REPORT

Integrating Mangrove Ecosystem Valuation, Land Certification, and Gender Inclusion in Nusantara Capital City

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Landesa INDONESIA

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This report is the final output from a comprehensive mangrove ecosystem service valuation conducted in Ibu Kota Nusantara (Nusantara Capital City) by a team led by Juan Robalino and composed of Rahmina Masdar and Oktovina Trisia from Landesa; and Sang Phan from the University of Queensland under contract number 901-LDMANGROVE.

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Table of Contents

Executive Summary

Indonesia's intended new capital city, Ibu Kota Nusantara (IKN), presents an unprecedented opportunity to demonstrate **integrated, inclusive tenure security and coastal management that balance urban development with ecosystem conservation.** This comprehensive study of mangrove ecosystem services in the IKN region reveals substantial economic, ecological, and social values, strongly justifying proactive conservation through innovative management approaches.

It is expected that **findings and recommendations from this study** contributes as evidence that can be used by government officials, practitioners, and academics alike to **inform decisions and actionable steps** to advance the implementation of proactive mangrove conservation initiatives by integrating ecosystem service economics with inclusive and enabling land tenure arrangements.

Key Findings

The valuation of mangrove ecosystem services from this study identified approximately **10,922.8 hectares** of mangrove ecosystems across four condition categories based on the aboveground tree biomass carbon stock: Healthy mangrove, moderately disturbed mangrove, degraded mangrove, and regenerating mangrove. Healthy mangroves represent the largest category (**8,655.2 hectares, 79.2%**), indicating substantial areas of healthy, intact mangrove forest that provide optimal ecosystem service delivery.

In terms of ecosystem services, mangroves in IKN provide annual ecosystem service values ranging from **USD 67.4 to 123.0 million**, representing per-hectare benefits of **USD 6,170 to 11,260** annually. This positions IKN's mangroves among Indonesia's highest-performing coastal ecosystems.

The exceptionally high ecosystem service values documented in this study (**USD 6,170-11,260 per hectare annually**) result from a unique combination of favorable conditions that create a "perfect storm" for ecosystem service delivery and economic valuation. These conditions include an exceptionally **high proportion of healthy mangroves** (79.2% of total area) providing optimal service delivery capacity, and an **immense development pressure from IKN's planned infrastructure** creating unprecedented demand for services like coastal protection. Consequently, this valuation should be understood as context-specific rather than representative of typical Indonesian mangrove values.

This study's community engagement analysis, based on **190 household surveys,** reveals strong conservation support, with **44.7%** of respondents expressing definite **willingness to pay** for mangrove conservation and an additional **28.9%** indicating **potential willingness** (total 73.6%). **High environmental awareness** (**76.8%** aware of climate change) and **ecosystem service recognition** (mean ratings 3.22-4.68 out of 5 across all service categories) provide robust foundations for mangrove conservation initiatives.

As a result, the study reveals **feasibility for implementing a Payment for Ecosystem Services** (PES) based on significant community willingness to participate in conservation finance, as well as favorable and enabling institutional conditions of the Nusantara Capital City Authority (OIKN). The strong environmental awareness, high ecosystem service valuation, and willingness to participate in conservation activities provide solid foundation for implementing community-based conservation initiatives alongside payments from external ecosystem service beneficiaries including coastal developers, government agencies purchasing coastal protection services, and carbon credit buyers.

Also, the study reveals **critical gender dimensions that must be addressed for a successful implementation of a PES in terms of equity and inclusion**. The survey included 26.3% female respondents, which reflects broader patterns of male representation in formal community roles and land ownership. Significantly, **female respondents demonstrated higher average willingness to pay for conservation** (IDR 42,000 vs 38,500 monthly among males), suggesting untapped potential for women's leadership in ecosystem stewardship. However, with only 34.2% of households owning land near mangroves and existing gender disparities in formal land documentation, there is substantial risk that PES, drawing on documented land rights owners who are predominately men, could inadvertently exclude women from ecosystem service benefits. Addressing these disparities through **gender-responsive certification of land rights, restrictions, and responsibilities, and targeted women's inclusion in PES design** represents both an equity imperative and an opportunity to enhance its effectiveness through women's demonstrated conservation commitment.

