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Optimization of institutional framework for mangrove ecosystem management in Jakarta Bay: A multi-stakeholder collaborative approach

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Abstract

This study explores the optimization of institutional frameworks for managing the mangrove ecosystem in Jakarta Bay, a complex social-ecological system requiring effective management across multiple jurisdictions. The research employs integrated DPSIR (Drivers, Pressures, State, Impact, Response), MICMAC (Matrix of Cross-Impact Multiplications Applied to Classification), and MACTOR (Matrix of Alliance and Conflict: Tactics, Objectives, and Recommendations) approaches. Data was collected between October 2023 and January 2024 from stakeholders in three provinces: Banten, DKI Jakarta, and West Java. The study used field observations, structured interviews, focus group discussions, and secondary data, including remote sensing analysis of Landsat 8 and Sentinel-2 imagery (2013-2023). Findings reveal five driving forces, four pressures, two states, seven impacts, and six responses through DPSIR analysis. MICMAC identified four key factors influencing mangrove management: monitoring system implementation, biodiversity levels, ecosystem health, and extreme event frequency. MACTOR analysis of 19 stakeholders shows central government actors possess high influence but low dependence, while regional governments, the private sector, and local communities display varying influence and high dependence. The study proposes four strategic approaches for institutional optimization: (1) Determinant-Driver Factors, (2) Autonomous-Divergence, (3) Influential-Convergence, and (4) Influential-Intermediate Convergence. The optimal structure recommends the Jakarta Bay Mangrove Management Forum (FPMTJ) for coordination and the Jakarta Bay Mangrove Management Agency (BPMTJ) for implementation. Comparative analysis indicates significant improvements in institutional performance, with average scores rising from 2.3 to 4.2, demonstrating better coordination, reduced task duplication, enhanced adaptability, and faster decision-making (1-2 months).

Keywords: Institutional optimization, Jakarta Bay, Mangrove management, MICMAC-MACTOR analysis, Multi-stakeholder collaboration, Social-ecological system.

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1. Introduction

Mangrove ecosystems in urban coastal areas represent complex social-ecological systems (SES) where human activities and ecological processes interact dynamically, requiring sophisticated institutional arrangements for sustainable management [1, 2]. The Jakarta Bay coast exemplifies such complexity, spanning three provincial jurisdictions—Banten, DKI Jakarta, and West Java—with approximately 9,749 hectares of mangrove ecosystems under intense anthropogenic pressure [3, 4]. This inter-jurisdictional nature creates unique institutional challenges that demand innovative collaborative governance approaches.

Social-ecological systems are defined as integrated systems where humans and nature maintain reciprocal relationships through multiple feedback mechanisms [5, 6]. In coastal contexts, these systems are particularly vulnerable to rapid changes driven by increasing population, per capita consumption, and climate variability [7]. The institutional dimension becomes critical as it determines how stakeholders interact, make decisions, and implement management strategies across different scales and sectors [8, 9].

Contemporary institutional theory distinguishes between formal institutions (codified rules, regulations, and policies) and informal institutions (norms, traditions, and social practices), both of which influence ecosystem management outcomes [10]. Effective institutional arrangements for mangrove management require integration of both formal and informal mechanisms to address the multi-scale, multi-actor nature of these systems [11, 12]. The concept of institutional optimization refers to the systematic arrangement of governance structures, rules, and processes that maximize ecological, social, and economic outcomes while minimizing transaction costs and coordination failures [13, 14].

The Jakarta Bay mangrove ecosystem faces multiple institutional challenges including fragmented governance across jurisdictions, overlapping mandates among agencies, limited stakeholder participation, and inadequate coordination mechanisms [15, 16]. These challenges are compounded by rapid urbanization, industrial development, aquaculture expansion, and pollution, resulting in significant mangrove degradation and loss of ecosystem services [17-19].

Recent advances in institutional analysis provide sophisticated tools for understanding and optimizing complex governance systems. The DPSIR framework offers a systematic approach to analyzing cause-and-effect relationships in social-ecological systems [20, 21] while MICMAC enables identification of key variables and their interactions in complex systems [4, 22]. MACTOR analysis complements these approaches by examining stakeholder relationships, conflicts, and convergences around specific objectives [23].

This study addresses the critical gap in institutional optimization for inter-jurisdictional mangrove management by developing a comprehensive framework that integrates stakeholder analysis, variable interaction modeling, and strategic planning approaches. The research contributes to the growing literature on collaborative governance for ecosystem management while providing practical recommendations for institutional reform in complex urban coastal systems.

2. Materials and Methods

2.1. Research Site

This research was conducted between October 2023 and January 2024 in the coastal area of Jakarta Bay, encompassing mangrove ecosystems across three provincial jurisdictions: Banten Province (Tangerang Regency), DKI Jakarta Province (North Jakarta Administrative City), and West Java Province (Bekasi Regency). The study area was selected based on its characteristics as a complex inter-jurisdictional ecosystem with significant ecological value and intense management challenges. Jakarta Bay represents one of Indonesia's largest urban coastal areas, serving as a major business center experiencing heavy environmental pressure, exceeded carrying capacity, and natural resource degradation.

Figure 1.
Research site in the coastal area of Jakarta Bay.

2.2. Data Collection and Stakeholder Identification

Data collection employed a mixed-methods approach combining primary and secondary sources. Primary data were gathered through structured interviews, focus group discussions (FGDs), and field observations with key respondents identified from the National Mangrove Working Group (KKMN) and Regional Mangrove Working Groups (KKMD) across the three provinces. Secondary data sources included previous reports, scientific studies, and remote sensing data from Landsat 8 and Sentinel-2 satellite imagery covering the period 2013-2023 for analyzing mangrove area changes and coastline dynamics.

