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Collaborative governance in post-disaster rehabilitation and reconstruction planning: a social network analysis in Waisai, Raja Ampat

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ABSTRACT

The preparation of the Post-Disaster Rehabilitation and Reconstruction Plan (R3P) is a strategic phase in supporting the recovery of disaster-affected areas. However, its implementation continues to face significant challenges, including weak cross-sectoral coordination, limited inter-agency communication, inadequate information sharing, and insufficient integration among stakeholders involved in the planning process. This study aims to analyze collaborative governance in the preparation of the R3P for flood and landslide recovery in Waisai, Raja Ampat Regency, Indonesia. A descriptive quantitative approach was employed using Social Network Analysis (SNA). Data were collected through questionnaires administered to 21 respondents representing 15 stakeholder institutions, and analyzed using UCINET, NetDraw, and Gephi based on degree centrality, betweenness centrality, closeness centrality, and network density indicators. The results indicate that communication, coordination, and information sharing achieved mean scores of 3.81, 3.95, and 3.75, respectively, all classified as good. Stakeholders' perceptions of the collaborative network structure reached a mean score of 4.05, indicating strong support for inter-organizational collaboration. The network analysis identified the Regional Disaster Management Agency (BPBD) as the primary operational actor, with the highest degree centrality (14) and closeness centrality (0.875), while the Regional Development Planning Agency (Bappeda) recorded the highest betweenness centrality (42.35), highlighting its strategic role in coordinating policies across institutions. A network density value of 0.543 indicates a moderately strong collaborative network, although stronger cross-sectoral integration remains necessary. This study proposes a Dual Leadership Network Model that integrates BPBD's operational leadership with Bappeda's strategic leadership to strengthen collaborative governance in the preparation of the R3P. The proposed model contributes to the advancement of collaborative governance theory while providing a practical framework for post-disaster rehabilitation and reconstruction planning in archipelagic and disaster-prone regions.

Keywords: collaborative governance; post-disaster rehabilitation and reconstruction; social network analysis; stakeholder collaboration; Raja Ampat.

1 Introduction

Natural disasters have become increasingly frequent and complex, posing significant challenges to sustainable development and public infrastructure worldwide. Beyond causing physical damage, disasters frequently disrupt governance systems, public service delivery, economic activities, and community livelihoods. Consequently, post-disaster recovery is no longer viewed merely as the reconstruction of damaged infrastructure but as a comprehensive process that integrates institutional coordination, stakeholder participation, policy alignment, and long-term resilience. The Sendai Framework for Disaster Risk Reduction 2015–2030 and the Global Assessment Report on Disaster Risk Reduction 2022 emphasize that successful post-disaster recovery depends on inclusive governance systems capable of coordinating multiple actors across sectors and administrative levels, [1]-[3].

The growing complexity of post-disaster recovery has shifted the governance paradigm from a government-centered approach toward collaborative

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governance, in which public institutions, the private sector, academia, civil society organizations, and local communities jointly participate in decision-making and policy implementation. Collaborative governance promotes consensus-oriented decision-making, shared responsibility, mutual trust, and collective action among stakeholders to address complex public issues that cannot be effectively managed by a single institution alone [4], [5]. Within the context of disaster management, this approach has been widely recognized as an effective mechanism for strengthening institutional coordination, enhancing resource mobilization, and improving community resilience throughout the disaster management cycle [6]- [9]

Indonesia is one of the most disaster-prone countries in the world due to its location along the Pacific Ring of Fire and its exposure to multiple natural hazards, including earthquakes, tsunamis, floods, landslides, volcanic eruptions, and extreme weather events. These conditions require disaster management systems that are adaptive, integrated, and capable of coordinating multiple stakeholders throughout the disaster management cycle. Previous studies have demonstrated that disaster risk reduction cannot rely solely on structural mitigation measures but should also be supported by strengthened institutional capacity, stakeholder coordination, community participation, and inter-organizational collaboration during the prevention, mitigation, and preparedness phases. Sinarta *et al.* [10] emphasized that effective pre-disaster planning requires collaboration among government agencies, local communities, academic institutions, disaster management organizations, and other relevant stakeholders through coordinated planning, institutional strengthening, enhanced disaster preparedness, and participatory decision-making. Such collaborative efforts establish the institutional foundation necessary for reducing disaster risks while strengthening community resilience before disasters occur.

