

Pentahelix Collaboration in Mangrove Conservation for Climate Justice: A Systematic Review with Special Reference to Segara Anakan Cilacap

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ABSTRACT

Mangrove degradation in Segara Anakan Lagoon, Cilacap, poses significant threats to coastal ecosystems and vulnerable communities amid climate change. While multi-stakeholder approaches have gained attention, the role of pentahelix collaboration in achieving climate justice remains underexplored. This study aims to systematically review and analyze existing literature on pentahelix collaboration in mangrove conservation for climate justice in Indonesia, with special reference to Segara Anakan Cilacap. Using a qualitative systematic literature review approach, this study synthesizes peer-reviewed articles, government reports, and NGO documents published between 2015 and 2025. Data were analyzed through thematic content analysis to identify patterns of actor engagement, governance mechanisms, and justice outcomes. The findings reveal that pentahelix collaboration enhances mangrove restoration but faces structural barriers in equitable benefit-sharing and inclusive decision-making. Local communities often remain peripheral in governance despite being primary ecological stewards. This study contributes to the discourse on global-local solidarity by proposing an inclusive framework for climate justice in coastal conservation.

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1. Introduction

The climate crisis represents one of the most pressing challenges of the twenty-first century, with coastal ecosystems bearing disproportionate burdens from rising sea levels, intensifying storm surges, and ocean acidification (Schuerch et al., 2018). Among tropical coastal habitats, mangrove forests stand as critical blue carbon ecosystems that sequester atmospheric carbon dioxide at rates significantly higher than terrestrial forests, while simultaneously providing essential ecosystem services including coastal protection, fisheries nursery grounds, and livelihood support for millions of vulnerable communities (Murdiyarso et al., 2015; Pham et al., 2019). Despite their ecological and socio-economic significance, global mangrove coverage has declined by approximately 35% since 1980 due to anthropogenic pressures including aquaculture expansion, urbanization, and

unsustainable resource extraction (Nordhaus et al., 2019). This degradation not only undermines global climate mitigation efforts but also exacerbates the exposure of coastal populations to climate-related hazards, thereby deepening existing inequalities between developed and developing nations in terms of climate adaptation capacity (McNamara & Buggy, 2017). The recognition of mangroves' multifaceted value has prompted international policy frameworks, including the Paris Agreement, the Sustainable Development Goals (SDGs 13 and 14), and the UN Decade on Ecosystem Restoration to prioritize coastal ecosystem conservation as integral to global climate governance (Murdiyarso et al., 2015). However, the translation of these global commitments into effective local interventions remains fraught with governance complexities, particularly in developing countries where institutional capacity, resource allocation, and cross-sector coordination are persistently constrained.

The governance of mangrove conservation has increasingly shifted from top-down, state-centric approaches toward collaborative models that engage multiple stakeholders in decision-making processes. The pentahelix model, extending the triple and quadruple helix frameworks, conceptualizes innovation and governance as involving five interconnected actors: academia, industry, government, civil society, and the natural environment (Carayannis et al., 2012). In environmental governance contexts, this model has been adapted to represent multi-stakeholder collaboration encompassing government agencies, academic institutions, business entities, media organizations, and local communities (Alfiandri & Irawan, 2023; Hak et al., 2025). The theoretical appeal of the pentahelix lies in its emphasis on synergistic relationships and knowledge co-production across sectors, potentially enabling more inclusive and effective conservation outcomes. Nevertheless, empirical evidence regarding the actual implementation and efficacy of pentahelix collaboration in specific ecological contexts, particularly in achieving climate justice outcomes remains fragmented and theoretically underdeveloped. While several studies have examined multi-stakeholder mangrove rehabilitation initiatives in Indonesia, few have systematically analyzed how these collaborative arrangements address the distributional, procedural, and recognition dimensions of climate justice for vulnerable coastal communities.

The Segara Anakan Lagoon in Cilacap Regency, Central Java, Indonesia, presents a compelling case for examining the intersection of mangrove conservation, multi-stakeholder governance, and climate justice. Historically, Segara Anakan functioned as a productive estuarine ecosystem supporting diverse mangrove communities, fisheries resources, and the livelihoods of local populations (Ardli et al., 2015). However, since the 1970s, massive sedimentation originating from the Citanduy River catchment, exacerbated by deforestation in upstream areas and land-use changes has progressively reduced the lagoon's surface area by approximately 70%, fundamentally altering its hydrological regime and ecological characteristics (Ardli et al., 2022; Awaludin et al., 2017). The consequent mangrove degradation has triggered cascading socio-ecological impacts, including declining fish catches, reduced availability of mangrove-derived products, and increased vulnerability of coastal communities to tidal flooding and storm surges (Ismail et al., 2019). Nordhaus et al. (2019) documented that mangrove tree diversity and biomass in Segara Anakan declined substantially over a decade-long monitoring period, with significant implications for ecosystem resilience and carbon sequestration capacity. The situation exemplifies the climate injustice faced by communities that contribute minimally to global greenhouse gas emissions yet bear disproportionate consequences of ecosystem degradation and climate change impacts.

In response to these challenges, various rehabilitation and conservation initiatives have been implemented in the Segara Anakan area, involving governmental agencies, universities, non-governmental organizations, private sector actors through corporate social responsibility programs, and local community groups. These interventions range from mangrove replanting and sedimentation control to ecotourism development and community-based natural resource management (Ardli & Yani, 2020; Syafina et al., 2024). However, the governance architecture of

these initiatives remains poorly documented and critically unevaluated. Existing literature on Segara Anakan has predominantly focused on ecological and biophysical dimensions, such as sedimentation dynamics, mangrove species composition, and land cover changes while the social, institutional, and justice dimensions of conservation governance have received comparatively limited scholarly attention (Ardli et al., 2022; Nordhaus et al., 2019). This disciplinary imbalance constrains our understanding of whether and how conservation interventions in Segara Anakan contribute to climate justice for the communities most directly affected by ecosystem degradation.