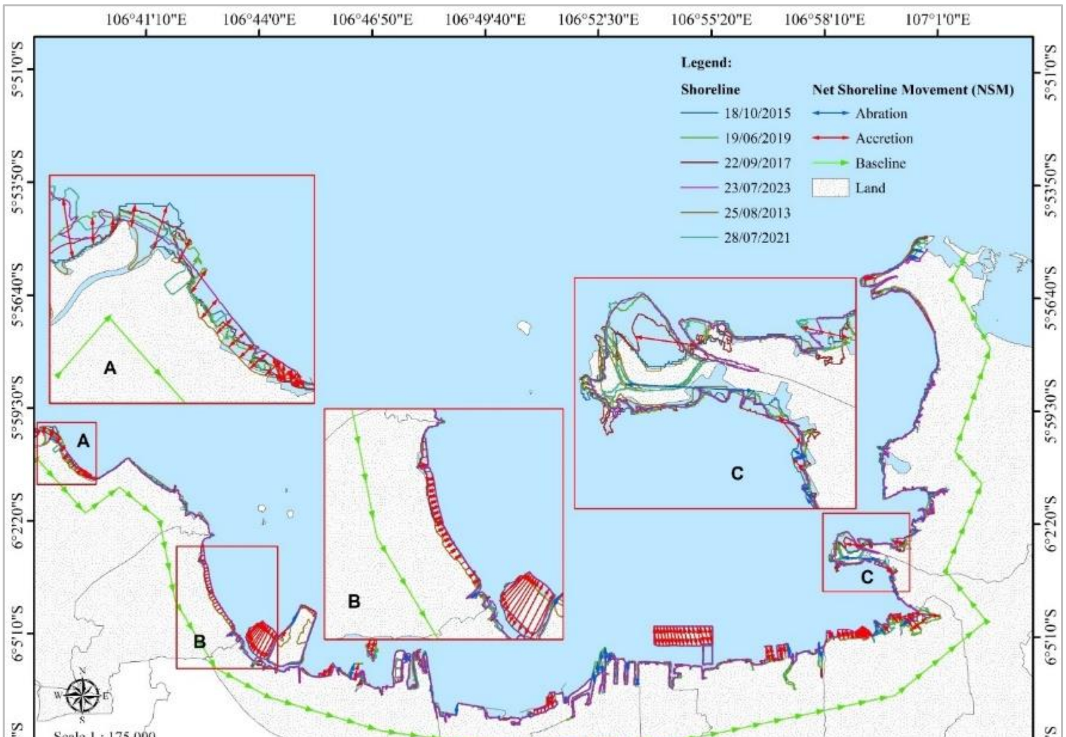

Figure 2.
Avarage changes in the coastline of the coast of Jakarta Bay from 2013—2023.

Based on stakeholder mapping exercises, 19 key actors were identified and categorized into five groups: (1) Central government including seven ministries and agencies; (2) Regional governments at provincial and regency/city levels; (3) Private sector representatives; (4) Local communities including farmer groups, aquaculture farmers, and fishermen; and (5) Other stakeholders including universities, NGOs, and law enforcement agencies.

2.3. Variable Identification and Categorization

Through extensive stakeholder consultations and literature review, 18 institutional variables were identified and systematically categorized using an input-process-output framework [24-26]. Input variables (7) represent foundational factors including genetic diversity of mangrove species, regulation availability, funding sources, water quality, pollution levels, erosion and sedimentation rates, and climate change exposure. Process variables (6) encompass operational aspects including organizational task implementation, community participation, inter-agency cooperation, regulation enforcement, monitoring system implementation, and government program execution. Output variables (5) reflect management outcomes including ecosystem health, biodiversity levels, fisheries sustainability, extreme event frequency/impact, and community access to mangrove benefits.

2.4. Analytical Framework

2.4.1. DPSIR Analysis

The DPSIR framework was applied to identify causal relationships among five categories: driving forces (socio-economic factors causing environmental changes), pressures (direct human activities affecting the environment), state (environmental condition), impact (consequences of environmental changes), and response (management actions) [27].

2.4.2. MICMAC Analysis

Structural analysis was conducted using MICMAC methodology to identify key variables and their interdependencies through cross-impact matrices. The Matrix of Direct Influence (MDI) was constructed based on expert assessments of variable relationships, categorizing factors into four quadrants based on influence and dependence levels: determinant factors (high influence, low dependence), crucial factors (high influence, high dependence), aim factors (moderate influence, low dependence), regulating factors (balanced influence and dependence), result factors (low influence, high dependence), and autonomous factors (low influence, low dependence) [28].

2.4.3. MACTOR Analysis

Stakeholder analysis employed MACTOR methodology to examine actor-by-actor and actor-by-objective relationships. The analysis focused on three strategic objectives: coordination, synchronization, and control in mangrove ecosystem management. Convergence and divergence patterns among stakeholders were mapped to identify potential alliances and conflicts, informing institutional optimization strategies [22, 23].

2.4.4. Remote Sensing Analysis

Mangrove distribution analysis utilized normalized difference vegetation index (NDVI) transformation on satellite imagery: NDVI = (NIR - Red)/(NIR + Red), where NIR is the near-infrared band and Red is the red band (Rouse et al., 1974). Coastline change analysis was performed using Digital Shoreline Analysis System (DSAS) to detect net shoreline movement (NSM) values, with negative values indicating erosion and positive values indicating accretion [29, 30].

2.4.5. Institutional Optimization Framework Development

The institutional optimization framework integrated findings from DPSIR, MICMAC, and MACTOR analyses to develop strategic approaches for improving mangrove ecosystem management. The framework incorporated good governance principles (transparency, accountability, participation, responsiveness) and collaborative governance theory to design optimal institutional arrangements for inter-jurisdictional ecosystem management.

3. Results and Discussion

3.1. Mangrove Ecosystem Social-Ecological System Dynamics

The Jakarta Bay mangrove ecosystem comprises at least 15 mangrove species, with 8 native species and 7 introduced species from other regions [29]. Species categorization includes true mangroves (7 species), mangrove associations (1 species), and introduced mangroves (7 species), with *Avicennia marina* and *Rhizophora mucronata* dominating the ecosystem composition.