Key Recommendations

The study proposes the **integration of multiple ecosystem services** (carbon storage and sequestration, coastal protection, and tourism and recreation) for a PES design in order to maximize economic sustainability and conservation impact while reducing dependence on single market mechanisms. Based on economic valuation results showing **USD 67.4 to 123.0 million** annually in total ecosystem service value, a **PES in mangrove areas in IKN can justify annual payments of USD 340-600 per hectare**, representing 4 - 10% of total ecosystem service value while providing sustainable financing for conservation.

The integration of ecosystem service economics with the **Rights, Restrictions, and Responsibilities** (3R) framework, advanced by the Ministry of Land Affairs and Spatial Planning/National Land Agency (ATR/BPN), creates transformative opportunities for coastal tenure and management. Considering this opportunity, the study recommends **pioneering gender-responsive ecosystem service rights certification**, moving away from traditional land rights—focused primarily on use and exclusion and applied in a gender-neutral manner—and moving towards leveraging a certification that could grant explicit and equal rights for women and men to both land and ecosystem services.

Building on this recommendation, **gender-responsive ecosystem service rights certification** can leverage OIKN's current efforts to explicitly support property rights for women (held individually and jointly) in coastal areas. These efforts are reflected in the Draft Regulation of the Head of OIKN on the Protection and Management of Coastal Areas and Small Islands in IKN, aligned with Article 9(2) of the Basic Agrarian Law, and could serve as both a national and international example.

Furthermore, **such certification provides an opportunity to integrate formal restrictions and responsibilities alongside recognized rights**. Embedding these elements within an enabling land certificate would allow women and men landholders to benefit equally from land rights and ecosystem services, while also complying with OIKN's Spatial Pattern Plan for areas designated as Protected Areas and Cultivation Areas.

A proposed 3R combination for an **enabling land certificate** that could allow women and men landholders to **equally benefit from ecosystem services**, while complying with OIKN's Spatial Pattern Plan in **forested mangrove areas currently designated as Protected Areas**, could be:

- **Right** – Ownership Rights (Hak Milik)
- **Restriction** – Zoning Regulation – Prohibition for cutting trees

- **Responsibility** – Provide information about environmental management

With this suggested land certificate in the documented names of women and men and considering their potential to engage in PES mechanism, **women and men landholders could benefit from conserving standing mangrove forests, while also gaining access to non-timber forest products and other resources from healthy mangrove ecosystems**. These access rights are often critical for women's and men's subsistence and livelihood needs, as well as communities' traditional practices.

Another proposed 3R combination that could serve as an **incentive for mangrove reforestation in Protected Areas without mangrove cover**, while still allowing for ecosystem service benefits and adhering to OIKN's Spatial Pattern Plan, could be:

- **Right** - Ownership Rights (Hak Milik)
- **Responsibility** – Maintain and improve the quality of land or space
- **Responsibility** – Provide information about environmental management

With this configuration, if a PES mechanism is available, **the land certificate could act as an enabling incentive for mangrove forest reforestation** by both women and men land rights holders, while also allowing for sustainable and equal use of non-timber forest products and other resources derived from restored mangrove areas.

Finally, in the case of **Cultivation Areas** that currently maintain mangrove forest cover or has no mangrove cover, a proposed 3R combination that could serve as an **incentive for mangrove conservation and reforestation**, if supported by an existing PES mechanism, could be:

- **Right** - Ownership Rights (Hak Milik)
- **Responsibility** - Provide information about environmental management

This **enabling land certificate supports the conservation of existing mangrove forests** in Cultivation Areas **as well as reforestation of areas without mangrove cover**, offering a formal pathway for women and men to benefit from ecosystem services while encouraging sustainable land stewardship.

This certification approach represents fundamental departure from conventional property rights by recognizing and protecting rights to flow of services rather than just stock of resources, as well as ensuring the rights to follow of service are equally enjoyed by women and men. Under this type of certification, women and men rights holders receive formal recognition through land certificates specifying the opportunity for carbon credit revenue entitlements, coastal protection service payment eligibility and tourism development participation rights.

Summary of Methods and Outcomes

This study employed a **mixed-methods research design integrating quantitative ecosystem service valuation with qualitative community engagement assessment**. Primary data collection included **190 household surveys**, 35 key informant interviews with government officials and experts, 9 focus group discussions across three districts, and environmental assessments of mangrove conditions.

Economic valuation utilized multiple approaches including market price methods for direct use values, replacement cost approaches for regulating services, and contingent valuation for cultural services. Carbon stock assessment revealed total storage of **11,036,190 Mg** across all mangrove areas, with healthy condition areas achieving optimal carbon density supporting climate mitigation objectives.