Although coordination during the prevention, mitigation, and preparedness phases has received considerable attention in previous studies, governance complexity becomes substantially greater during the post-disaster rehabilitation and reconstruction phase. At this stage, coordination extends beyond disaster preparedness to encompass policy synchronization, development planning integration, resource allocation, socio-economic recovery, and cross-sectoral collaboration to support sustainable recovery. In response to these challenges, the Government of Indonesia has established the Post-Disaster Rehabilitation and Reconstruction Plan (*Rencana Rehabilitasi dan Rekonstruksi Pascabencana*—R3P) as a strategic planning instrument for guiding post-disaster recovery. The preparation of the R3P requires close coordination among government agencies, technical institutions, academia, community organizations, the private sector, and affected communities to ensure that rehabilitation and reconstruction programs are comprehensive, accountable, and aligned with regional development priorities [2], [11]. Nevertheless, implementing collaborative governance during this phase remains challenging due to differences in institutional authority, organizational priorities, resource availability, communication mechanisms, and information-sharing practices, all of which frequently hinder effective collaboration among stakeholders [6], [12]- [14]

Previous studies have made significant contributions to the advancement of collaborative governance in disaster management from the perspectives of institutional coordination, stakeholder participation, and governance networks. Khafian [7] highlighted the strategic role of collaborative governance in improving disaster management practices in Indonesia, while Dewi et al. [8] demonstrated its contribution to strengthening community resilience at the local level. Danar and Novita [6] further argued that collaboration enhances disaster governance performance through stronger institutional interaction and more effective policy implementation. Likewise, Trias et al. [12] showed that governance network analysis provides valuable insights into institutional interaction patterns among disaster management stakeholders. Manandhar et al. [14] identified organizational challenges faced by public managers in governing post-disaster recovery networks, whereas Syuaib [15] emphasized the importance of inter-agency collaboration during rehabilitation and reconstruction processes in Indonesia. Despite these contributions, most previous studies have examined collaborative governance and Social Network Analysis (SNA) independently or have focused primarily on institutional coordination in general. Research integrating collaborative governance with SNA to analyze stakeholder relationships during the preparation of the Post-Disaster Rehabilitation and Reconstruction Plan (R3P) remains limited, particularly in small island regions, where geographical dispersion, institutional arrangements, and accessibility create additional governance complexities.

This research gap becomes particularly relevant in archipelagic regions such as Raja Ampat Regency, Southwest Papua Province. Characterized by dispersed islands, limited accessibility, and the involvement of multiple institutions in disaster management and regional development, post-disaster rehabilitation and reconstruction in such regions requires more complex cross-sectoral coordination than in mainland areas. These characteristics make small island regions an important context for understanding how stakeholder relationships are established, maintained, and coordinated throughout

the preparation of post-disaster rehabilitation and reconstruction plans.

Based on this research gap, the present study aims to analyze stakeholder interactions in the preparation of the R3P by applying Social Network Analysis (SNA) within a Collaborative Governance framework. Stakeholder positions, interaction patterns, and network structures are examined using degree centrality, betweenness centrality, closeness centrality, and network density to provide a comprehensive understanding of institutional relationships influencing collaborative governance in post-disaster rehabilitation and reconstruction planning. The findings are expected to provide empirical evidence that advances the application of collaborative governance in post-disaster recovery planning while supporting stronger stakeholder coordination in disaster-prone regions, particularly within small island contexts.

2 Data and Methods

2.1 Study Area

This study was conducted in Waisai City, Raja Ampat Regency, Southwest Papua Province, Indonesia, the administrative center of Raja Ampat Regency and one of the areas vulnerable to flood and landslide disasters. The study focuses on the preparation of the R3P as a strategic planning instrument for strengthening collaborative governance in post-disaster recovery. Waisai City was selected as the study area because it has experienced recurring hydrometeorological disasters that require coordinated rehabilitation and reconstruction planning involving multiple government institutions and other relevant stakeholders.