Table 1.
Types of mangroves in the Jakarta Bay mangrove ecosystem.

No.	Kelompok	Species
1	True Mangrove	Avicennia marina
		Rhizophora apiculata
		Rhizophora mucronata
		Rhizophora stylosa
		Sonneratia caseolaris
		Exocoecaria agalloca
		Xylocarpus moluccensis
2	Association mangrove	Terminalia catappa
3	Introduction mangrove	Bruguiera gymnorhiza
		Callophyllum inophyllum
		Carbera manghas
		Paraserianthes falcataria
		Tamarindus indica
		Acacia mangium
		Acacia Auriculiformis

Temporal analysis of mangrove area changes from 2013-2023 reveals significant fluctuations, with coverage decreasing from ±1,575.70 ha (2013) to ±1,026.09 ha (2015), then increasing to ±1,300.92 ha (2017), declining to ±1,140.26 ha (2019), and reaching ±2,787.36 ha by 2023. These variations reflect the dynamic interplay between degradation pressures and rehabilitation efforts across the study period.

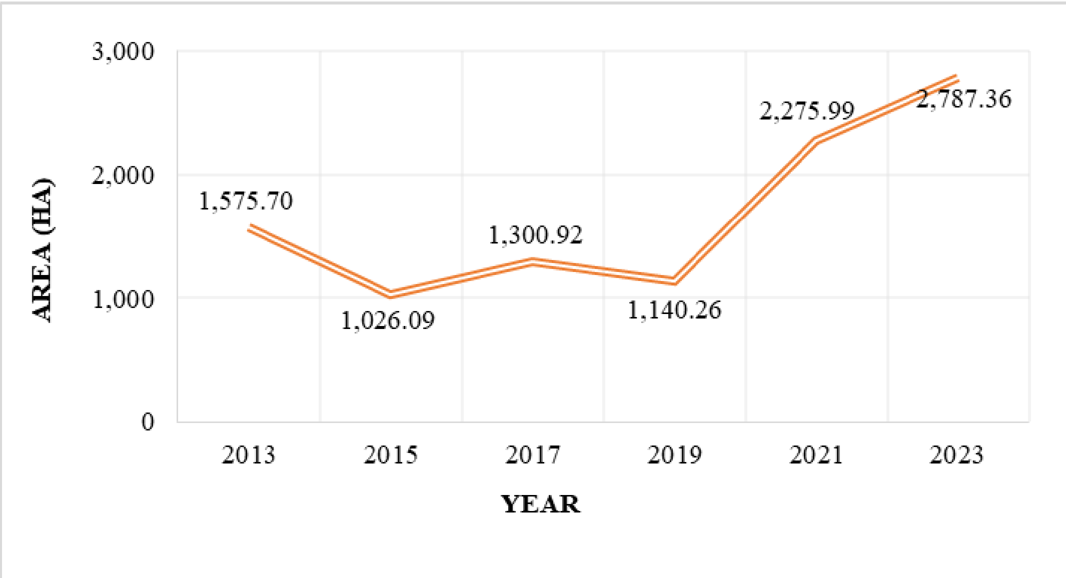

Figure 3.
Graph of changes in mangrove areas on the coast of Jakarta Bay 2013-2023.

Coastline analysis using Net Shoreline Movement (NSM) indicates predominant accretion (average 67,127.44 m) over erosion (average 25,213.93 m), with accretion ranging from 7.42 m to 1,452.78 m and erosion from 6.07 m to 1,694.23 m (Table2). This pattern occurs primarily in areas with sparse mangrove coverage, while coasts with dense mangrove ecosystems experience more stable shoreline conditions.

Table 2.
Results of calculations of coastline changes from 2013-2023].

No.	Condition	Minimum (meter)	Maximum (meter)	Total
1	Accretion	7.42	1,452.78	67,127.44
2	Abrasion	6.07	1,694.23	25,213.93

3.2. DPSIR Framework Analysis

The DPSIR analysis identified five driving force factors (mangrove ecosystem services, population growth, welfare levels, economic activities, and land use patterns), four pressure factors (land conversion, water quality decline, reclamation, and sedimentation), two state factors (ecosystem degradation and intensive utilization), seven impact factors (spatial conflicts, deforestation, pollution, ecosystem function decline, coastal dynamics, tidal flooding, and social conflicts), and six response factors (rehabilitation programs, ecotourism development, institutional optimization, community education, sustainable management, and conservation area establishment).

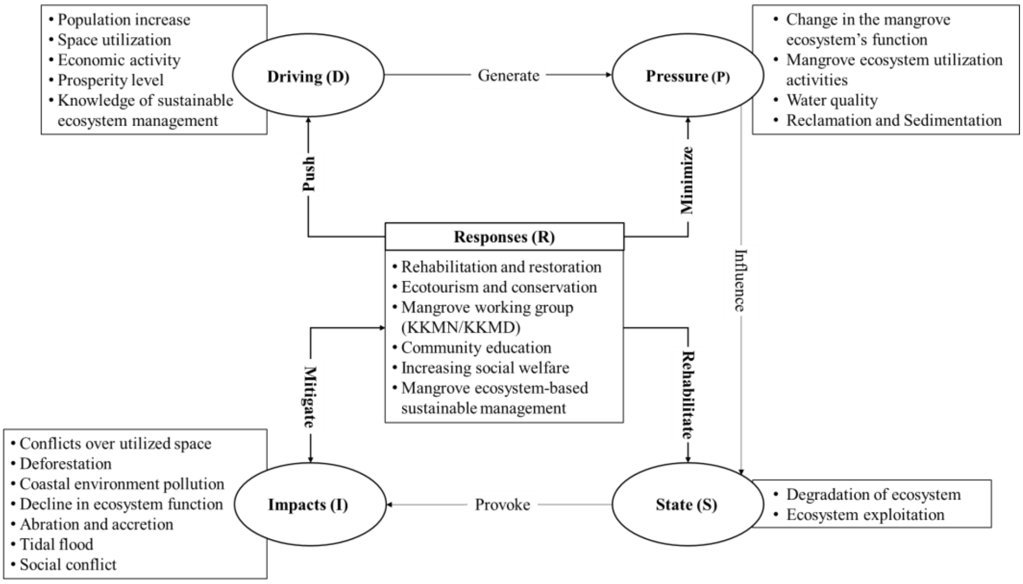

Figure 4.
Results of DPSIR factors for managing mangrove ecosystems on the coast of Jakarta Bay.