By aggregating all quantified ecosystem services, the total annual economic value of IKN's mangrove ecosystems ranges from **USD 67.4 to 123.0 million** across **10,922.8 hectares**, representing per-hectare values of **USD 6,170 to 11,260** annually.

Ecosystem Service	Annual Value (USD million)	2025-2042 NPV* (USD million)	Community Priority Ranking
Coastal protection	24.1-35.2	290-424	Highest (4.68)
Water quality regulation	2.8-8.9	34-107	Very High (4.52)
Fisheries support	28.7-42.3	346-509	Very High (4.41)
Tourism and recreation	8.2-26.2	99-315	High (4.23)
Carbon sequestration/storage	3.1-9.2	37-111	High (4.15)
Raw materials	0.5-1.2	6-14	Moderate (3.87)
Total Annual Value	**67.4-123.0**	**812-1,480**	**-**

**Using a social discount rate of 5%.*

1. Introduction

1.1. Landesa's Coastal Livelihoods and Mangroves Program

Landesa, through its Coastal Livelihoods and Mangroves Program, is strengthening coastal land tenure rights in the Bay of Bengal (Bangladesh and India) and Southeast Asia (Myanmar, Thailand, Cambodia, Malaysia, and Indonesia). This ambitious project aims to sustain livelihoods, protect mangrove forests, and mitigate climate change through context-specific and gender equality and social inclusion (GESI) responsive activities in each country. These include policy advising, legislative support, community assessments, forest cover mapping, tenure strengthening efforts, and locally led climate adaptation and mitigation.

In Indonesia, Landesa Indonesia is supporting and collaborating with the Nusantara Capital City Authority (OIKN), the Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (ATR/BPN), and the Ministry of Marine Affairs and Fisheries at the intersection of land rights, spatial planning, and climate change.

Under the guidance of the Nusantara Capital City Authority (OIKN), Landesa and Landesa Indonesia partnered with the University of Queensland with the main goal of conducting a comprehensive valuation of mangrove ecosystem services in the IKN area, supporting evidence-based decision-making for integrated, inclusive coastal management, spatial planning, and climate resilience.

1.2. Background and Importance of Mangroves in IKN

Indonesia's designation of Ibu Kota Nusantara (IKN) as the intended new national capital represents one of the most ambitious urban development projects in Southeast Asia. Located strategically in East Kalimantan between Balikpapan Bay and the Mahakam Delta, IKN encompasses diverse coastal ecosystems including over 10,922.8 hectares of mangrove forests, distributed across three coastal districts.

The development vision positions IKN as a "smart, green, beautiful, and sustainable city" aligned with Indonesia's international commitments including the Paris Agreement, the Kunming-Montreal Global Biodiversity Framework, national Net Zero emissions targets and Sustainable Development Goals (SDGs) by 2045 (Government of Indonesia, 2023). However, rapid urbanization and supporting infrastructure development present significant ecological challenges, particularly for sensitive coastal and mangrove ecosystems.

Mangrove ecosystems rank among the most productive and valuable coastal habitats globally, delivering essential ecosystem services for both environmental sustainability and human wellbeing (Barbier, 2012; Lee et al., 2014). In the IKN context, these services assume particular significance for climate change adaptation and mitigation, biodiversity conservation, and sustainable livelihoods.

The ecological importance of mangroves centers on their role as critical carbon sinks, sequestering significant atmospheric CO_2 both above and below ground (Murdiyarso et al., 2015). Their dense root networks protect coastlines from erosion, attenuate wave energy, and reduce flood risks—functions of increasing importance given projected sea-level rise and hydro-meteorological risks for the IKN region (Narayan et al., 2016).

Despite their importance, mangrove areas in and around IKN have experienced degradation due to land conversion, port construction, and unregulated activities. However, strong local momentum for conservation exists, including community-based planting initiatives and recognition of Payment for Ecosystem Services (PES) potential.

1.3. Objectives and Study Questions

This study addresses critical knowledge gaps and provides actionable insights by conducting a comprehensive valuation of mangrove ecosystem services in the IKN area, supporting evidence-based decision-making for integrated coastal management, spatial planning, and climate action.

Primary Objectives:

1. Assess current status and spatial extent of mangrove ecosystems across IKN's three coastal districts;
2. Quantify ecological, economic, and social values of key ecosystem services provided by mangroves;
3. Evaluate community (including women's) readiness and potential for implementing Payment for Ecosystem Services schemes; and
4. Formulate recommendations for integrating mangrove conservation into IKN's spatial planning using ATR/BPN's Rights, Restrictions, and Responsibilities (3R) framework.

