



Social Network Analysis of Mangrove Ecosystem Management: Understanding Stakeholder Interaction in Mundu, Cirebon

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Abstract

Effective management of mangrove ecosystems is essential for the conservation of these vital habitats and the maintenance of their ecosystem services. This process involves multiple stakeholders to ensure sustainability. This study aims to identify the stakeholders involved in mangrove management in Mundu, Cirebon, map their relationships, and assess their roles within this context. Employing a qualitative approach, the research describes stakeholder involvement in mangrove ecosystem management and utilizes UCINET 6 software for analysis. This analysis identifies the stakeholders with the strongest engagement and those playing pivotal roles in mangrove management. The findings indicate that the primary actors in mangrove management in Mundu are the Community-Based Coastal Resource Management group (Pokmaswas), which has a degree centrality of 1.2222; the Village Government, with a value of 1.3333; and the Department of Marine Affairs and Fisheries, which has a value of 0.6666. These results suggest that both Pokmaswas and Village Governments play central roles in mangrove management, with the Department of Marine Affairs and Fisheries following closely behind. This highlights the critical contribution of community groups to the success of mangrove conservation efforts in the region. However, UCINET analysis also reveals that interactions among stakeholders are limited, indicating a gap in collaboration. This lack of interaction may lead to suboptimal management and hinder the development of the mangrove ecosystem in Mundu.

INTRODUCTION

Mangrove ecosystems, found in tropical and subtropical coastal regions, play a vital role in both terrestrial and marine environments (K et al., 2024). These ecosystems provide a multitude of benefits through their essential ecosystem services for human populations (Ellison et al., 2020). The key roles of mangrove ecosystems include the conservation of biodiversity, the protection of coastlines, and the provision of crucial ecosystem services (Suhardi et al., 2024). Additionally, mangroves serve as critical spawning grounds for various fish species. This unique ecosystem, characterized by complex root systems and nutrient-rich environments, offers optimal conditions that protect fish from predators, thereby enhancing the sustainability of local fisheries (K et al., 2024). However, many mangrove ecosystems are experiencing rapid degradation (Wang et al., 2024), and Indonesian mangroves have suffered significant damage due to anthropogenic activities in recent decades (Suhardi et al., 2024).

Mangrove conservation efforts are essential to restore degraded mangrove ecosystems and revitalize their vital environmental services. Global Mangrove Watch (2020) identifies Indonesia as having one of the highest rates of mangrove degradation in the world, with a documented decline of 1,739.04 km² of mangrove forests between 1996 and 2020. Therefore, ongoing mangrove conservation efforts remain crucial. Effective strategies for mangrove conservation include co-management approaches, which involve local communities in managing mangrove ecosystems, and local community empowerment, which has demonstrated high levels of success in mangrove rehabilitation activities.

The conservation status and management effectiveness of mangrove ecosystems in Indonesia are influenced by the implementation of effective strategies that contribute to sustainable mangrove management (Suhardi et al., 2024). Furthermore, Suhardi et al., (2024) noted that several obstacles hinder mangrove conservation, including the absence of

equitable land management decisions, which can cause conflicts of interest between the public and private entities. Additional significant challenges encountered in preserving mangrove forests include weak regulatory enforcement, technical limitations, and poor coordination among stakeholders (Winanti et al., 2023). Inadequate coordination between stakeholders significantly impacts the success of mangrove conservation efforts. Therefore, this research aims to study social network analysis (SNA) in mangrove conservation in Mundu, Cirebon, to map actors and stakeholders involved in mangrove conservation. This study is crucial because effective mangrove management and conservation require the involvement of multiple parties, necessitating a deep understanding of stakeholders through Social Network Analysis.

Numerous previous studies have employed Social Network Analysis in mangrove management, including research by Fathima Mafaziya Nijamdeen et al. (2023), which identified various problems that impede effective mangrove management, including inefficient communication, inconsistencies between policies and their implementation, and differences in the number of stakeholders involved across provinces. Similar findings have been reported in additional studies (Borgatti et al., 2002; Pratama & Iqbal, 2018), supporting these findings (Fathima Mafaziya Nijamdeen et al., 2023). Moreover, Ilham Q et al. (2016) suggest that multi-party forest management can serve as an integrated management model that balances the interests of various parties and ensures the equitable distribution of information (Ilham et al., 2016).