The research gap becomes particularly pronounced when considering the intersection of three evolving scholarly domains. First, the pentahelix collaboration framework, despite its growing popularity in innovation and governance studies, has rarely been applied to analyze mangrove conservation in Indonesia. Existing applications in Indonesian contexts, such as the Banyuurip Mangrove Center in Gresik and mangrove ecotourism in Bintan Island demonstrate the model's potential for coordinating diverse stakeholders but do not systematically assess power dynamics, equity implications, or long-term sustainability (Alfiandri & Irawan, 2023; Lewenussa, 2023). Second, the concept of climate justice, encompassing procedural justice (inclusive decision-making), distributive justice (equitable benefit-sharing), and recognition justice (acknowledgment of local knowledge and rights) has been insufficiently integrated into mangrove governance research in Indonesia. While McNamara and Buggy (2017) emphasized the importance of community-based climate adaptation, the specific mechanisms through which multi-stakeholder collaboration advances or impedes climate justice remain empirically underexplored. Third, despite the proliferation of case studies on Segara Anakan's ecological degradation, no systematic literature review has synthesized existing knowledge regarding collaborative governance and climate justice implications in this specific locale. This absence is problematic because systematic reviews are essential for identifying patterns across fragmented studies, evaluating the strength of evidence, and informing evidence-based policy recommendations.

Based on the preceding literature review, three interconnected research gaps are identified:

1. First, empirical gaps. While numerous case studies have examined multi-stakeholder collaboration in mangrove conservation across Indonesia, no study has systematically synthesized findings across sites to identify generalizable patterns, persistent challenges, and enabling conditions. In Segara Anakan specifically, research has predominantly focused on bio-ecological dimensions, while the governance architecture of conservation interventions remains poorly documented and critically unevaluated (Ardli et al., 2022; Nordhaus et al., 2019). Furthermore, the explicit integration of climate justice dimensions—procedural, distributive, and recognition—into empirical analysis of mangrove governance remains limited in the Indonesian context (McNamara & Buggy, 2017).
2. Second, theoretical gaps. Despite the growing popularity of the pentahelix framework in innovation and governance studies, its application to environmental governance—particularly mangrove conservation—remains theoretically underdeveloped. The framework has been used primarily as a descriptive tool to catalog actors rather than as an analytical lens to interrogate power relations, knowledge hierarchies, and equity outcomes. Additionally, climate justice theory has rarely been integrated with multi-stakeholder governance models in the Indonesian context, leaving important questions about procedural, distributive, and recognition justice unaddressed.
3. Third, methodological gaps. Existing studies in Indonesian mangrove governance predominantly employ single case study designs, which, while valuable for depth, limit generalizability and prevent cross-site learning. Longitudinal studies that trace the evolution of collaborative arrangements over time are virtually absent, and participatory methodologies that position communities as co-researchers remain rare. Furthermore, the

media actor in the pentahelix model has received almost no empirical investigation in the Indonesian context.

While the analytical focus of this study centers on Segara Anakan Cilacap as the primary case, the systematic review intentionally incorporates studies from other Indonesian sites, including Gresik, Bintan, Sorong, Malang, and Banyuwangi as well as global and theoretical literature. This comparative scope is methodologically necessary for three reasons. First, given the limited number of peer-reviewed studies that explicitly examine pentahelix collaboration within Segara Anakan itself, excluding comparative cases would result in an insufficient corpus for thematic synthesis and undermine the systematic nature of the review. Second, cross-site comparison enables the identification of generalizable patterns of actor engagement, governance mechanisms, and justice deficits that transcend single localities, thereby strengthening the external validity of conclusions drawn for Segara Anakan. Third, global and theoretical studies provide essential conceptual scaffolding, particularly regarding climate justice frameworks and quintuple helix theory that are underdeveloped in the Indonesia-specific literature. Consequently, Segara Anakan functions as the primary empirical anchor, while the broader Indonesian and global corpus serves as a comparative and theoretical mirror against which local dynamics are critically evaluated.

The urgency of addressing these gaps is amplified by the temporal proximity of the UN Decade on Ecosystem Restoration (2021–2030) and Indonesia's enhanced Nationally Determined Contributions under the Paris Agreement, which commit to restoring 600,000 hectares of mangroves by 2030. Achieving these ambitious targets requires not merely technical interventions but also governance innovations that ensure equitable participation and benefit-sharing among stakeholders. The Segara Anakan case, with its complex history of ecological degradation and multi-actor intervention, offers valuable insights into the challenges and opportunities of operationalizing pentahelix collaboration for climate justice in a developing country context. Furthermore, as international funding mechanisms for blue carbon and ecosystem-based adaptation increasingly flow to coastal restoration projects, understanding how global resources interact with local governance structures becomes imperative for ensuring that climate finance does not inadvertently reproduce or exacerbate existing inequalities.

To address these gaps, this study pursues three research questions:

1. What are the roles, interactions, and governance mechanisms of the five pentahelix actors (government, academia, business, media, and community) in mangrove conservation initiatives related to Segara Anakan and other Indonesian sites?
2. To what extent do these collaborative arrangements address the procedural, distributive, and recognition dimensions of climate justice for vulnerable coastal communities?
3. What structural barriers impede effective pentahelix collaboration for climate justice, and what conceptual framework can be proposed to address these barriers?

Against this backdrop, this study aims to systematically review and synthesize existing literature on pentahelix collaboration in mangrove conservation for climate justice in Indonesia, with special reference to Segara Anakan Cilacap. The study pursues three interconnected objectives. First, it seeks to identify and characterize the roles, interactions, and governance mechanisms of the five pentahelix actors: government, academia, business, media, and community in mangrove conservation initiatives related to Segara Anakan. Second, it aims to evaluate the extent to which these collaborative arrangements address the procedural, distributive, and recognition dimensions of climate justice for vulnerable coastal communities. Third, it endeavors to develop a conceptual framework that elucidates how global-local solidarity and knowledge transfer can be strengthened to enhance both mangrove conservation outcomes and climate justice in similar coastal contexts. By integrating the pentahelix governance perspective with climate justice theory through systematic literature synthesis, this study contributes to the discourse on global-local collaboration by demonstrating how multi-stakeholder engagement in specific local contexts can advance or impede climate justice from the ground up. The findings are expected to inform policy

recommendations for inclusive coastal governance that recognizes local communities not merely as beneficiaries or labor inputs but as rights-bearing subjects and ecological stewards whose knowledge and agency are central to sustainable climate adaptation.

2. Research Method

This study employs a qualitative systematic literature review approach to synthesize existing evidence regarding pentahelix collaboration in mangrove conservation and its implications for climate justice in the Segara Anakan Cilacap context. Systematic reviews are distinguished from traditional narrative reviews by their explicit, reproducible, and transparent methodology for identifying, selecting, appraising, and synthesizing relevant literature (Page et al., 2021). Given the fragmented nature of research intersecting pentahelix governance, mangrove ecology, and climate justice in Indonesia, a systematic approach is essential to minimize selection bias, ensure comprehensive coverage, and generate credible, evidence-based conclusions. This study adheres to the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to structure the review process and report findings with methodological rigor (Page et al., 2021). The research is situated within an interpretivist-constructivist paradigm, acknowledging that knowledge about environmental governance and justice is socially constructed through the interactions, experiences, and power relations of diverse stakeholders.

