



Implementation of the Complex Adaptive System and Capability Approach in Poverty Alleviation in Coastal Communities in Takalar Regency

Adriana M¹, Gita Susanti²

¹Public Administration, Faculty of Social and Political Sciences, Hasanuddin University, Makassar

*Corresponding Author: Adriana M

Article Info

Article History:

Received September 8, 2025

Revised September 20, 2025

Accepted: October 15, 2025

Keywords:

Adaptive governance,
Capability approach, Coastal
poverty, Community resilience,
Complex adaptive system.

Abstract

This study analyzes the implementation of coastal poverty alleviation policies in Takalar Regency, Indonesia, through the perspectives of Complex Adaptive System and Capability Approach. The research aims to examine how interactions among government institutions, local communities, and non-governmental organizations shape adaptive governance and influence the development of community capabilities in coastal areas. Using a qualitative case study approach, data were collected through interviews, observations, and document analysis involving government agencies, village authorities, environmental organizations, fishermen, and seaweed farmers. The findings reveal that coastal poverty alleviation operates as an adaptive governance system characterized by dynamic actor interaction, feedback mechanisms, livelihood adaptation, and the emergence of community-based innovations. Poverty alleviation programs contribute not only to economic survival but also to the enhancement of practical reason, social affiliation, ecological awareness, and community resilience. However, unequal access to training, market dependency, and limited literacy continue to constrain capability expansion among coastal residents. The novelty of this study lies in integrating Complex Adaptive System and Capability Approach perspectives to explain coastal poverty alleviation as both an adaptive institutional process and a multidimensional capability development process. The study provides theoretical and practical insights for developing adaptive, participatory, and capability-oriented coastal governance policies.

Introduction

Coastal poverty remains one of the most persistent development challenges in many developing countries, particularly in regions where communities depend heavily on marine resources and climate-sensitive livelihoods. Despite continuous government interventions, poverty among coastal households often persists because economic vulnerability is closely intertwined with ecological uncertainty, limited institutional capacity, fluctuating market access, and social inequality (Rahmat & Neilson, 2023; Ahinsah, 2024; Syahza et al., 2025). In Indonesia, coastal communities are frequently characterized by unstable income, dependence on seasonal fisheries, inadequate infrastructure, and restricted access to education, healthcare, and financial resources (Rosado et al., 2022; Solihati & Dayanti, 2025; Apriyanti et al., 2025). These structural constraints create multidimensional poverty conditions that cannot be addressed solely through income-based approaches. Consequently, poverty reduction in coastal areas requires an integrated perspective capable of explaining the dynamic interaction between institutions, communities, environmental systems, and adaptive livelihood strategies.

Previous studies have demonstrated that poverty in coastal societies is strongly influenced by environmental vulnerability and institutional limitations. Hoang et al. (2022) argued that small-scale fishing communities often experience livelihood insecurity due to climate variability, resource degradation, and seasonal uncertainty. Similarly, Kapapa et al. (2024) emphasized that fisheries-based livelihoods are embedded within complex socio-ecological systems where economic survival depends not only on resource availability but also on institutional responsiveness, social resilience, and adaptive capacity. Furthermore, Onyenekwe et al. (2022) explained that coastal vulnerability emerges from the interaction between environmental change and social inequality, which often weakens local resilience against external shocks. These conditions are increasingly relevant in Indonesia's coastal regions, where communities continuously adapt to ecological degradation, changing weather patterns, and fluctuating fishery production. As a result, conventional poverty alleviation policies focusing primarily on direct financial assistance frequently fail to generate long-term empowerment and sustainable welfare improvements.

In response to these limitations, scholars have increasingly emphasized the importance of adaptive governance and capability-oriented development approaches. The Complex Adaptive System (CAS) perspective explains that social systems evolve through interactions among heterogeneous actors, feedback mechanisms, adaptation processes, and the emergence of new institutional patterns (May, 2022; Silva, 2024; Qiang, 2025). CAS theory views society not as a static structure but as a dynamic system characterized by continuous adaptation and nonlinear interactions. Head (2022) further argued that public policy systems should be understood as adaptive networks in which institutions, communities, and environmental factors constantly influence one another (Howlett & Ramesh, 2023; van, 2025). In the context of coastal development, government agencies, local communities, non-governmental organizations, markets, and ecological conditions interact in ways that shape policy effectiveness. This perspective becomes important because poverty alleviation programs often involve multiple actors whose actions influence each other through coordination, negotiation, conflict, and learning processes.