2.2 Research Design

This study employed a descriptive quantitative research design using Social Network Analysis (SNA) to examine the interaction patterns, network structure, and strategic roles of stakeholders involved in the preparation of the R3P. A descriptive quantitative approach was selected to provide empirical evidence regarding collaborative relationships among stakeholder institutions. Social Network Analysis was adopted because it enables the quantitative assessment of stakeholder interactions, identifies key actors occupying strategic positions within the network, and evaluates the overall structure of institutional collaboration. Compared with conventional descriptive approaches, SNA provides a more systematic and objective evaluation of institutional relationships, stakeholder interactions, and overall network performance [12], [13], [16]

2.3 Stakeholder Identification and Data Collection

The study involved 21 respondents representing 15 stakeholder institutions directly engaged in the preparation of the R3P in Raja Ampat Regency. Respondents were selected using purposive sampling based on their institutional authority, responsibilities, and active involvement in post-disaster rehabilitation and reconstruction planning [17].

Primary data were collected through structured questionnaires and semi-structured interviews to obtain information on communication, coordination, information sharing, and collaborative relationships among stakeholder institutions. Secondary data were obtained from government regulations, policy documents, disaster reports, regional development plans, and other official documents related to disaster management and post-disaster rehabilitation and reconstruction planning [2], [11], [18], [19]

The questionnaire consisted of two sections. The first section collected respondents' institutional profiles, while the second assessed collaborative relationships among stakeholder institutions, which served as the primary data source for the subsequent Social Network Analysis.

2.4 Social Network Analysis

The collaborative stakeholder network was quantitatively analyzed using UCINET 6 to calculate network indicators, while NetDraw and Gephi were employed to visualize stakeholder interaction patterns and the overall network structure [12], [13], [16], [20]

This study employed four principal Social Network Analysis (SNA) indicators, namely Degree Centrality, Betweenness Centrality, Closeness Centrality, and Network Density. Degree Centrality measures the number of direct connections maintained by each stakeholder within the network. Betweenness Centrality evaluates the ability of a stakeholder to act as an intermediary connecting other actors. Closeness Centrality measures the relative proximity of each stakeholder to all other actors, reflecting the efficiency of information exchange throughout the network. Network Density assesses the overall level of connectivity and collaboration among stakeholders [12], [13], [16]

The questionnaire responses were transformed into a binary adjacency matrix, in which a value of 1 indicates the existence of a collaborative relationship between two stakeholders and 0 indicates no relationship. This matrix served as the primary input for the Social Network Analysis to calculate network indicators and examine stakeholder interaction patterns [12], [16].

The calculated network indicators were subsequently interpreted to identify key stakeholders, institutional interaction patterns, and governance structures supporting collaborative post-disaster rehabilitation and reconstruction planning.

2.5 Data Analysis

Data analysis was conducted in two sequential stages. The first stage involved descriptive statistical analysis to summarize respondents' characteristics and evaluate communication, coordination, information sharing, and stakeholders' perceptions of collaborative governance using mean scores.

The second stage employed Social Network Analysis (SNA) to identify key stakeholders, examine inter-organizational relationships, evaluate network connectivity, and assess stakeholder roles based on Degree Centrality, Betweenness Centrality, Closeness Centrality, and Network Density [12], [13], [16], [20] The analytical results were subsequently interpreted to explain stakeholder interaction patterns and collaborative governance in the preparation of the R3P.

The overall research procedure adopted in this study is illustrated in **Figure 1**.