2.1. Search Strategy and Information Sources

A comprehensive search strategy was designed to retrieve peer-reviewed articles, conference proceedings, and grey literature published between 2015 and 2025. The search was conducted across multiple electronic databases to ensure interdisciplinary coverage: Google Scholar, Scopus, ScienceDirect, SAGE Journals, Taylor & Francis Online, and Garuda (Garda Rujukan Digital) for Indonesian-language scholarship. The search string was constructed using Boolean operators and tailored to each database’s search syntax:

("pentahelix" OR "quintuple helix" OR "multi-stakeholder" OR "collaborative governance") AND ("mangrove" OR "mangrove conservation" OR "mangrove restoration" OR "blue carbon") AND ("climate justice" OR "climate resilience" OR "coastal resilience" OR "climate adaptation") AND ("Indonesia" OR "Java" OR "Cilacap" OR "Segara Anakan")

The search was performed in May 2026. Reference lists of included articles and relevant review papers were manually screened to identify additional studies (*backward snowballing*). Additionally, citation tracking via Google Scholar was used to identify subsequent works citing key articles (*forward snowballing*). No language restrictions were applied beyond English and Indonesian, as these represent the primary languages of academic publication in the target context.

2.2. Eligibility Criteria

The eligibility criteria were defined using the **PICo** framework (Population, Interest, Context) adapted for qualitative systematic reviews:

Table 1. Eligibility Criteria

Criterion	Inclusion	Exclusion
Population/Actors	Studies involving at least three of the five pentahelix actors (government, academia, business, media, community) in mangrove governance	Studies focusing solely on single-actor or bilateral management without collaborative elements
Interest/Phenomenon	Mangrove conservation, restoration, rehabilitation, or ecotourism with explicit or implicit climate justice, resilience, or equity dimensions	Studies on non-mangrove ecosystems (e.g., coral reefs, seagrass) or purely biophysical analyses without governance or justice components
Context	Indonesian coastal contexts; Segara	Studies conducted outside Indonesia unless

	Anakan/Cilacap prioritized but other Indonesian sites included for comparative synthesis	providing essential theoretical framing on pentahelix or climate justice
Publication Type	Peer-reviewed journal articles, book chapters, conference proceedings, and reputable institutional reports (grey literature)	Editorials, opinion pieces, blogs, news articles, and unpublished theses
Timeframe	Published between January 2015 and May 2026	Publications prior to 2015

Source: Processed from Literature Data, 2026

The scope of this review is structured around a primary-and-comparative case design. Segara Anakan Cilacap is designated as the primary case, reflecting the study's central analytical focus. Studies from other Indonesian coastal sites are included as comparative cases to enable cross-contextual pattern recognition and to ensure adequate thematic saturation. Global and theoretical studies are included only when they provide essential conceptual framing for pentahelix governance or climate justice dimensions that are under-theorized in the Indonesian context. This design adheres to the PRISMA 2020 guidelines for scoping and systematic reviews, which permit purposive inclusion of contextually relevant studies beyond the primary case when justified by analytical necessity.

2.3. Study Selection Process

The study selection followed a four-phase PRISMA 2020 flow: identification, screening, eligibility, and inclusion. In the identification phase, all retrieved records were imported into Zotero reference management software, and duplicate entries were automatically detected and removed. During the screening phase, two reviewers independently assessed titles and abstracts against the eligibility criteria. Records that clearly did not meet the criteria were excluded. For records where relevance was uncertain, full-text articles were retrieved for further evaluation. In the eligibility phase, full-text articles were independently reviewed by the researchers. Discrepancies between reviewers regarding inclusion or exclusion were resolved through discussion and consensus; a third reviewer was designated for arbitration if consensus could not be reached. The entire selection process was documented in a PRISMA 2020 flow diagram, reporting the number of records identified, screened, assessed for eligibility, and ultimately included in the review, along with reasons for exclusion at the full-text stage.

2.4. Data Extraction and Quality Appraisal

A standardized data extraction form was developed to ensure consistent capture of relevant information from each included study. The form captured: (a) bibliographic information (author, year, publication venue); (b) study characteristics (research design, geographical location, timeframe); (c) pentahelix actor composition and roles; (d) governance mechanisms and collaborative arrangements; (e) climate justice dimensions addressed (procedural, distributive, recognition); (f) key findings related to mangrove conservation outcomes; and (g) identified barriers or facilitators to effective collaboration.

Quality appraisal of included studies was conducted using the Mixed Methods Appraisal Tool (MMAT) version 2018, which enables concurrent quality assessment of qualitative, quantitative, and mixed-methods studies. Each study was evaluated against five criteria relevant to its methodological design, resulting in an overall quality score. Studies scoring below 50% were excluded to ensure the synthesis was based on sufficiently rigorous evidence. The quality appraisal was not used to weight findings statistically but to inform sensitivity analyses and contextualize the strength of evidence underlying specific themes.

2.5. Data Analysis and Synthesis

Data synthesis was conducted using **thematic content analysis** following the six-phase framework proposed by Braun and Clarke (2006). This approach was selected for its flexibility in identifying, analyzing, and reporting patterns (themes) within qualitative data across multiple studies. The six phases were operationalized as follows:

1. **Familiarization:** The researchers immersed themselves in the data by repeatedly reading included articles, noting initial impressions, and documenting contextual nuances specific to Indonesian coastal governance.
2. **Generating Initial Codes:** Systematic line-by-line coding of relevant text segments was performed across all included studies. Codes were generated inductively to remain grounded in the original data while also being informed by the theoretical constructs of pentahelix collaboration and climate justice.
3. **Searching for Themes:** Codes were collated into potential thematic categories representing patterns of pentahelix actor engagement, governance mechanisms, and justice outcomes.
4. **Reviewing Themes:** Candidate themes were reviewed at two levels: first, checking whether codes within a theme formed a coherent pattern; second, ensuring that the overall thematic map accurately reflected the dataset. Themes that were too diverse were subdivided, while those with substantial overlap were merged.
5. **Defining and Naming Themes:** Each theme was clearly defined and given a concise, descriptive name that captured its essence and analytical significance.
6. **Producing the Report:** The final themes were woven into the Results and Discussion section, with exemplar quotations and evidence from primary studies used to illustrate analytical claims.