At the same time, the Capability Approach developed by Bartolomei et al. (2024) provides a normative framework for evaluating welfare beyond material indicators. Rather than measuring poverty solely through income, the Capability Approach emphasizes individuals' substantive freedoms to achieve valuable ways of living. Wagle (2023) argued that development should be understood as the expansion of human freedom and capability rather than merely economic growth. Meanwhile, Domínguez & del (2022) identified several central human capabilities, including life, bodily health, bodily integrity, practical reason, affiliation, and control over one's environment, which collectively reflect human dignity and social participation. This framework is particularly relevant for coastal communities because poverty is often manifested not only in economic deprivation but also in restricted opportunities, low educational access, vulnerability to occupational risks, and limited participation in decision-making processes.

Although previous studies have examined coastal poverty, adaptive governance, and community resilience separately, limited research integrates the CAS perspective with the Capability Approach in analyzing poverty alleviation policies within coastal societies. Existing studies tend to focus either on institutional coordination and governance effectiveness (Eilstrup & Westerwinter, 2022; Masyk et al., 2023) or on socioeconomic welfare indicators without comprehensively examining how adaptive interactions among actors influence the expansion of community capabilities (Greenwood, 2023). Furthermore, many studies still adopt linear policy perspectives that overlook the dynamic, evolving, and interconnected nature of coastal governance systems. This creates an important theoretical gap because policy effectiveness in complex coastal environments cannot be fully understood without considering adaptive

relationships, feedback loops, and local innovation processes simultaneously. Empirically, this gap is particularly visible in coastal areas of South Sulawesi, including Takalar Regency, where fishing and marine-based livelihoods dominate local economic activities. Coastal communities in Takalar frequently experience seasonal income instability, extreme weather conditions, fluctuating fish catches, and dependence on middlemen or informal market networks. In response, the government has implemented various poverty alleviation programs, including social assistance, conditional cash transfers, fishing equipment support, community empowerment initiatives, and livelihood diversification programs. At the same time, non-governmental actors such as environmental organizations and local community groups contribute through conservation programs, seaweed processing training, and ecological awareness campaigns. These interventions create a complex network of interactions involving state institutions, local actors, ecological systems, and adaptive livelihood strategies.

The effectiveness of these interventions remains uneven. While some communities successfully adapt through livelihood diversification and collective action, others remain trapped in dependency, low literacy, and limited market access (Liu et al., 2022; Cavalleri et al., 2022; He et al., 2024). This condition indicates that poverty alleviation outcomes are shaped not only by the availability of assistance programs but also by the adaptive capacity of local actors, the quality of institutional coordination, and the extent to which policies enhance community capabilities. Therefore, understanding coastal poverty alleviation requires an analytical framework capable of capturing both systemic complexity and human capability development simultaneously.

This study addresses these issues by analyzing the implementation of coastal poverty alleviation policies in Takalar Regency through the integration of the Complex Adaptive System and Capability Approach perspectives. The study investigates how interactions among government institutions, local communities, non-governmental organizations, and environmental dynamics form adaptive governance mechanisms that influence the development of community capabilities. Unlike previous studies that examine poverty reduction through single-dimensional perspectives, this research combines systemic adaptability with multidimensional human capability analysis to explain how adaptive policy networks shape social resilience and community empowerment in coastal areas.

The novelty of this research lies in its integrative analytical framework that combines CAS and the Capability Approach to examine coastal poverty alleviation as both an adaptive governance process and a capability expansion process. The study contributes theoretically by bridging complexity theory and human development perspectives within coastal governance research. Practically, it provides insights for policymakers regarding the importance of adaptive coordination, participatory governance, and capability-oriented interventions in strengthening the resilience and welfare of coastal communities.