Based on the description above, this study on Social Network Analysis in mangrove ecosystem management is necessary to identify the actors or stakeholders involved, review the mapping of collaborative efforts, and assess the roles of stakeholders in mangrove management in Mundu, Cirebon. The results of this study will provide a valuable foundation for policymakers engaged in mangrove ecosystem management.

METHOD

Design Study

This research employs a qualitative approach with a case study method. The qualitative approach was selected because this study aims to understand, in an in-depth manner, the stakeholders involved in the management of the mangrove ecosystem in Mundu, Cirebon.

Study Site

The study was conducted from September to November 2024. The research was carried out in Mundu Village, Mundu District, Cirebon Regency, West Java. Mundu Village was selected as the study location because it has a significant mangrove forest area and has been actively involved in mangrove conservation since 2018, and is currently being developed into an ecotourism area.

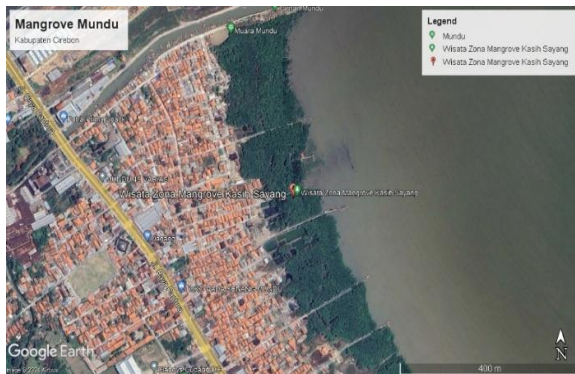


Figure 1. Research location

Data Collection

Research data were collected using several methods:

1. Observation: Direct observations were conducted to examine the management of the mangrove ecosystem in Mundu, Cirebon.
2. Interviews: Semi-structured interviews were conducted with various key informants, including mangrove farmer groups, local village government officials, and local community members involved in mangrove ecosystem management in Mundu, Cirebon.
3. Documentation: Documentation was gathered to collect secondary data, such

as the Mundu Village profile, mangrove ecosystem management plans, and mangrove ecosystem management reports.

Data Analysis

Research data was analyzed with the use of qualitative data analysis techniques:

1. Miles and Huberman Analysis: This technique was used to analyze observation and interview data, focusing on data reduction, data display, and conclusion drawing.
2. Document analysis: This technique was used to analyze data in the form of documents, extracting relevant information and identifying key themes.
3. UCINET Analysis: Analysis of stakeholder mapping in the mangrove ecosystem in Mundu was conducted using the SNA method. *The Social Network Analysis* (SNA) method is used to analyze how strong stakeholders play a role in managing the mangrove ecosystem. The processing of the most dominant stakeholder mapping data was analyzed using UCINET Software to map stakeholder involvement in managing the mangrove ecosystem in Mundu, Cirebon.

Data Validation

The validity of the research data was enhanced using triangulation techniques, employing various data sources and data collection methods to ensure the reliability and consistency of the findings.

RESULT AND DISCUSSION

The results of the actor network analysis of the mangrove ecosystem management in Mundu, obtained using UCINET software, are shown in Figure 2.

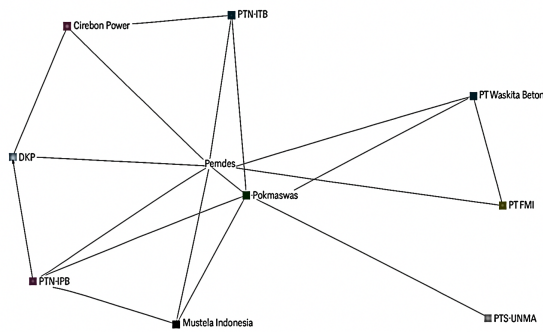


Figure 2. Results of actor network analysis using UCINET

Figure 2 illustrates that each node represents an actor, while the lines (edges) connecting the nodes indicate the relationship between the actors. The analysis provides insights into the *degree centrality*, which measures the number of direct connections possessed by each actor; *betweenness centrality*, which indicates how often an actor serves as a bridge for other actors; *closeness centrality*, which measures the proximity of an actor to other actors in the network; density, which measures the level of connectivity in the network; and *network centralization*, which assesses the extent to which the network depends on one or more particular actors.