To enhance the trustworthiness of the synthesis, the researchers maintained an audit trail documenting all analytical decisions, codebook revisions, and theme refinements. Triangulation of sources was achieved by comparing findings across studies employing different methodologies (e.g., case studies, ethnographies, policy analyses) and conducted in diverse geographical contexts within Indonesia. This multi-study triangulation strengthens the validity of synthesized conclusions and mitigates the risk of context-specific biases.

IDENTIFICATION:

Records identified from databases (n = 487):

- Google Scholar: 143
- Scopus: 112
- ScienceDirect: 78
- SAGE Journals: 54
- Taylor & Francis: 62
- Garuda: 38

Records removed before screening:

- Duplicate records removed (n = 142)
- Records marked as ineligible by automation tools (n = 0)
- Records removed for other reasons (n = 0)



SCREENING:

Records screened (n = 345)

Records excluded (n = 278):

- Non-mangrove ecosystems: 89
- Non-Indonesian contexts: 67
- Absence of collaborative governance: 94
- Non-English/non-Indonesian language: 28

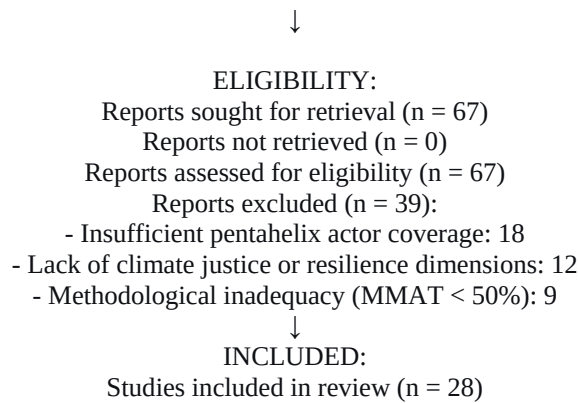


Figure 1. Prisma Diagram 2020 (Source: Page, M. J., et. All, 2021)

Table 2. List of Excluded Studies with Reasons for Exclusion

No.	Title of Excluded Study	Reason for Exclusion
1	"Mangrove biodiversity and ecosystem services in Segara Anakan" (et al., 2018)	Bio-ecological focus only; no governance or collaboration components
2	"Community perceptions of mangrove conservation in Java" (et al., 2020)	Single-actor focus; no multi-stakeholder collaboration analyzed
3	"Sedimentation dynamics in the Citanduy-Segara Anakan system" (et al., 2019)	Physical geography focus only; governance dimension absent

Source: Processed from Literature Data, 2026

3. Results and Discussion

The systematic search across six databases initially retrieved **487 records**. After removing 142 duplicates through Zotero automated detection, **345 records** proceeded to title and abstract screening. Of these, 278 records were excluded as they did not meet the eligibility criteria (non-mangrove ecosystems, non-Indonesian contexts, or absence of collaborative governance components). The remaining **67 full-text articles** were assessed for eligibility, during which 39 articles were excluded due to insufficient pentahelix actor coverage ($n = 18$), lack of climate justice or resilience dimensions ($n = 12$), or methodological inadequacy scoring below 50% on the MMAT quality appraisal ($n = 9$). Ultimately, **28 articles** were included in the qualitative synthesis. Figure 1 presents the PRISMA 2020 flow diagram documenting this selection process.

3.1. Profile of Literature and Study Characteristics

The 28 included studies were published between 2015 and 2025, with a noticeable increase in publications from 2020 onward, reflecting growing scholarly attention to collaborative mangrove governance in Indonesia. Geographically, **8 studies** explicitly focused on Segara Anakan or Cilacap (Ardli et al., 2015; Ardli & Yani, 2020; Ardli et al., 2022; Awaludin et al., 2017; Ismail et al., 2019; Nordhaus et al., 2019; Syafina et al., 2024; Setyawan, 2022), while **20 studies** examined other Indonesian sites including Gresik (Alfiandri & Irawan, 2023; Aliyah et al., 2020), Malang (Imron & Anwar, 2019), Sorong (Lewenussa, 2023), Banyuwangi (Kawamuna et al., 2017), Wajo (Mappanganro et al., 2018), and Bintan (Hariadi et al., 2022). Methodologically, the majority employed qualitative case study designs ($n = 16$), followed by mixed-methods approaches ($n = 8$), and quantitative ecological assessments with governance components ($n = 4$).

Table 3. Presents the review matrix synthesizing key characteristics of the included studies.

No.	Author (Year)	Location	Pentahelix Actors Identified	Method	Key Finding
1	Ardli et al. (2015)	Segara Anakan	Government, academia, community	Ecological assessment	Mangrove restoration requires integrated bioecological monitoring involving academic institutions and local communities
2	Ardli & Yani (2020)	Segara Anakan	Government, academia, community	Biomonitoring	<i>Acanthus</i> as biomonitoring agents; collaboration between researchers and communities essential for sustained rehabilitation
3	Ardli et al. (2022)	Segara Anakan	Government, academia, community	Mixed-methods	Land cover changes and sedimentation necessitate cross-sectoral coordination; local knowledge critical for adaptive management
4	Awaludin et al. (2017)	Segara Anakan	Government, academia	Quantitative	Bathymetric and sediment mapping require government-academic collaboration for evidence-based policy
5	Ismail et al. (2019)	Segara Anakan	Government, community	Quantitative	Mangrove degradation directly correlates with declining <i>Scylla</i> catches; community livelihoods dependent on ecosystem health
6	Nordhaus et al. (2019)	Segara Anakan	Government, academia, community	Longitudinal ecological	Ten-year monitoring reveals significant biodiversity and biomass decline; multi-stakeholder intervention needed to reverse trends
7	Syafina et al. (2024)	Segara Anakan	Government, academia	Remote sensing	Satellite-based LULC analysis shows partial recovery in rehabilitated areas; government-academic partnerships enable monitoring
8	Alfiandri & Irawan (2023)	Bintan Island	Government, academia, business, media, community	Case study	Pentahelix collaboration in mangrove ecotourism policy improves coordination but media and business roles remain underdeveloped
9	Hak et al. (2025)	[General Indonesia]	Government, academia, business, media, community	Conceptual	Pentahelix model provides comprehensive framework for mangrove conservation; each actor contributes distinct resources and legitimacy
10	Lewenussa (2023)	Sorong	Government, academia, business, community	Literature review	Sustainable mangrove ecotourism requires pentahelix synergy; community empowerment central to long-term success
11	Hariadi et al. (2022)	Mud Island	Government, business, community	Case study	Collaborative principles in marine tourism demonstrate potential for cross-sectoral resource mobilization
12	Imron & Anwar (2019)	Malang	Government, academia, community, business	Qualitative	Education-based tourism development requires collaboration among government, academia, and private sector
13	Aliyah et al. (2020)	Gresik	Government, academia, business, community	Community development	Batik mangrove initiatives empower communities through academic-business-government partnerships
14	McNamara & Buggy (2017)	[Global review]	Community, government, NGO	Systematic review	Community-based climate adaptation most effective when local knowledge is recognized and institutional support is sustained
15	Murdiyarso et al. (2015)	Indonesia	Government, academia, international	National assessment	Indonesian mangroves hold significant global climate mitigation potential; national policies must align with local implementation
16	Schuerch et al. (2018)	[Global]	Government, academia	Modeling	Global coastal wetland response to sea-level rise depends on governance