The DPSIR framework reveals how driving forces create pressures that alter ecosystem states, generating multiple impacts requiring comprehensive response strategies. This systematic analysis demonstrates the interconnected nature of social-ecological challenges in Jakarta Bay's mangrove ecosystem and the need for integrated management approaches.

3.3. Institutional Variable Analysis Using MICMAC

3.3.1. Key Variable Identification and Categorization

MICMAC analysis of 18 institutional variables revealed four determinant factors with very high influence: mangrove ecosystem monitoring system implementation (MONEV-MAN), mangrove biodiversity levels (BIODIV-MAN), ecosystem health conditions (HEALTH-MAN), and frequency/impact of extreme events (FREQ-EXTR). These variables represent the primary drivers of institutional optimization in mangrove ecosystem management.

Table 3.
Institutional variables for mangrove ecosystem management in Jakarta Bay coastal area.

No	Variable Category	Variable Name	Short Label	Theme
1	Input	Genetic diversity level of mangrove species	KG-SPMAN	Input
2	Input	Availability of mangrove regulations	REG-MAN	Input
3	Input	Funding sources and investment for mangrove management	DANA-MAN	Input
4	Input	Water quality as mangrove habitat	KA-HABMAN	Input
5	Input	Pollution level around mangrove ecosystem	POL-MAN	Input
6	Input	Erosion and sedimentation rates in mangrove areas	EDS-MAN	Input
7	Input	Climate change exposure level on mangroves	PI-MAN	Input
8	Process	Implementation of management organization tasks and functions	TUPOKSI-OP	Process
9	Process	Local community participation level	PAR-MASY	Process
10	Process	Inter-institutional management cooperation implementation	KERJA-LP	Process
11	Process	Regulation implementation and enforcement	PENEG-REG	Process
12	Process	Mangrove ecosystem condition monitoring system implementation	MONEV-MAN	Process
13	Process	Government programs and mangrove-related initiatives implementation	PROG-MAN	Process
14	Output	Mangrove ecosystem health condition	HEALTH-MAN	Output
15	Output	Mangrove ecosystem biodiversity level	BIODIV-MAN	Output
16	Output	Fisheries resource sustainability	SUST-FISH	Output
17	Output	Extreme event frequency and impact level	FREQ-EXTR	Output
18	Output	Community access level to mangrove ecosystem benefits	ACC-BEMAN	Output

One crucial factor identified was community access to mangrove ecosystem benefits (ACC-BEMAN), described as a system instability factor requiring serious attention to maintain consistency. Two aim factors emerged: regulation implementation and enforcement (PENEG-REG) and community participation levels (PAR-MASY), representing intermediate influence variables requiring strategic management.

Four regulating variables showed balanced influence and dependence: government program implementation (PROG-MAN), inter-agency cooperation (KERJA-LP), regulation availability (REG-MAN), and organizational task implementation (TUPOKSI-OP). These variables play important roles in achieving strategic objectives through their equilibrium position in the system.

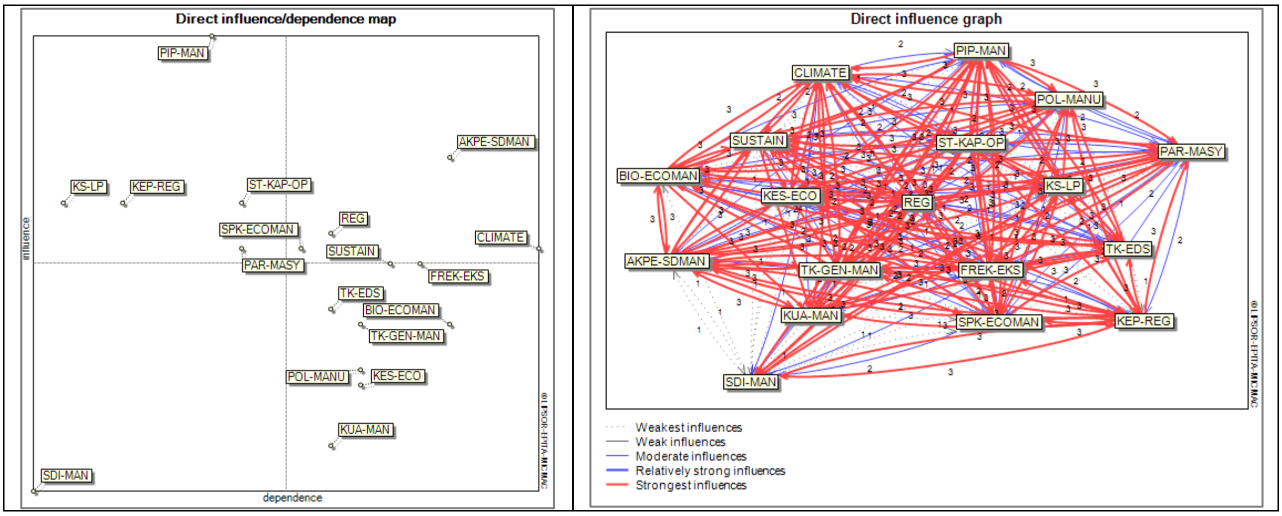

Figure 5-6.
Categorization of key factors according to the influence and dependence of direct influence relationships between factors: a). categorization of key factors; b). Influence dependence.