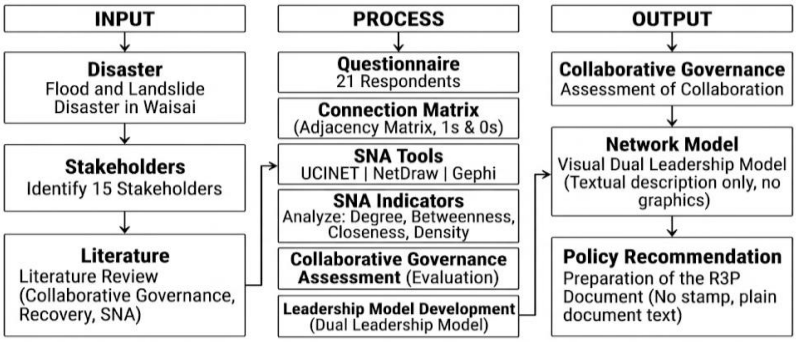


Figure 1. Research workflow based on the Input-Process-Output (IPO) framework.

3 Results and Discussion

3.1 Stakeholder Collaboration Network

The collaborative network established for the preparation of the R3P involved 15 stakeholder institutions representing government agencies, academia, community organizations, the private sector, the media, and supporting institutions. The network was constructed based on institutional relationships involving communication, coordination, and information sharing among stakeholders. These collaborative interactions formed the basis for the subsequent Social Network Analysis (SNA) to evaluate stakeholder positions, network structure, and institutional collaboration.

3.2 Social Network Analysis

Social Network Analysis (SNA) was conducted to evaluate stakeholder interaction patterns and collaborative governance during the preparation of the R3P. The analysis employed four network indicators, namely Degree Centrality, Betweenness Centrality, Closeness Centrality, and Network Density, to identify influential stakeholders, intermediary actors, communication efficiency, and the overall structure of institutional collaboration [12], [13], [16], [20]

Table 1. Social Network Analysis Results of Stakeholder Collaboration in the Preparation of the R3P

No	Stakeholder Institution	Degree Centrality	Betweenness Centrality	Closeness Centrality	Interpretation
1	Regional Disaster Management Agency (BPBD)	14	39,28	0,875	Operational leader and primary coordination hub
2	Regional Development Planning Agency (Bappeda)	12	42,35	0,842	Strategic leader and principal bridging
3	Public Works and Spatial Planning Agency (PUPR)	10	26,74	0,801	Technical coordinator for infrastructure recovery
4	Communication and Informatics Agency	10	18,47	0,794	Information dissemination and communication support
5	Regional Secretariat	9	21,16	0,771	Policy coordination and institutional facilitation
6	Waisai District Office (Kecamatan)	9	15,82	0,754	Local coordination and community liaison
7	Housing and Settlement Agency (Perkim)	8	12,65	0,736	Housing and settlement reconstruction
8	Transportation Agency (Perhubungan)	8	11,44	0,724	Transportation infrastructure recovery

No	Stakeholder Institution	Degree Centrality	Betweenness Centrality	Closeness Centrality	Interpretation
9	Environmental Agency (LH)	8	10,97	0,719	Environmental rehabilitation support
10	Academia	5	7,83	0,633	Scientific and technical advisory
11	Community Leaders	5	6,92	0,619	Community representation and participation
12	Non-Governmental Organization (NGO)	5	6,34	0,612	Community facilitation and social assistance
13	Vertical Government Institutions	4	5,41	0,587	Operational leader and primary coordination hub
14	Private Sector	4	4,62	0,574	Strategic leader and principal bridging
15	Media	3	3,78	0,548	Technical coordinator for infrastructure recovery
	Total Actors: 15			**Density: 0,543**	

Source: Processed primary data using UCINET 6 (2026)

The results demonstrate that BPBD occupies the most central position in the stakeholder network, recording the highest Degree Centrality (14) and Closeness Centrality (0.875). These values indicate that BPBD maintains the largest number of direct collaborative relationships and can communicate with other stakeholders more efficiently than any other institution. This finding confirms the operational role of BPBD as the leading agency responsible for coordinating disaster management and facilitating communication during the preparation of the R3P [7], [12], [14].

Although BPBD dominates direct interactions, Bappeda records the highest Betweenness Centrality (42.35), indicating its strategic position as the principal intermediary connecting government agencies and other stakeholders. This bridging function enables Bappeda to integrate post-disaster rehabilitation and reconstruction programs with regional development planning, budgeting, and policy implementation. The complementary positions of BPBD and Bappeda demonstrate that effective collaborative governance requires both operational coordination and strategic policy integration [6], [8], [13].