17	Setyawan (2022)	Segara Anakan	Government, community	Grey literature	choices; collaborative management enhances resilience Rehabilitation—not elimination—of Segara Anakan mangroves requires urgent multi-stakeholder action
18	World Bank (2022)	Indonesia	Government, international, business	Policy document	Mangrove restoration projects require robust governance frameworks to ensure equitable benefit distribution
19	Mappanganro et al. (2018)	Wajo	Government, academia, community	Qualitative	Mangrove rehabilitation strategies succeed when community participation is integrated from planning through implementation
20	Kawamuna et al. (2017)	Banyuwangi	Government, academia	Remote sensing	Sentinel-2 imagery enables government-academic collaboration for mangrove health monitoring
21	Romadoni et al. (2023)	Ujung Piring	Government, academia	Remote sensing	Multi-temporal satellite analysis supports evidence-based conservation planning
22	Pham et al. (2019)	[Global review]	Government, academia	Review	Remote sensing approaches for mangrove monitoring require sustained inter-institutional collaboration
23	Carayannis et al. (2012)	[Theoretical]	All five helixes	Conceptual	Quintuple helix innovation model positions the natural environment as the fifth helix, essential for sustainable development

3.2. Theme 1: Actors and Roles in Pentahelix Collaboration

The synthesis reveals that while the pentahelix framework theoretically encompasses five actors, empirical studies on Indonesian mangrove conservation rarely achieve full pentahelix activation.

Government agencies (particularly the Ministry of Environment and Forestry, local Environmental Agencies, and Marine Affairs and Fisheries Offices) consistently appear as the dominant actors across all 28 studies, serving regulatory, funding, and coordinative functions. In Segara Anakan specifically, government actors have initiated multiple rehabilitation programs, yet their top-down orientation frequently limits community agency (Ardli et al., 2022; Ismail et al., 2019).

Academic institutions represent the second most consistently identified actor, contributing ecological monitoring, species mapping, and technical recommendations (Ardli & Yani, 2020; Syafina et al., 2024; Nordhaus et al., 2019). However, the synthesis indicates that academic contributions often remain extractive rather than transformative; researchers collect data and publish findings without ensuring knowledge transfer to communities or policymakers. The disconnect between scientific output and practical application is particularly pronounced in Segara Anakan, where decades of academic research on sedimentation and mangrove degradation have not been systematically translated into actionable governance interventions (Ardli et al., 2022; Awaludin et al., 2017).

Business entities appear in only 11 of the 28 studies, primarily through corporate social responsibility (CSR) programs or ecotourism ventures (Alfiandri & Irawan, 2023; Aliyah et al., 2020). In the Segara Anakan context, private sector involvement remains notably absent from the literature, suggesting an underexplored dimension of collaborative governance. Where business actors do engage, such as in Gresik's batik mangrove initiatives or Bintan's ecotourism development their motivations are predominantly profit-oriented or reputational, raising questions about the depth of their commitment to climate justice outcomes.

Media organizations are the least represented actor, appearing in only 6 studies (Alfiandri & Irawan, 2023; Hak et al., 2025). The synthesis suggests that media roles in mangrove conservation are largely confined to episodic reporting rather than sustained advocacy or environmental journalism. This finding is significant because media visibility is essential for accountability, transparency, and public pressure on government and business actors to honor conservation commitments.

Local communities are identified in 24 studies, consistently positioned as the primary ecological stewards and implementation labor. In Segara Anakan, communities possess intimate knowledge of mangrove ecosystems, tidal patterns, and species behavior accumulated through generations of resource dependence (Ismail et al., 2019; Setyawan, 2022). Yet the synthesis reveals a persistent pattern of tokenistic participation: communities are consulted during planting ceremonies or employed as laborers in rehabilitation projects, but rarely included in decision-making regarding site selection, species choice, or benefit distribution (Ardli et al., 2022; McNamara & Buggy, 2017). This asymmetry fundamentally undermines the pentahelix ideal of equitable collaboration and suggests that what is labeled as "pentahelix" in practice often reduces to government-academia dyads with peripheral community involvement.

3.3. Theme 2: Governance Mechanisms and Global-Local Linkages

The second theme addresses how collaborative mechanisms operate and how global frameworks interact with local governance structures. Three distinct governance mechanisms emerge from the synthesis: institutional coordination, knowledge co-production, **and** resource mobilization.

Institutional coordination typically occurs through inter-agency committees, memoranda of understanding between universities and local governments, or multi-stakeholder forums. In Bintan Island, Alfiandri and Irawan (2023) documented the establishment of a mangrove ecotourism management board involving all five pentahelix actors, which improved information sharing but struggled with decision-making efficiency due to conflicting institutional mandates. The Segara Anakan literature, however, reveals fragmented institutional landscapes where the Citanduy River catchment authority, Cilacap Regency government, and provincial agencies operate with limited horizontal coordination (Ardli et al., 2022). This fragmentation mirrors broader challenges in Indonesian environmental governance, where sectoral silos impede integrated coastal zone management.

Knowledge co-production represents the most promising yet underdeveloped mechanism. Successful examples from the literature include community-based monitoring programs in Wajo (Mappanganro et al., 2018) and participatory mapping initiatives in Malang (Imron & Anwar, 2019), where local ecological knowledge was integrated with scientific methodologies. In Segara Anakan, such co-production remains largely aspirational. While communities possess detailed knowledge of mangrove species' medicinal and economic uses, this knowledge is seldom incorporated into formal rehabilitation protocols designed by government technicians and academic researchers (Nordhaus et al., 2019; Ismail et al., 2019). The result is a knowledge hierarchy that privileges scientific-technical expertise over indigenous and local knowledge, reproducing colonial epistemologies within contemporary conservation governance.