Network Structure, Key Actors, and Connectivity Analysis

The Social Network Analysis (SNA) reveals a network density of 0.3111 (31.11%). This value indicates that only 31% of all possible connections between stakeholders in the Mundu Mangrove ecosystem management are active. Such a moderate density points to a network with sub-optimal collaboration and significant structural vulnerabilities. The degree centrality values highlight three key actors: Pokmaswas (1.2222), Pemdes (1.3333), and DKP (0.6666), demonstrating their central roles in network coordination. However, this over-reliance creates a critical risk: the network is susceptible to fragmentation. The withdrawal or inaction of one of these central actors could severely disrupt communication flow and paralyze collaborative efforts, highlighting a lack of overall network resilience. Consequently, information

dissemination is likely inefficient, requiring multiple steps to travel between actors, which delays decision-making and coordinated action.

A direct consequence of the network's moderate density and centralized structure is the passivity of numerous actors. While the analysis highlights the core actors, it implicitly shows that other vital stakeholders—such as academic institutions, the private sector, and non-governmental organizations—remain disconnected or poorly integrated.

This moderate density creates both opportunities and vulnerabilities in the network structure. First, communication pathways rely heavily on Pokmaswas and Pemdes as intermediaries, creating a potential single point of failure. Second, if key actors withdraw, network fragmentation becomes likely due to insufficient alternative pathways.

Several factors explain why these actors remain passive

1. Academic Institutions (PTN-ITB, PTN-IPB, PTS-UNMA): Limited to project-based involvement due to a lack of sustained funding mechanisms for long-term engagement.
2. Corporate Entities (Cirebon Power, PT PNM, PT Waskita): Constrained by CSR frameworks that emphasize:
 - a. Compliance-driven rather than collaborative approaches
 - b. Short-term project cycles that don't align with ecosystem management timelines
 - c. Limited stakeholder engagement protocols beyond financial contributions
2. DKP (Marine and Fisheries Agency): Despite regulatory authority, shows minimal networking engagement due to:
 - a. Bureaucratic constraints limit direct community interaction
 - b. Resource limitations for sustained field presence
 - c. Lack of inter-agency coordination mechanisms

DISCUSSION

Mangrove Management Based on Community

Table 1 presents a mapping of the roles of various stakeholders in the mangrove ecosystem management in Mundu.

Table 1. Stakeholders and their roles in the management of the mangrove ecosystem in Mundu

No	Actors (stakeholders)	Role in Mangrove Planting	Role in Networking
1.	Village Government	-	Protecting and creating village regulations on mangroves in Mundu Pesisir
2.	Community Development Group	Conduct monitoring of mangrove planting and maintenance	-
3.	DKP	1,500 sticks	-
4.	Cirebon Power	3,000 sticks	Environmental Social Responsibility (CSR)
5.	PTN-IPB	2,000 sticks together with Mustela Indonesia	Research and Innovation
6.	PTN-ITB	300 sticks	Research and Innovation
7.	Mustela Indonesia	2,000 sticks together with IPB	NGO focused on biodiversity and conservation
8.	PT PNM	5,000 sticks with PT Waskita Beton Precast Tbk	Environmental Social Responsibility (CSR)
9.	PT Waskita Beton Precast Tbk	5,000 sticks with PT PNM	Environmental Social Responsibility (CSR)
10.	PTS-UNMA	200 sticks	Institutions that educate communities