Other government agencies, including PUPR, the Communication and Informatics Agency, and the Regional Secretariat, also exhibit relatively high centrality values, reflecting their significant contributions to infrastructure recovery, information exchange, and institutional coordination. In contrast, supporting stakeholders such as academia, community organizations, the private sector, and the media occupy peripheral positions within the network. While these institutions maintain fewer direct connections, they continue to contribute specialized expertise, community engagement, technical support, and public communication, thereby strengthening the overall collaborative governance system [7], [8], [17].

The stakeholder network achieved a Network Density value of 0.543, indicating that approximately 54.3% of all possible collaborative relationships were established among stakeholder institutions. This value reflects a moderately strong collaborative network, characterized by active communication and coordination among key organizations. Nevertheless, the limited connectivity of several supporting stakeholders suggests opportunities to further strengthen institutional collaboration through more inclusive coordination mechanisms and broader stakeholder engagement [4], [5], [8].

Overall, the Social Network Analysis reveals a collaborative governance structure characterized by complementary leadership roles. BPBD functions as the operational coordination center, while Bappeda serves as the strategic coordination hub linking disaster recovery with regional development planning. These empirical findings provide the foundation for the proposed Dual Leadership Network Model, which is presented and discussed in the following section.

3.3 Proposed Dual Leadership Network Model and Collaborative Governance Implications

The Social Network Analysis demonstrates that collaborative governance in the preparation of the R3P is characterized by complementary leadership rather than dominance by a single institution. The analysis reveals that BPBD and Bappeda occupy

different but mutually reinforcing positions within the stakeholder network. BPBD records the highest Degree Centrality and Closeness Centrality, indicating its primary role in operational coordination, communication, and stakeholder engagement. In contrast, Bappeda exhibits the highest Betweenness Centrality, reflecting its strategic role in connecting stakeholder institutions and integrating disaster recovery planning with regional development policies. These findings suggest that effective collaborative governance depends on the complementary functions of both institutions rather than on centralized leadership alone [4]- [6], [8], [14]