3.4. Direct and Indirect Influence Relationships

The analysis of direct influence relationships reveals that regulation availability (REG-MAN) and government program implementation (PROG-MAN) most significantly influence other variables in the system. Government programs function as key variables, synergizing all system variables continuously and influencing adjustments to system changes to improve institutional effectiveness and efficiency.

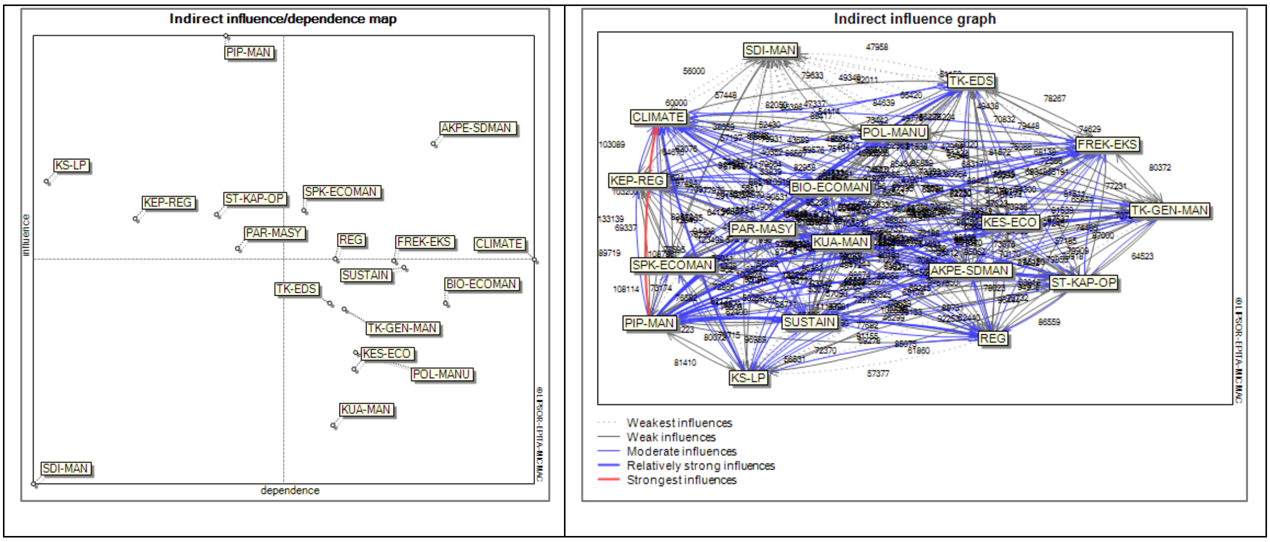

Figure. 6-7.
Key factors according to indirect influence and dependence and indirect influence relationships between factors: a). Key factors b). indirect influence relationships.

Indirect influence analysis shows shifts in variable positioning, with genetic diversity of mangrove species moving to regulating variables and fisheries sustainability moving to result factors. The strongest indirect influence was observed from extreme event frequency/impact on community participation, demonstrating complex feedback mechanisms within the institutional system.

These findings demonstrate the dominance of institutional variables in the system, with institution-related variables ranking among the top 5 direct and indirect influence factors. This result reinforces that institutional roles strongly influence ecosystem management in Jakarta Bay coastal areas.

3.5. Stakeholder Analysis Using MACTOR

3.5.1. Actor Influence and Dependence Mapping

MACTOR analysis of 19 stakeholders reveals distinct positioning patterns across four quadrants. Quadrant I (influential actors) is dominated by central government agencies with high influence and low dependence, including the Coordinating Ministry for Maritime Affairs and Investment (KEMENKOMAR), Ministry of Environment and Forestry (KLHK), Ministry of Marine Affairs and Fisheries (KKP), Peat and Mangrove Restoration Agency (BRGM), Ministry of National Development Planning (KPPN-BAPP), and Ministry of Villages and Disadvantaged Regions Development (KEMENDESA).

Table 4.
Actors involved in institutional management of mangrove ecosystems].

No	Stakeholder Groups	Institutional Actors
1	Central Government	Ministry of Environment and Forestry (KLHK); Ministry of Marine Affairs and Fisheries (KKP); Peatland and Mangrove Restoration Agency (BRGM); Coordinating Ministry for Maritime and Investment Affairs (KEMENKOMAR); Ministry of Villages, Development of Disadvantaged Regions, and Transmigration (KEMENDESA); Ministry of National Development Planning/BAPPENAS (KPPN-BAPP); Ministry of Home Affairs (KEMENDAGRI)
2	Regional Government	**Banten Province and Tangerang Regency**: Regional secretariat, Environment and Forestry Agency, Marine Affairs and Fisheries Agency, BAPPEDA. **DKI Jakarta Province and North Jakarta Administrative City**: Regional secretariat, Parks and Urban Forest Agency, BAPPEDA, Food Security and Marine Affairs Agency, Environment Agency, Naval Main Base III Jakarta, BKSDA DKI Jakarta, Citarum-Ciliwung Watershed Management Center. **West Java Province and Bekasi Regency**: Regional secretariat, Forestry Agency, BAPPEDA, Perhutani Regional Division, Marine and Fisheries Agency, BKSDA West Java, Regional Agrarian and Spatial Planning Office, BPDASHL Citarum-Ciliwung
3	Private Sector	PT Asianagro Agungjaya and other companies operating in coastal areas
4	Local Community	Forest Farmers Groups, Pond Farmers Groups, and Fishermen's Groups
5	Other Stakeholders	**Universities**: ITB, IPB, UNPAD, UNSOED. **NGOs**: Lestari Mangrove dan Alam (LEVA), Komunitas Mangrove Muara Angke (KOMMA), Lindungi Hutan. **Law Enforcement**: Environmental law enforcement agencies

Quadrant II (intermediate actors) contains provincial governments with high influence but also high dependence: Banten Province (PMPROV-BTN), West Java Province (PMPROV-JABAR), and DKI Jakarta Province (PMPROV-DKI). Quadrant III (dependent actors) includes private sector (DU), local communities (MSY-LOK), and regency/city governments, while Quadrant IV (autonomous actors) contains law enforcement (GAKKUM), NGOs, local communities (KOMUN), and universities (UNIV-LA).