Method

Research Design

This study employed a qualitative case study design to examine the implementation of coastal poverty alleviation policies in Takalar Regency, South Sulawesi, Indonesia. A qualitative approach was considered appropriate because the study sought to understand the complexity of interactions among governmental institutions, local communities, environmental organizations, and ecological conditions that cannot be adequately captured through quantitative measurement alone. The case study design enabled an in-depth exploration of how poverty alleviation policies operate within a real-life social and institutional context characterized by uncertainty, adaptation, and continuous interaction among multiple actors.

The analytical framework integrates the Complex Adaptive System (CAS) perspective with the Capability Approach. The CAS perspective was employed to explain how adaptive governance emerges through nonlinear interactions, feedback mechanisms, institutional learning, and self-organization among diverse stakeholders involved in coastal governance. Meanwhile, the Capability Approach provided a normative framework for examining how policy implementation contributes to expanding the substantive freedoms and capabilities of coastal communities beyond conventional income-based measures of poverty. Combining these perspectives allowed the study to capture both institutional dynamics and human development outcomes within coastal poverty alleviation.

Research Site

Takalar Regency was purposively selected as the research site because it represents one of the coastal regions in South Sulawesi where marine-based livelihoods dominate local economic activities and poverty remains a persistent development challenge. The regency possesses an extensive coastal area with communities highly dependent on capture fisheries, seaweed cultivation, and other marine-related economic activities. Livelihoods in these communities are particularly vulnerable to seasonal weather variability, fluctuating fish catches, environmental degradation, and unstable market conditions.

Furthermore, Takalar has become the focus of numerous poverty alleviation initiatives implemented by multiple actors, including local government agencies, village governments, community organizations, and non-governmental organizations. These diverse interventions provide an appropriate context for examining adaptive governance processes and institutional interactions within a complex policy environment. Therefore, the regency offers a rich empirical setting for understanding how coastal poverty alleviation evolves through collaboration, adaptation, and community participation.

Participants and Sampling Strategy

The study employed purposive sampling to identify participants who possessed direct knowledge and practical experience regarding coastal poverty alleviation policies. Purposive sampling was selected because the research emphasized information-rich cases capable of providing comprehensive insights into institutional processes, community adaptation, and policy implementation.

The participants represented multiple stakeholder groups involved in the coastal governance system, including officials from the Social Affairs and Village Community Empowerment Office (Dinas Sosial dan PMD), the Fisheries Office (Dinas Perikanan), members of the Regional House of Representatives (DPRD Commission II), village governments, environmental organizations represented by PPLH Puntundo, fishermen, and seaweed farmers. This diversity of participants enabled the study to capture multiple perspectives regarding policy formulation, implementation, institutional coordination, livelihood adaptation, and community empowerment.

Participant recruitment continued until data saturation was achieved, meaning that additional interviews no longer generated substantially new information or analytical categories relevant to the research objectives.

Data Collection

Data collection was conducted over several field visits using three complementary qualitative techniques: semi-structured interviews, participant observation, and document analysis. Combining multiple methods facilitated triangulation and strengthened the credibility of the findings. Semi-structured interviews served as the primary source of empirical data. Interview

guides were developed based on the concepts of adaptive governance and human capability development while allowing sufficient flexibility for participants to elaborate on their experiences. The interviews explored several themes, including implementation of social assistance programs, fisheries development initiatives, livelihood diversification, institutional collaboration, environmental conservation, community participation, adaptive responses to environmental uncertainty, and perceived impacts of poverty alleviation policies on household welfare.

Participant observation was undertaken within selected coastal communities to understand everyday social interactions, economic activities, institutional participation, and local adaptation practices. Observations focused on fishermen's activities, seaweed farming, community meetings, environmental conservation initiatives, and interactions among government officials, local organizations, and community members. Field notes were recorded throughout the observation process to complement interview findings.

Document analysis was conducted to provide contextual and institutional evidence supporting the interview data. The documents included regional development plans, poverty alleviation policy documents, fisheries development programs, village reports, statistical publications, meeting minutes, program implementation reports, and relevant regulatory documents issued by local government agencies. Documentary evidence facilitated verification of institutional arrangements, policy objectives, and implementation mechanisms.

Data Analysis

Data analysis followed the thematic analysis procedure. The analysis was conducted iteratively throughout the research process rather than only after data collection had been completed.