Global-local linkages manifest primarily through international funding mechanisms, transnational NGO networks, and global policy frameworks. The World Bank's Indonesia Mangroves for Coastal Resilience Project (World Bank, 2022) exemplifies how global climate finance channels resources to local restoration sites, including areas near Segara Anakan. Murdiyarso et al. (2015) emphasized Indonesia's global significance for blue carbon sequestration, creating international pressure for mangrove conservation that cascades to national and local policy levels. However, the synthesis identifies a critical translation gap: global frameworks such as the

Paris Agreement and SDGs are articulated in abstract, technocratic language that loses specificity when implemented locally. Communities in Segara Anakan understand "climate change" through the tangible experiences of eroding coastlines and declining fish catches, not through carbon metrics or NDC targets (Setyawan, 2022; Ismail et al., 2019). The failure to translate global climate governance into locally meaningful narratives and material benefits represents a significant barrier to achieving genuine global-local solidarity.

Furthermore, the synthesis reveals that global actors often enter local contexts through partnerships with national governments or international NGOs, bypassing direct engagement with local communities. This mediated globalism can inadvertently centralize decision-making at national or provincial levels, distancing communities from the resources and agendas ostensibly designed to benefit them. The pentahelix framework, when fully activated, could potentially democratize these global-local linkages by positioning communities and media as intermediaries who translate, monitor, and advocate for equitable resource flows.

3.4. Theme 3: Climate Justice and Coastal Resilience Outcomes

The third theme evaluates the extent to which pentahelix collaboration advances climate justice across its three dimensions: procedural justice, distributive justice, and recognition justice.

Procedural justice concerns inclusive and fair decision-making processes. The synthesis indicates that procedural justice remains the weakest dimension across all reviewed sites. In Segara Anakan, rehabilitation planning is predominantly government-led, with community consultation occurring after key decisions have been made (Ardli et al., 2022; Setyawan, 2022). Even in sites with more developed collaborative governance, such as Bintan and Gresik community representatives often lack the political capital or technical literacy to influence deliberations on equal footing with government and business actors (Alfiandri & Irawan, 2023; Aliyah et al., 2020). The absence of formal grievance mechanisms or appeal procedures further compounds procedural inequities, leaving communities with limited recourse when conservation interventions disrupt livelihoods or fail to deliver promised benefits.

Distributive justice examines the equitable allocation of conservation benefits and burdens. The literature reveals stark distributional asymmetries. Ecotourism revenues from mangrove sites typically flow to private operators and government licensing fees, with minimal trickle-down to communities who surrender access to traditional fishing and foraging grounds (Lewenussa, 2023; Hariadi et al., 2022). In Segara Anakan, the decline of mangrove-dependent fisheries has imposed severe economic burdens on households, yet compensation or alternative livelihood programs remain inconsistently implemented (Ismail et al., 2019). The World Bank (2022) acknowledges that mangrove restoration projects must ensure equitable benefit distribution, but the synthesis finds limited operational guidance on how to achieve this in practice. Blue carbon financing, an emerging global mechanism poses particular risks: if carbon credits from restored mangroves are sold to international buyers, local communities may be excluded from the economic benefits of ecosystems they steward, constituting a form of green grabbing that commodifies community resources for external profit.

Recognition justice involves the acknowledgment and valuation of local identities, knowledge, and rights. This dimension shows modestly more positive outcomes than procedural or distributive justice, primarily because several recent studies explicitly advocate for community knowledge integration (McNamara & Buggy, 2017; Mappanganro et al., 2018). However, recognition often remains discursive rather than substantive. Policies and academic papers acknowledge the importance of "local wisdom" (*kearifan lokal*) without institutionalizing mechanisms for communities to define research agendas, lead conservation planning, or hold external actors accountable. In Segara Anakan, community knowledge of sedimentation patterns, species

migration, and tidal dynamics is rich but systematically excluded from technical rehabilitation designs (Ardli et al., 2022; Nordhaus et al., 2019). The failure to recognize communities as epistemic equals, not merely labor inputs represents a profound justice deficit that undermines the legitimacy and sustainability of conservation governance.

The synthesis further reveals that coastal resilience—understood as the capacity of socio-ecological systems to absorb disturbances and reorganize—cannot be achieved through ecological restoration alone. Resilience requires justice: communities that are procedurally marginalized, economically disadvantaged, and epistemically silenced lack the adaptive capacity to respond to climate shocks. McNamara and Buggy (2017) emphasized that community-based adaptation is most effective when supported by institutional frameworks that empower rather than constrain local agency. The Segara Anakan case demonstrates the inverse: despite decades of mangrove planting, coastal communities remain vulnerable because governance structures have not simultaneously built social, economic, and political resilience.

3.5. Theme 4: Structural Barriers and Literature Gaps

The fourth theme synthesizes persistent barriers and identifies critical gaps in the existing literature. Four interrelated barriers emerge: power asymmetries, knowledge hierarchies, institutional fragmentation, and temporal misalignment.

Power asymmetries permeate all collaborative arrangements. Government actors control regulatory authority and funding flows; business actors command economic resources; academia holds epistemic legitimacy; while communities possess only their labor and local knowledge, which are systematically devalued in formal governance structures. This asymmetry is not accidental but structural, reflecting broader political-economic configurations in Indonesia where coastal communities are politically marginalized and economically dependent on state and market actors (Hak et al., 2025; Alfiandri & Irawan, 2023).

Knowledge hierarchies privilege scientific-technical expertise over indigenous knowledge. The dominance of remote sensing, biomonitoring, and ecological modeling in Segara Anakan research (Ardli & Yani, 2020; Syafina et al., 2024; Kawamuna et al., 2017) reflects a methodological bias that renders community knowledge invisible or "unscientific." This hierarchy is reinforced by publication norms that prioritize quantitative, generalizable findings over situated, qualitative community narratives.

Institutional fragmentation refers to the lack of horizontal coordination among government agencies and vertical integration across governance scales. In the Citanduy-Segara Anakan system, upstream deforestation in the river catchment is governed by forestry and agricultural agencies, while downstream mangrove degradation falls under marine and fisheries jurisdictions. No integrated watershed-coastal governance mechanism exists in the literature, creating policy blind spots where upstream actions undermine downstream conservation investments (Ardli et al., 2022; Awaludin et al., 2017).