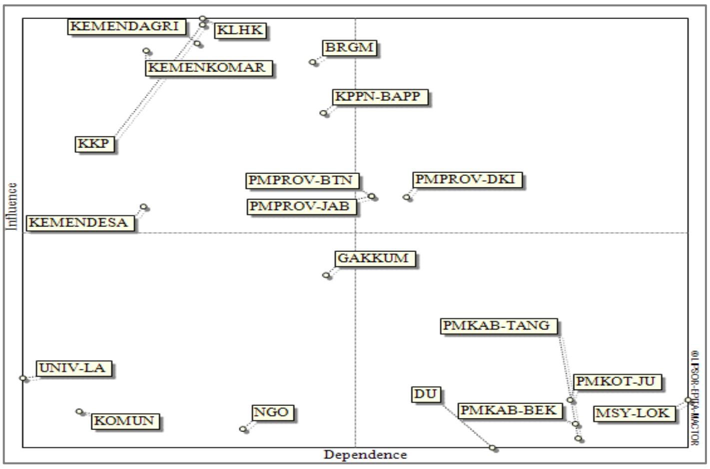

Figure 8.
Influence and dependence among actors.

3.6. Convergence and Divergence Analysis

Convergence mapping reveals that most central and regional government actors maintain close positions regarding coordination, synchronization, and control objectives, except for KEMENDESA and other actors such as MSY-LOK, GAKKUM, DU, KOMUN, NGO, and UNIV-LA, which appear distant from the main cluster.

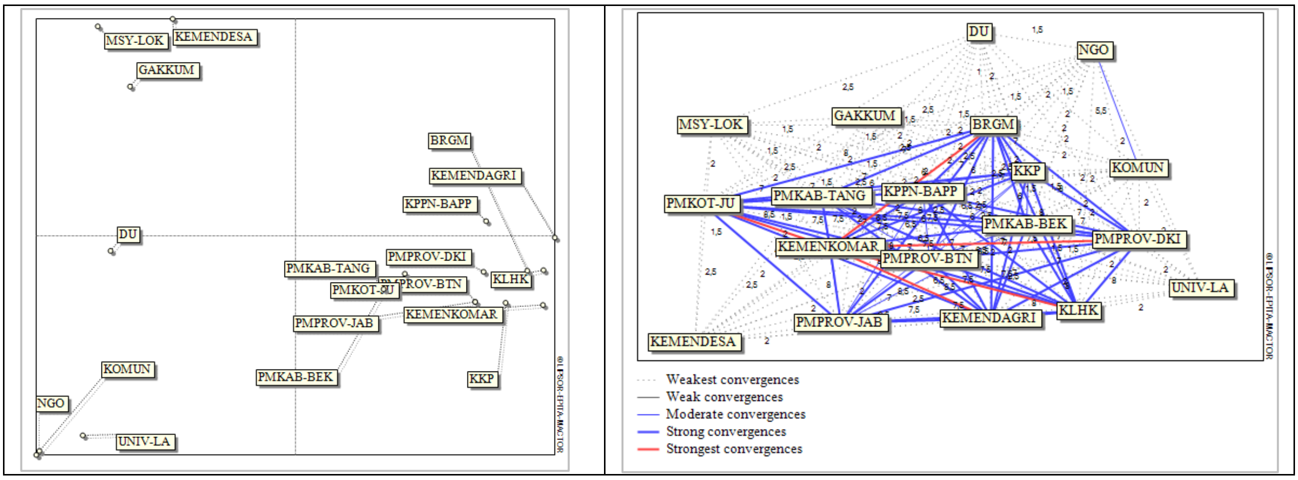

Figure 9-10.
Map of convergence between actors and graph of the level of convergence relationship between actors: a). Map of convergence; b) graph of the level of convergence.

Strong convergence exists between KEMENKOMAR-KEMENDAGRI and KLHK, while divergence analysis shows that DU, MSY-LOK, GAKKUM, NGO, and KOMUN actors maintain significant divergent relationships, indicating differences in approaches to institutional management objectives.

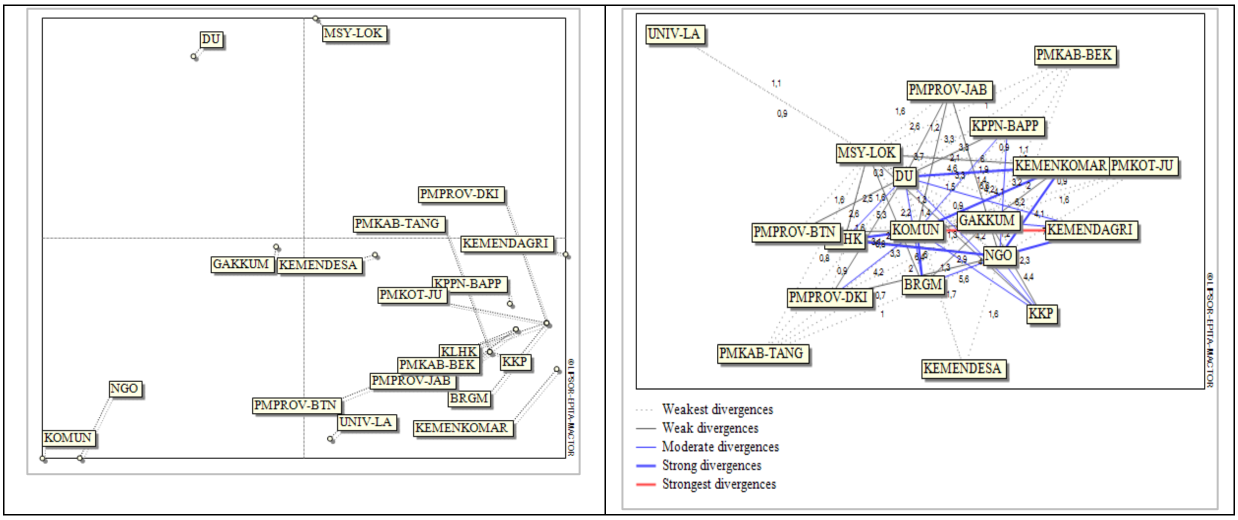

Figure 11-12.
Map of the divergence between actors and graph of the level of the divergence relationship between actors: a). Map of divergence; b) graph of the level of divergence