The first stage involved transcribing interview recordings and organizing field notes and documentary materials into a unified database. During the second stage, the researchers conducted open coding by identifying meaningful statements and assigning initial conceptual labels. Similar codes were subsequently grouped into broader categories representing recurring patterns across participants and data sources.

The third stage consisted of developing analytical themes through continuous comparison between empirical findings and the theoretical frameworks employed in the study. Within the Complex Adaptive System perspective, the analysis focused on identifying adaptive interactions among actors, institutional networks, feedback loops, self-organization, learning processes, and the emergence of new governance practices. Simultaneously, the Capability Approach guided the interpretation of how poverty alleviation policies influenced key dimensions of human capability, including life, bodily health, practical reason, affiliation, environmental stewardship, and control over one's social and economic environment.

Results and Discussion

This section presents the findings derived from the thematic analysis of interview data, field observations, and document analysis concerning the implementation of coastal poverty alleviation policies in Takalar Regency. The analysis is organized according to the two theoretical perspectives guiding this study: the Complex Adaptive System (CAS) and the Capability Approach. The findings first examine how adaptive governance emerges through institutional interactions, feedback mechanisms, livelihood adaptation, and community innovation. Subsequently, the analysis explores how this governance processes contribute to the expansion of community capabilities, including life security, bodily health, practical reason, social affiliation, and environmental stewardship. Throughout the discussion, empirical evidence is interpreted in relation to existing literature to demonstrate how adaptive governance

and capability development jointly shape the effectiveness of coastal poverty alleviation policies.

Adaptive Governance as a Complex Adaptive System in Coastal Poverty Alleviation

The thematic analysis identified four interrelated themes characterizing the implementation of coastal poverty alleviation policies in Takalar Regency as a Complex Adaptive System (CAS): (1) institutional interaction and coordination, (2) adaptive feedback mechanisms, (3) livelihood adaptation, and (4) community-based innovation. These themes emerged consistently across interviews, field observations, and documentary analysis, indicating that poverty alleviation is implemented through a dynamic governance network rather than a hierarchical administrative structure. The first theme concerns institutional interaction and coordination. Interviews with officials from the Social Affairs and Village Community Empowerment Office (Social Services and PMD), Fisheries Office, village governments, and DPRD Commission II revealed that poverty alleviation programs involve continuous collaboration among multiple actors. Government agencies coordinate beneficiary verification, fisheries assistance, social protection, and village development planning through routine meetings and cross-sectoral communication. Rather than operating independently, institutions continuously exchange information regarding community needs, program implementation, and environmental challenges.

One official explained:

"The distribution of social assistance is no longer determined solely by administrative data. Village governments, PKH facilitators, and community representatives jointly verify beneficiary eligibility because the economic condition of fishermen changes rapidly according to the fishing season."

This finding suggests that institutional flexibility has become essential for responding to rapidly changing socioeconomic conditions in coastal communities. Such adaptive coordination reflects the fundamental characteristics of CAS, where governance evolves through decentralized interactions and continuous institutional learning rather than rigid bureaucratic procedures.

These findings support Limberg et al. (2023) proposition that adaptive systems continuously reorganize themselves in response to environmental changes. Similarly, Zyzak & Farsund (2025) argue that policy effectiveness within complex systems depends on the quality of interactions among heterogeneous actors instead of centralized command structures. The present study extends this perspective by demonstrating how adaptive governance enables poverty alleviation policies to remain responsive under conditions of seasonal uncertainty.

Adaptive Feedback Mechanisms

The second theme emerging from the data relates to adaptive feedback mechanisms between coastal communities and policy actors. Interviews revealed that local knowledge regarding declining fish catches, weather variability, and livelihood disruption frequently informs government decision-making. Community feedback is collected through village consultations, fisheries extension officers, and routine coordination meetings before policy adjustments are implemented.

Following reports of prolonged bad weather, fisheries assistance shifted from fishing equipment distribution toward temporary livelihood support and alternative income generation. Rather than maintaining standardized interventions, implementing agencies modified program priorities according to local conditions.

Field observations further confirmed that community members continuously adjusted their own livelihood strategies in response to both environmental changes and available government support. Fishermen reported combining fishing activities with seaweed cultivation, small trading businesses, or casual labor during periods of low fish production.