Table 1 shows that the roles of stakeholders fall into two broad categories: planting and managing mangroves. Some stakeholders are primarily involved in planting activities, which limits their broader engagement within the network. This confirms that, in addition to the UCINET analysis, the strong roles of key stakeholders in mangrove ecosystem management in Mundu are also evident in the mapping of stakeholder roles. The two key stakeholders identified are Pokmaswas and Pemdes. As Abdullah et al. (2014) emphasized, sustainable mangrove conservation and restoration hinge on effective community involvement (Abdullah et al., 2014). This involvement can be fostered by providing diverse opportunities for participation beyond planting mangroves, such as training and mentoring programs. Empowering the community through training and

capacity-building in mangrove management enhances their participation in establishing sustainable mangrove management governance standards (Ahmed et al., 2023). Moreover, the Village Government, as the formal institution leading the partnership, plays a critical role in ensuring transparent and impartial policies. While all actors involved in the partnership are equal stakeholders, government support can serve as a catalyst for building effective partnerships (Sahputra et al., 2022). This is the opinion of Mafaziya Nijamdeen et al. (2024) that while all actors involved in the partnership are equal stakeholders, government support can serve as a catalyst for building effective partnerships. As previously argued, when mangroves are managed through a top-down approach, management is implemented through higher-level political authority vested in

bureaucrats, with limited communication to those at lower levels.

Mangrove ecosystem management in Mundu exhibits a notable gap characterized by indirect relationships between actors, which can create disconnects in their interactions. This interaction gap presents a significant challenge to the sustainable management of the Mundu mangrove area. Moreover, this gap contributes to the emergence of hierarchical communication patterns between actors. Limitations exist in communication between various actors, with Pokmaswas and Pemdes engaging with nearly all actors, while other actors communicate primarily with Pokmaswas and/or Pemdes. There is a need for concerted efforts to unite these actors in building collaborative relationships for sustainable mangrove management.

Nyangoko et al. (2022) argue that poor collaboration or a lack of collaboration can exacerbate problems associated with the overexploitation of mangroves and non-compliance, contributing to the degradation of natural capital and generating negative perceptions regarding mangrove management efforts (Nyangoko et al., 2022). This assertion is supported by Walters et al. (2008) and Baruah et al. (2016), who state that ineffective governance leads to limited commitment and local participation in mangrove conservation because the needs and interests of local stakeholders are frequently overlooked.

Public participation is paramount in mangrove management and conservation initiatives, as it significantly enhances the effectiveness and acceptance of biodiversity management policies by integrating local knowledge and providing incentives for sustainable practices (Rahmadi et al., 2023). Addressing social aspects in mangrove management requires prioritizing extensive outreach and mentoring programs. These initiatives aim to enhance public awareness, knowledge, and active involvement in mangrove conservation and management (Rumondang et al., 2024). Moreover, collaborative institutional strengthening can be achieved by reinforcing the commitment of villages and communities to upholding

local wisdom, while simultaneously increasing the participation and capacity of individual community members in managing mangrove ecosystem areas for ecotourism development (Sukuryadi et al., 2021). As argued by Sahputra et al. (2022), the necessity of collaborative efforts between communities and government in the utilization and management of mangroves, including the community in the planning and implementation processes. Constitution Number 23 of 1997 further underscores this principle by outlining the government's responsibility to foster partnerships with communities and relevant actors in environmental management endeavors (Sahputra et al., 2022). These combined perspectives highlight that community participation is a foundational element in sustainable mangrove management, contributing significantly to the long-term sustainability of environmental resources and livelihoods (Ahmed et al., 2023).

CONCLUSION

This study identified and mapped stakeholder involvement in the management of the mangrove ecosystem in Mundu, Cirebon. Analysis using UCINET software revealed that the Community-Based Coastal Resource Management Group (Pokmaswas) and the Village Government (Pemdes) play the most central roles in mangrove management, followed by the Department of Marine Affairs and Fisheries (DKP). This indicates that community groups are crucial to the success of mangrove conservation efforts in the area. However, the UCINET analysis also demonstrated that interactions between actors in mangrove management are limited, with notable gaps and distances within the network. This limited interaction results in suboptimal management and development of the mangrove ecosystem in Mundu. These research findings emphasize the importance of public participation in sustainable mangrove management, underscore the need for strong collaboration and synergy among stakeholders, and highlight the critical role of government

support through policies promoting sustainable mangrove management. The limitations of this study provide avenues for further research, including a more in-depth analysis of the roles of each stakeholder to better characterize mangrove management in Mundu, as well as an evaluation of the economic, social, and environmental impacts of mangrove management on the community.

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