Temporal misalignment describes the disconnect between short-term project cycles and long-term ecological processes. Most rehabilitation programs operate on 1–3 year timelines dictated by government budget cycles or CSR reporting periods, whereas mangrove ecosystem recovery requires decades (Nordhaus et al., 2019). This misalignment encourages planting ceremonies over sustained stewardship, photo opportunities over monitoring, and superficial indicators over genuine ecosystem health.

Regarding literature gaps, the synthesis identifies three critical absences. First, no longitudinal study tracks the evolution of pentahelix collaboration over time in any Indonesian mangrove site, including Segara Anakan. The cross-sectional nature of existing research prevents understanding of

how partnerships form, deteriorate, or adapt. Second, the media helix remains virtually unstudied; no empirical research examines how media framing, investigative journalism, or digital advocacy influence mangrove governance outcomes. Third, explicit theorization of climate justice within pentahelix frameworks is absent from the Indonesian literature. While climate justice is discussed in global reviews (McNamara & Buggy, 2017; Schuerch et al., 2018), its integration with multi-stakeholder governance models in the Indonesian context remains theoretically underdeveloped.

These findings collectively suggest that the pentahelix model, while conceptually promising, requires significant normative and structural refinement to realize its potential for climate justice in Indonesian coastal governance. The model cannot be merely descriptive, cataloging which actors are present but must become prescriptive and evaluative, specifying how power should be distributed, knowledge should be integrated, and benefits should be shared to achieve genuinely collaborative and just conservation outcomes.

3.6. Beyond Pentahelix: Power Asymmetries and the Political Ecology of Mangrove Governance

This section extends the analysis by drawing upon political ecology and political economy perspectives to critically interrogate the power relations embedded in pentahelix collaborative arrangements (Robbins, 2012; Peluso & Vandergeest, 2020).

Knowledge Hierarchies and Epistemic Injustice

The synthesis reveals a persistent knowledge hierarchy that privileges scientific-technical expertise over indigenous and local knowledge. The dominance of remote sensing, biomonitoring, and ecological modeling in Segara Anakan research (Ardli & Yani, 2020; Syafina et al., 2024; Kawamuna et al., 2017) reflects a methodological bias that renders community knowledge invisible or "unscientific" (Adger et al., 2018). This hierarchy constitutes a form of epistemic injustice—the systematic devaluation of local ways of knowing—that undermines recognition justice and perpetuates colonial epistemologies within contemporary conservation governance.

Structural Power Asymmetries

The analysis identifies structural power asymmetries across all collaborative arrangements. Government actors control regulatory authority and funding flows; business actors command economic resources; academia holds epistemic legitimacy; while communities possess only their labor and local knowledge, which are systematically devalued in formal governance structures (Hak et al., 2025; Alfiandri & Irawan, 2023). This asymmetry is not accidental but structural, reflecting broader political-economic configurations in Indonesia where coastal communities are politically marginalized and economically dependent on state and market actors (Robbins, 2012).

Green Grabbing and the Commodification of Carbon

The analysis also highlights the risk of green grabbing—the appropriation of environmental resources and benefits from local communities under the guise of conservation (Peluso & Vandergeest, 2020). Blue carbon financing mechanisms, if not carefully governed, could commodify community resources for external profit, excluding local communities from the economic benefits of ecosystems they steward. This risk is particularly acute in Segara Anakan, where international funding mechanisms (e.g., World Bank, 2022) channel resources through national governments, bypassing direct engagement with local communities.

Institutional Fragmentation and Policy Blind Spots

Political economy analysis reveals that institutional fragmentation is not merely a technical coordination problem but reflects deeper political divisions. In the Citanduy-Segara Anakan system, upstream deforestation is governed by forestry and agricultural agencies, while downstream mangrove degradation falls under marine and fisheries jurisdictions. No integrated watershed-coastal governance mechanism exists, creating policy blind spots where upstream actions undermine downstream conservation investments (Ardli et al., 2022; Awaludin et al.,

2017). This fragmentation mirrors broader challenges in Indonesian environmental governance, where sectoral silos impede integrated coastal zone management.

Implications for Critical Governance Analysis

This political ecology analysis demonstrates that pentahelix collaboration cannot be understood as a neutral, technical process of stakeholder coordination. Rather, it is embedded in and shaped by broader structures of power, knowledge, and political economy. Achieving climate justice requires not merely technical fixes but structural transformations that redistribute power, democratize knowledge production, and ensure that communities are recognized as rights-bearing subjects and epistemic partners.

3.7. Theoretical Discussion: The Inclusive Pentahelix-Climate Justice Framework

This section articulates the theoretical contributions of this systematic review and presents a new conceptual framework that integrates pentahelix governance with climate justice theory. Contributions to Theory:

- 1) **Extension of Pentahelix Governance Theory:** This study extends the application of pentahelix theory from its origins in innovation studies (Carayannis et al., 2012) to the domain of environmental governance. The synthesis demonstrates that the pentahelix model cannot be merely descriptive—cataloging which actors are present—but must become prescriptive and evaluative, specifying how power should be distributed, knowledge should be integrated, and benefits should be shared to achieve genuinely collaborative outcomes.
- 2) **Integration with Climate Justice Theory:** The study integrates three dimensions of climate justice—procedural (inclusive decision-making), distributive (equitable benefit-sharing), and recognition (acknowledgment of local knowledge and rights)—into the pentahelix governance framework. This integration addresses a significant theoretical gap, as these dimensions have rarely been systematically applied to analyze multi-stakeholder collaboration in mangrove conservation.
- 3) **The "Inclusive Pentahelix-Climate Justice Framework":** Based on our synthesis, we propose a novel conceptual framework that operationalizes the relationship between pentahelix actors, collaborative mechanisms, and climate justice outcomes. The framework identifies three key components:
 - a. **Actors (Who):** Mapping the roles, capacities, and power positions of the five actors, with particular attention to the dominant actors (government, academia) and marginalized actors (media, community).
 - b. **Processes (How):** Three governance mechanisms—institutional coordination, knowledge co-production, and resource mobilization—that mediate the relationship between actors and justice outcomes.
 - c. **Justice Outcomes (What):** Three dimensions of climate justice—procedural, distributive, and recognition—that should serve as evaluative criteria for collaborative governance.
- 4) **Theoretical Implications for Global-Local Solidarity:** The framework highlights the "translation gap" between global climate governance frameworks (e.g., Paris Agreement, SDGs) and local implementation. This concept contributes to the discourse on global-local solidarity by demonstrating the need for intermediaries, including media and communities that can translate, monitor, and advocate for equitable resource flows.