These reciprocal adjustments illustrate the nonlinear feedback loops emphasized in Complex Adaptive System theory. Policy implementation therefore becomes an iterative learning process in which institutional responses and community adaptation mutually reinforce one another. Unlike conventional top-down governance models, adaptive feedback mechanisms create opportunities for policy learning, institutional flexibility, and continuous improvement.

Livelihood Adaptation and Community Innovation

The third and fourth themes demonstrate how adaptive governance encourages the emergence of new livelihood practices and community innovation. Participants described how seaweed processing groups, women's cooperatives, mangrove conservation initiatives, and waste management programs gradually evolved through collaboration between village governments, PPLH Puntundo, and community organizations.

Rather than simply implementing externally designed programs, communities actively modified interventions according to local needs and available resources. Women began producing processed seaweed products during periods of low fishing activity, while fishermen diversified income sources through aquaculture and temporary employment.

One seaweed farmer stated:

"Previously we only sold raw seaweed, but after participating in the training we learned how to process it into food products that generate higher income."

These findings illustrate the concept of emergence, one of the defining characteristics of CAS. Innovation does not originate exclusively from government intervention but emerges from repeated interactions, collective learning, and experimentation among local actors.

This finding complements Menon (2024), who argue that adaptive governance strengthens resilience through social learning and collaborative innovation. However, the present study further demonstrates that community innovation simultaneously contributes to poverty reduction and institutional adaptation, reinforcing both governance capacity and local resilience.

Capability Expansion among Coastal Communities

The second major theme emerging from the thematic analysis concerns the expansion of community capabilities following the implementation of coastal poverty alleviation policies in Takalar Regency. Across interviews with government officials, village authorities, environmental organizations, fishermen, and seaweed farmers, the findings consistently indicate that poverty alleviation has generated outcomes extending beyond income support. Rather than functioning solely as an economic intervention, the various assistance and empowerment programs have contributed to strengthening several dimensions of human capability, particularly life security, bodily health, practical reason, social affiliation, and environmental stewardship. These dimensions emerged repeatedly during data analysis, suggesting that the effectiveness of poverty alleviation should be evaluated not only in terms of financial improvement but also according to the extent to which individuals gain greater opportunities, resilience, and autonomy in responding to socioeconomic and environmental challenges. This finding supports the Capability Approach, which argues that development should be understood as the expansion of people's substantive freedoms rather than merely the accumulation of economic resources (Luz & Portugal, 2022; McGrath & Yamada, 2023).

One of the most visible capability outcomes relates to life security, particularly through the implementation of social protection programs such as the Conditional Cash Transfer (PKH), Direct Cash Assistance (BLT), and food assistance. Participants explained that these programs play an essential role in protecting household welfare during periods of declining fish catches, prolonged bad weather, and seasonal unemployment, when fishing activities are significantly disrupted. The assistance enables vulnerable households to maintain access to food, healthcare, children's education, and other basic necessities despite unstable income. Village officials also emphasized that beneficiary verification has gradually become more adaptive because household economic conditions frequently fluctuate according to seasonal fishing cycles. Nevertheless, interviews also reveal that social assistance mainly functions as a short-term coping strategy rather than a sustainable poverty reduction mechanism. Several participants acknowledged that continued dependence on government assistance remains evident among poorer households, indicating that economic security has not yet been accompanied by sufficient livelihood diversification or productive capacity. These findings suggest that while social protection effectively prevents households from falling into deeper poverty, long-term capability expansion requires complementary interventions aimed at strengthening productive assets, skills development, and economic independence. This observation is consistent with De Soysa & Vadlamannati (2023) argument that income should be viewed as an instrument for expanding human freedom rather than the ultimate objective of development (Lestari & Arumi, 2024; Avdukic & Asutay, 2025).