3.7. Institutional Optimization Framework

Based on comprehensive analysis, four strategic approaches emerge for institutional optimization:

3.7.1. Determinant-Driver Factors Strategy

This strategy focuses on strengthening the four determinant factors: monitoring system implementation, biodiversity conservation, ecosystem health maintenance, and extreme event mitigation. These factors require holistic, data-based management with consideration of climate change impacts and human activities to maintain mangrove sustainability and enhance ecological and economic benefits.

3.7.2. Autonomous-Divergence Strategy

Autonomous actors (NGOs, KOMUN, GAKKUM) with low influence and dependence present strategic opportunities for building new, more effective and responsive relationship patterns. National and Regional Mangrove Working Groups (KKMN and KKMD) can facilitate information sharing, develop annual forums, create online communication networks, and establish community-based monitoring systems with technology support.

3.7.3. Influential-Convergence Strategy

Influential actors (central and regional governments) can serve as initiators in formulating divergence impact reduction strategies. Actors like KLHK, KKP, KEMENKOMAR, KEMENDAGRI, and BRGM can develop approaches independently or collaboratively with divergent actors to enhance system coordination.

3.7.4. Influential-Intermediate Convergence Strategy

The combination of influential and intermediate actors can promote divergence impact reduction and ensure coordination, synchronization, and control flow to divergent actors. This approach ensures stakeholders share common understanding about the urgency of expected objectives.

3.8. Optimal Institutional Structure and Champion Analysis

3.8.1. Proposed Institutional Architecture

The optimal institutional structure comprises four integrated levels:

1. Strategic and Policy Level - Jakarta Bay Mangrove Management Forum (FPMTJ) Functions as a multi-stakeholder coordination platform for policy formulation, advocacy, and performance evaluation, including central government, regional governments, academia, NGOs, private sector, and communities.
2. Operational and Management Level - Jakarta Bay Mangrove Management Agency (BPMTJ) Serves as the implementation body with seven divisions: Rehabilitation and Conservation, Planning and Zoning, Sustainable Management and Utilization, Supervision and Law Enforcement, Community Participation and Ecotourism, Data and Technology Management, and Finance and Administration.
3. Support and Monitoring Level Includes the Jakarta Bay Mangrove Data and Information Center (PDIMTJ) providing GIS-based analysis and satellite monitoring, and Community Mangrove Care Groups (KMPM) as local partners in rehabilitation and monitoring.
4. Legal and Financial Framework Features Inter-Regional Cooperation Agreements (KAD) binding three administrative areas and sustainable financing schemes including regional budgets, grants, Payment for Ecosystem Services (PES), and Corporate Social Responsibility (CSR) programs.

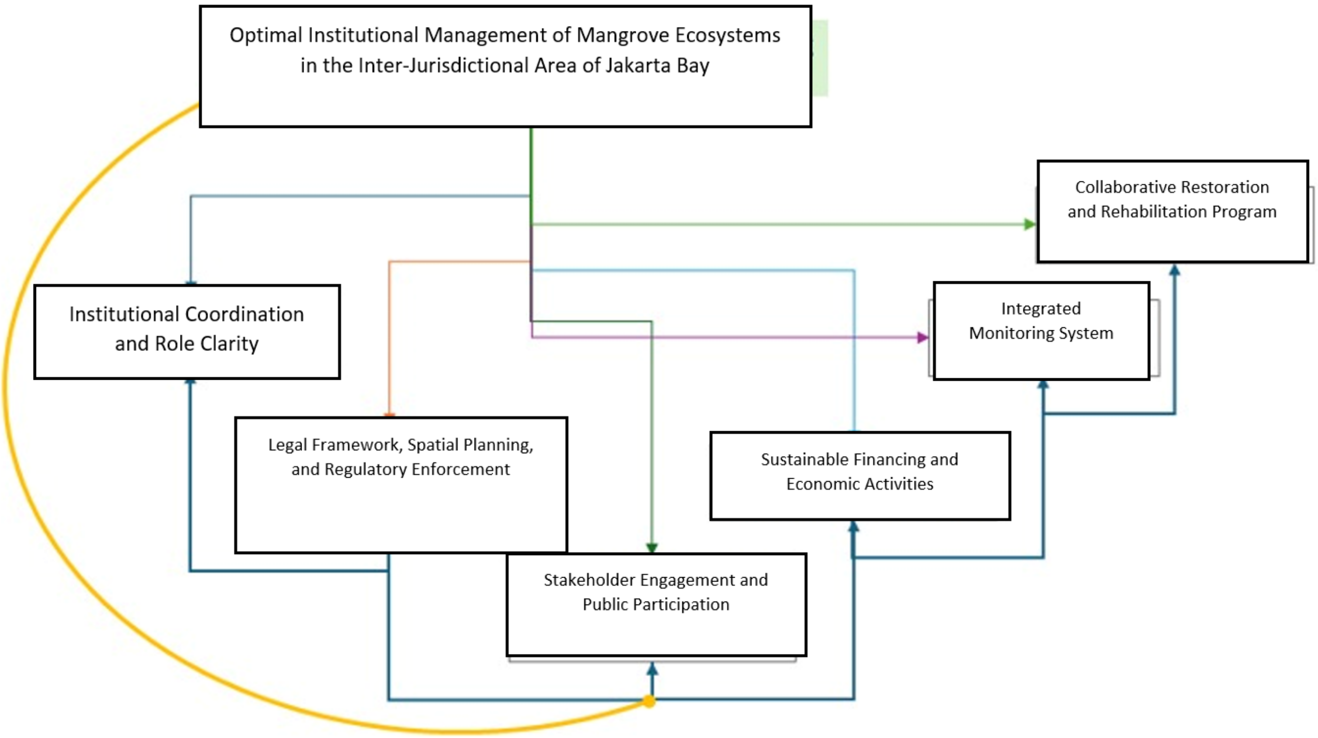

Figure 13.
Optimal institutional structure schematic.

