze, interpret, or validate the research data, nor to formulate the study's findings or conclusions. The author takes full responsibility for the accuracy, originality and integrity of the content presented in this manuscript. No AI-generated figures, images, tables, or graphical materials were included in this study. The authors have critically reviewed all AI-assisted content and assume full responsibility for the manuscript's accuracy and integrity.

Ethics Approval

Formal ethics approval was not required for this study, as it involved the voluntary participation of adult consumers through an anonymous, non-invasive survey, in line with the ethical standards and guidelines of the affiliated institution. Although formal ethics approval was not required for this study, the researchers still sought and obtained a research permit or recommendation from the Government of Gorontalo Province, numbered 070/Kesbangpol/168/VI/2025, which can be accessed at the following link: https://s.ung.ac.id/ResearchRecommendations_RH.

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