3.8. Policy Recommendations for Operationalizing the Inclusive Pentahelix-Climate Justice Framework

Based on the synthesis findings, we propose the following operational policy recommendations for Segara Anakan and comparable coastal sites in Indonesia.

a. Institutional Model for Pentahelix Collaboration

We propose the establishment of a "**Mangrove Collaborative Governance Forum**" (Forum Tata Kelola Kolaboratif Mangrove) at the regency level, with the following composition and responsibilities:

Tabel 4. Mangrove Collaborative Governance Forum

Actor	Roles and Responsibilities	Policy Instruments
Government (Cilacap Regency, KLHK, DKP)	Regulatory facilitation; budget provision; cross-sector coordination; monitoring and evaluation	Regent Regulation on Mangrove Collaborative Governance; designation of community-managed conservation zones
Academics (Unsoed, UNS, UGM)	IPB, Scientific data provision; ecological monitoring; training and mentorship; participatory action research	Long-term Research and Community Service MoU (≥5 years); internship and field school programs
Business/Private (PLN local enterprises)	EPI, Sustainable funding (beyond CSR); ecotourism development; value-added product processing and marketing	Public-Private Partnership (PPP) schemes for ecotourism and blue carbon; green investment tax incentives
Community (Forest Groups, Women's Groups, Youth)	Farmer Groups, Conservation implementation; ecotourism management; product processing; participatory monitoring	Village Mangrove Self-Reliance Program; community cooperatives; benefit-sharing agreements
Media (local, national, digital)	Environmental advocacy; public education; investigative journalism; watchdog function	Environmental journalism training programs; sustainable media coverage incentives; social media campaigns

Source: Data Analysis, 2026

b. Benefit-Sharing Scheme

To ensure equitable distribution of conservation benefits, we propose the following benefit-sharing mechanism:

Tabel 5. Benefit Sharing Mechanism

Revenue Source	Distribution Formula	Responsible Actors
Ecotourism entrance fees	60% Community Fund; 20% Conservation Fund; 20% Infrastructure Maintenance	Forum; Community Cooperative
Blue carbon credits	40% Community Direct Share; 30% Community Development Fund; 30% Monitoring & Capacity Building	Forum; Certifying Body; Government
Processed mangrove products	100% Community Cooperative (full profit retained)	Community Cooperative; Academia (for quality/safety support)
Endowment fund (trust fund)	10% from all revenue sources for sustainability	Forum; Government

Source: Data Analysis, 2026

c. Climate Justice Evaluation Indicators

We propose the following indicators to monitor and evaluate progress toward climate justice:

Tabel 6. Indicators to Monitor and Evaluate Progress Toward Climate Justice

Justice Dimension	Indicators	Measurement Methods	Responsible Actors
Procedural Justice	Level of community participation in planning and decision-making (measured by % of decisions involving community consent); existence of multi-stakeholder forums; grievance mechanism availability and utilization.	Participation surveys; document analysis of planning documents; interviews; complaint tracking	Government; Academics
Distributive Justice	Proportion of tourism and carbon revenue reaching communities; changes in household income; access to resources (fisheries, mangrove products)	Economic analysis; financial reports; baseline and endline surveys	Academics; Tourism Office; DKP
Recognition Justice	Integration of local knowledge in rehabilitation design (% of technical plans incorporating community input); community involvement in research and monitoring; tenure security recognition	Document analysis; interviews; participatory mapping; policy analysis	Academics; Government; NGOs

Source: Data Analysis, 2026

d. Legal and Regulatory Framework

We recommend the following legal instruments to institutionalize the framework:

- 1) Regent Regulation (Peraturan Bupati) on Mangrove Collaborative Governance: Formalizing the roles, responsibilities, funding commitments, and coordination mechanisms of all five actors.
- 2) Memorandum of Understanding (MoU) between all actors: With a minimum duration of 5 years and annual evaluation mechanisms.
- 3) Benefit-Sharing Agreement (PKS) : Legally binding agreement specifying the distribution formulas for ecotourism and blue carbon revenue.
- 4) Community Tenure Recognition: Formal recognition of community rights to manage and benefit from mangrove areas.

e. Management Regeneration and Environmental Literacy

To address the regeneration challenge, we recommend:

- 1) Youth internship programs at mangrove ecotourism sites, facilitated by academics and village government.
- 2) Integration of mangrove topics into the local curriculum for schools in coastal Cilacap.
- 3) Entrepreneurship training for youth and women in mangrove-based products and services.
- 4) Environmental literacy campaigns through social media and digital platforms, engaging media actors.

4. Conclusion

This systematic literature review has examined the intersection of pentahelix collaboration, mangrove conservation, and climate justice in the context of Segara Anakan Cilacap, Indonesia. The synthesis of 28 studies published between 2015 and 2025 reveals that while multi-stakeholder initiatives have proliferated in response to severe mangrove degradation, genuine pentahelix collaboration remains largely aspirational rather than operational. Government and academic actors dominate governance architectures, while business, media, and most critically local communities occupy peripheral or tokenistic roles. This asymmetry fundamentally undermines the collaborative ideal and perpetuates structural inequities in coastal resource management.

The analysis demonstrates that climate justice remains inadequately addressed across all three dimensions. Procedural justice is constrained by top-down decision-making that limits meaningful community participation. Distributive justice is compromised by benefit flows that favor state and

market actors over livelihood-dependent populations. Recognition justice, while increasingly acknowledged in discourse, remains substantively unrealized as local ecological knowledge continues to be marginalized in technical rehabilitation designs. Consequently, coastal resilience cannot be achieved through ecological restoration alone; it requires simultaneous transformation of governance structures to empower communities as rights-bearing subjects and epistemic partners.

The study contributes to the discourse on global-local solidarity by highlighting the translation gaps between international climate frameworks and local implementation. Global policy commitments and blue carbon financing mechanisms risk reproducing green grabbing dynamics unless mediated by inclusive governance that channels resources equitably to community stewards. The proposed conceptual framework emphasizes that pentahelix collaboration must evolve from actor cataloging toward power redistribution, knowledge democratization, and benefit-sharing mechanisms that are institutionally embedded rather than rhetorically invoked. Future research should prioritize longitudinal analyses of partnership evolution, empirical investigation of media roles in environmental governance, and participatory methodologies that position communities as co-researchers rather than data sources. For policymakers, the findings underscore the urgency of integrating climate justice metrics into mangrove restoration planning and establishing accountability mechanisms that render cross-sectoral collaboration transparent, equitable, and responsive to the needs of Indonesia's most vulnerable coastal populations.

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