3.9. Champion Analysis and Selection

Comprehensive evaluation of potential institutional champions using five criteria (legal legitimacy, coordination capacity, geographical proximity, resources, political neutrality) identifies the Minister of Environment and Forestry (KLHK) as the optimal leader with a total score of 23/25, followed by the Minister of Home Affairs (Mendagri) with 21/25.

Table 5.
Comparative Analysis of Potential Institutional Champions.

Champion	Legal Legitimacy	Coordination Capacity	Geographic Proximity	Resource Access	Political Neutrality	Total Score
Ministry of Environment and Forestry	5	5	3	5	5	23 (Optimal)
Ministry of Home Affairs	5	5	2	4	5	21 (High)
DKI Jakarta Governor	4	4	5	5	3	21 (High)
Ministry of Marine Affairs and Fisheries	4	3	3	4	4	18 (Medium)
West Java Governor	3	3	2	3	4	15 (Medium)
Banten Governor	3	2	2	2	5	14 (Low)
Ministry of ATR/BPN	3	2	2	3	4	14 (Low)

Note: Scale: 1 = Very Low, 2 = Low, 3 = Medium, 4 = High, 5 = Very High.

KLHK demonstrates superior performance across most criteria, with natural legitimacy for environmental coordination, orchestrator capacity for multi-stakeholder collaboration, strategic neutrality from sectoral conflicts, and sustainability assurance for long-term program continuity. Mendagri serves as an effective co-champion with strong administrative coordination capabilities and inter-regional formalization authority.

3.10. Institutional Performance Comparison

Comparative analysis of existing versus proposed institutional arrangements reveals significant improvements across all dimensions. The average institutional performance score increases from 2.3 (existing) to 4.2 (proposed), with the most dramatic improvement in decision-making speed (from score 1 to 5) and substantial reduction in task duplication risk (from score 5 to 1).

Table 6.
Comparison of Current vs. Optimized Institutional Performance.

Performance Aspect	Current System Score	Optimized Model Score	Improvement
Coordination Structure	2	5	+3
Implementation Efficiency	2	4	+2
Task Duplication Risk	5	1	-4*
Adaptation to Change	2	5	+3
Decision-Making Speed	1	5	+4
Data Integration	2	5	+3
Average Performance	2.3	4.2	+1.9

The existing system's hierarchical structure with three bureaucratic levels results in slow decision-making (3-6 months), budget inefficiency (~67% administration, 33% field programs), and high mangrove seedling mortality (~80%). The proposed collaborative model transforms this into 1–2-month decision cycles, optimized budget allocation (<30% overhead, >70% field programs), and reduced seedling mortality (<20%).

Key transformation elements include:

- Elimination of task duplication through clear role division
- Implementation of adaptive management based on scientific data with annual evaluations
- Data integration through web-based Integrated Mangrove Information System (SIMT) for real-time stakeholder access
- Diversified funding sources combining government budgets, PES mechanisms, and CSR programs

4. Conclusion

This study demonstrates that optimizing institutional frameworks for inter-jurisdictional mangrove ecosystem management requires sophisticated integration of stakeholder analysis, variable interaction modeling, and strategic coordination mechanisms. The DPSIR-MICMAC-MACTOR analytical framework successfully identified key system drivers, stakeholder dynamics, and institutional optimization pathways for Jakarta Bay's complex social-ecological system.

The research reveals four determinant factors with highest influence on institutional optimization: monitoring system implementation, biodiversity conservation, ecosystem health maintenance, and extreme event mitigation. Central government actors, particularly KLHK and coordinating ministries, demonstrate highest influence with lowest dependence, while regional governments, private sector, and local communities show varying patterns of influence and dependence requiring tailored engagement strategies.

The proposed institutional optimization framework addresses current system limitations through four strategic approaches: Determinant-Driver Factors, Autonomous-Divergence, Influential-Convergence, and Influential-Intermediate Convergence. These strategies collectively transform fragmented, hierarchical governance into collaborative, adaptive, and responsive institutional arrangements.

The optimal institutional architecture features the Jakarta Bay Mangrove Management Forum (FPMTJ) as a strategic coordination platform and the Jakarta Bay Mangrove Management Agency (BPMTJ) as an integrated implementation body, supported by data systems, legal frameworks, and sustainable financing mechanisms. Comparative analysis demonstrates substantial performance improvements across all institutional dimensions, with decision-making acceleration from 3-6 months to 1-2 months and enhanced coordination efficiency.

Champion analysis identifies the Minister of Environment and Forestry as the optimal institutional leader, supported by the Minister of Home Affairs as co-champion, providing natural legitimacy, orchestrator capacity, and strategic neutrality for long-term program sustainability. This leadership structure enables effective integration of national policies with regional implementation while maintaining scientific integrity and stakeholder engagement.

The study contributes to collaborative governance theory and practice by demonstrating how systematic institutional analysis can inform the design of optimal governance arrangements for complex inter-jurisdictional ecosystem management. The framework provides a replicable methodology for analyzing and optimizing institutional arrangements in similar complex social-ecological systems globally.

Future research should examine the implementation dynamics of proposed institutional reforms, evaluate their effectiveness over time, and explore adaptive mechanisms for responding to changing social-ecological conditions. Additionally, comparative studies across different inter-jurisdictional ecosystem management contexts would strengthen the generalizability of these findings and contribute to the broader understanding of collaborative environmental governance.

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