The analysis further demonstrates that poverty alleviation policies have contributed to improving bodily health and occupational security, particularly among fishing households. Fisheries-related interventions, including the provision of adaptive fishing equipment, cold storage facilities, and technical assistance, have reduced post-harvest losses while improving productivity and occupational efficiency. Participants generally perceived these interventions as beneficial because better equipment enables fishermen to preserve fish quality, increase selling prices, and reduce financial losses resulting from fluctuating market conditions. Moreover, extension services have enhanced community knowledge regarding weather forecasting, navigation safety, and sustainable fishing practices, allowing fishermen to make more informed decisions before going to sea. However, despite these improvements, substantial inequalities remain. Small-scale fishermen operating traditional boats continue to face high occupational risks due to limited access to safety equipment, insurance schemes, and healthcare services. Consequently, although institutional support has improved certain aspects of physical well-being, structural vulnerability remains a major constraint to capability development. These findings reinforce (Moore, 2023; Dua et al., 2025; Uzoigwe & Chukwuma, 2025) argument that bodily health and bodily integrity require institutional conditions that allow individuals to pursue their livelihoods safely and with dignity rather than merely increasing economic productivity.

Another important finding concerns the expansion of practical reason and social affiliation, both of which emerged as significant outcomes of community empowerment initiatives. Entrepreneurship training, seaweed processing programs, environmental education, and village development forums have encouraged residents to develop alternative livelihood strategies while strengthening their capacity to participate in local decision-making. Women involved in seaweed-processing groups reported increased confidence in managing household businesses and generating additional income during periods of low fishing activity. Likewise, fishermen described how technical training and community meetings enhanced their ability to evaluate economic opportunities, manage production risks, and plan household finances more strategically. Beyond individual benefits, these activities also strengthened social cohesion within coastal communities. Village meetings, fishermen associations, women's groups, and

collaborative conservation activities created opportunities for knowledge sharing, collective problem-solving, and mutual support among community members. The findings therefore suggest that poverty alleviation contributes not only to economic resilience but also to strengthening social capital and community participation, both of which represent essential components of sustainable capability expansion. In accordance with Bonvin & Laruffa (2022) Capability Approach, the ability to reason independently and participate meaningfully in social life constitutes an important dimension of human development that enables communities to exercise greater control over their own futures.

The final capability identified through thematic analysis is environmental stewardship, reflecting the increasing awareness among coastal residents that environmental sustainability is inseparable from long-term economic security. Conservation initiatives implemented collaboratively by local government agencies, village institutions, and PPLH Puntondo including mangrove restoration, coral reef conservation, seagrass protection, and coastal waste management have gradually strengthened public understanding of the relationship between healthy ecosystems and sustainable fisheries. Participants acknowledged that declining fish catches, coastal erosion, and marine pollution directly affect household livelihoods, leading many communities to become more actively involved in environmental conservation activities. Nevertheless, interviews indicate that these initiatives remain highly dependent on external facilitation, financial support, and technical guidance from government agencies and environmental organizations. Independent environmental stewardship has therefore not yet become fully institutionalized within local communities. This finding suggests that ecological capability is still developing and requires continuous investment in environmental education, community leadership, and locally managed conservation institutions capable of sustaining collective action beyond externally funded projects.

Conclusion

This study concludes that the implementation of coastal poverty alleviation policies in Takalar Regency represents a dynamic governance process that is best understood through the integration of the Complex Adaptive System (CAS) and Capability Approach perspectives. The findings demonstrate that adaptive interactions among government agencies, village institutions, non-governmental organizations, and coastal communities foster institutional coordination, feedback mechanisms, livelihood adaptation, and community-based innovation, thereby strengthening the resilience of the coastal governance system. At the same time, poverty alleviation policies contribute to the expansion of community capabilities by improving life security, occupational safety, practical reason, social affiliation, and environmental stewardship. However, the effectiveness of these interventions remains constrained by structural challenges, including unequal access to education and training, dependence on middlemen, limited market opportunities, and uneven institutional capacity. These findings suggest that sustainable coastal poverty alleviation requires not only social protection and economic assistance but also adaptive, participatory, and capability-oriented governance that empowers communities to respond to socioeconomic and environmental uncertainties. Theoretically, this study contributes by integrating CAS and the Capability Approach into a unified analytical framework for understanding coastal poverty alleviation as both an adaptive governance process and a multidimensional capability expansion process. Practically, it provides policy implications for designing more inclusive, collaborative, and adaptive poverty alleviation strategies that strengthen community resilience and promote sustainable coastal development.

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