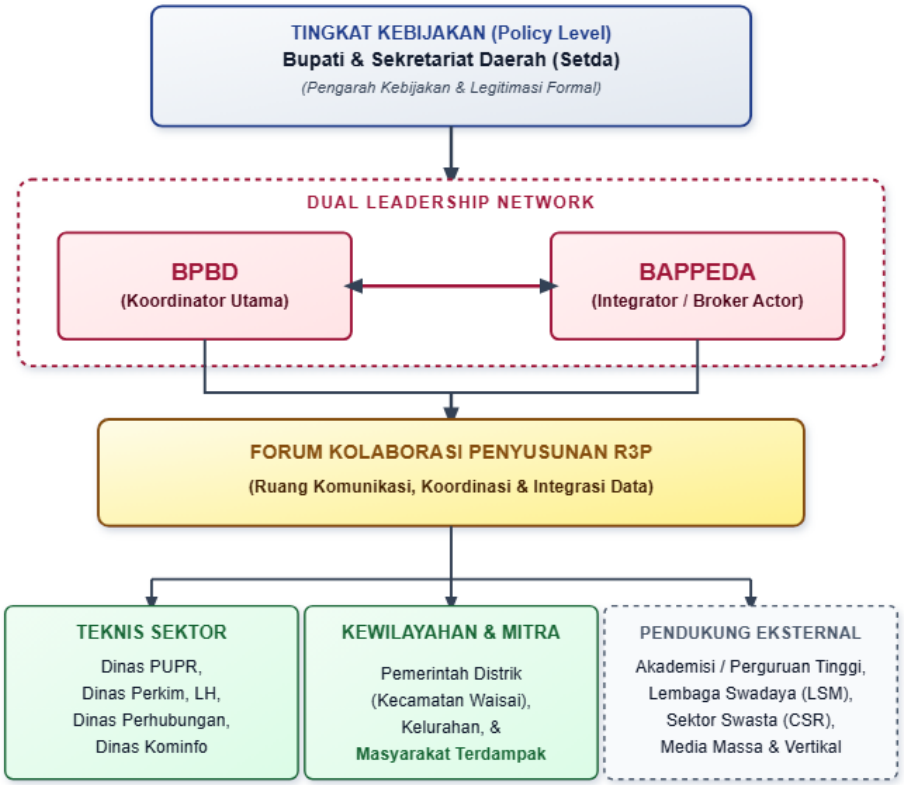


Figure 2. Dual Leadership Network Model.

Based on these findings, this study proposes a Dual Leadership Network Model to strengthen collaborative governance during the preparation of the R3P (**Figure 2**). The model positions BPBD as the Operational Leadership Hub, responsible for coordinating disaster response, facilitating communication, managing stakeholder interactions, and ensuring the implementation of post-disaster rehabilitation and reconstruction activities. Meanwhile, Bappeda functions as the Strategic Leadership Hub, responsible for policy integration, development planning, resource allocation, inter-sectoral coordination, and alignment between disaster recovery programs and regional development priorities. The complementary interaction between these two institutions enhances institutional coordination while maintaining clear functional responsibilities.

The proposed model also emphasizes the active participation of supporting stakeholders, including technical agencies, academia, community organizations, the private sector, the media, and vertical government institutions. Rather than functioning as isolated actors, these stakeholders contribute specialized expertise, technical assistance, community participation, information dissemination, and resource mobilization through continuous collaboration with the two leadership hubs. Such a governance structure promotes shared responsibility, improves communication efficiency, and strengthens institutional resilience in disaster recovery planning [7], [8], [17].

The findings extend previous studies on collaborative governance by demonstrating that stakeholder effectiveness is influenced not only by institutional authority but also by network position and interaction patterns. While earlier studies highlighted the importance of collaboration in disaster management [7], [8], this study integrates Collaborative Governance Theory with Social Network Analysis to provide empirical evidence of leadership distribution within stakeholder networks. Therefore, the proposed Dual Leadership Network Model represents the principal scientific contribution of this

study by providing an evidence-based collaborative governance framework that strengthens institutional coordination, enhances stakeholder collaboration, and supports sustainable post-disaster rehabilitation and reconstruction planning in disaster-prone regions.

4 Conclusion

This study demonstrates that Social Network Analysis (SNA) is an effective approach for evaluating stakeholder collaboration in the preparation of the R3P in Waisai City, Raja Ampat Regency. The analysis identified a collaborative network involving 15 stakeholder institutions with a moderately strong network density (0.543), indicating that institutional collaboration has been established but still requires further strengthening to achieve more integrated disaster recovery planning.

The findings reveal complementary leadership roles within the stakeholder network. BPBD occupies the highest position in Degree Centrality and Closeness Centrality, reflecting its function as the primary operational coordinator responsible for communication, coordination, and stakeholder engagement. In contrast, Bappeda records the highest Betweenness Centrality, indicating its strategic role in connecting institutions and integrating post-disaster rehabilitation and reconstruction programs with regional development planning. These complementary roles demonstrate that effective collaborative governance relies on balanced operational and strategic leadership rather than on a single dominant institution.

Based on these findings, this study proposes the Dual Leadership Network Model as its principal scientific contribution. The model provides an evidence-based collaborative governance framework that integrates the operational leadership of BPBD with the strategic leadership of Bappeda while strengthening stakeholder participation, institutional coordination, and information sharing throughout the R3P preparation process. This framework offers a practical reference for improving collaborative governance and supporting more effective, integrated, and sustainable post-disaster rehabilitation and reconstruction planning, particularly in disaster-prone regions.

Future research is recommended to validate and refine the proposed Dual Leadership Network Model by applying it to different disaster types, geographical settings, and institutional contexts. Comparative studies across regions are also needed to evaluate the model's adaptability and effectiveness in strengthening collaborative governance for post-disaster rehabilitation and reconstruction planning.

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