Study Questions:

The study addresses several critical questions:

1. What is the current state and value of mangrove ecosystem services in IKN's coastal areas?
2. How do local communities depend on and interact with mangrove ecosystems?
3. What institutional mechanisms and policy tools best support PES and sustainable mangrove management in IKN?

1.4. Study Design and Data Collection

This study implemented a mixed-methods research design rooted in participatory approaches to ecosystem service valuation (Millennium Ecosystem Assessment, 2005). The methodology addresses the complex socio-ecological nature of mangrove ecosystems where community interactions, ecological processes, and policy considerations are deeply interconnected. The design integrated quantitative valuation techniques with qualitative methods ensuring both rigorous measurement and contextual understanding.

The study approach followed community-centered participation principles that recognize and value local knowledge while maintaining scientific rigor in ecosystem service assessment. This integration ensured policy relevance for sustainable coastal management while enabling triangulation of findings and appropriate capture of both tangible and intangible ecosystem values.

For the sample size calculation, using parameters of $N = 444$ households (total population engaged in mangrove activities), $Z = 1.96$ (95% confidence level), $P = 0.5$ (conservative proportion estimate), and $e = 0.05$ (±5% margin of error), the calculated sample size was 206 respondents. The study achieved 190 completed surveys, representing 92% of the target sample size and providing robust statistical power for analysis.

The sampling employed purposive sampling ensuring representation of different stakeholder groups. Community members included residents of the 26 IKN villages (kelurahan and desa) with mangrove ecosystems, aged 18 and above, involved in mangrove-related activities. Government officials represented OIKN and ATR/BPN working on coastal management, spatial planning, or environmental protection. Local experts included academics, Non-Governmental Organization (NGO) representatives, or practitioners with expertise in mangroves, coastal management, or local development.

In terms of data collection, the study employed four methods to ensure appropriate community engagement and local administrative compliance:

1. **Primary Household Surveys** – 190 face-to-face interviews (conducted in Bahasa Indonesia and held at times and in places to accommodate the schedules of women and men respondents) gathered data on demographic characteristics and socioeconomic status, mangrove resource use patterns and dependency levels, community perceptions of ecosystem services importance, willingness to pay for conservation initiatives, climate change awareness and adaptation strategies, and land tenure and resource access rights. Each survey lasted 60-120 minutes. The standardized questionnaire included eight sections covering demographic information, mangrove use patterns, ecosystem service perceptions, willingness to pay, climate change awareness, land tenure rights, future development concerns, and additional comments.
2. **Key Informant Interviews (KIIs)** – 35 semi-structured interviews with local stakeholders explored management approaches, policy frameworks, and institutional arrangements. Participants included government officials from OIKN and ATR/BPN, traditional community leaders, environmental NGO representatives, and academic experts and practitioners. The interview guide covered eight thematic areas: background information, mangrove ecosystem status and trends, ecosystem services, community interactions and livelihoods, management and conservation approaches, policy and institutional frameworks, IKN development impacts, climate change and resilience, research gaps, and future recommendations.
3. **Focus Group Discussions (FGDs)** – Nine FGD sessions facilitated deeper community engagement and stakeholder dialogue. Community FGDs included three sessions (three per district) with 6-12 participants each from homogeneous backgrounds. Sessions incorporated participatory mapping exercises, ecosystem services mapping activities, stakeholder mapping, and structured discussions about mangrove values and management options. Each session lasted 120-150 minutes including activities such as identifying high ecosystem service value areas on maps and discussing collaborative approaches for sustainable conservation.
4. **Environmental Assessments** – Field surveys examined mangrove ecosystem conditions, species composition, and physical characteristics relevant to ecosystem service provision. Two field campaigns were conducted to survey mangrove ecosystems within the region. In total, 96 sampling plots were established across mangrove habitats and adjacent land uses.

In addition to primary data collection listed above, this study employed satellite image interpretation and mapping with the primary objective to generate spatial maps illustrating mangrove extent and land use types across IKN region. High-resolution satellite imagery from the PlanetScope constellation (Planet Team, 2025) was processed and interpreted to produce the maps. The outputs were subsequently validated using Google Earth imagery and Spot 5 satellite data.

Given the complexity of land use patterns in densely populated coastal zones in IKN—where agricultural and aquaculture activities are highly interspersed—a semi-supervised classification approach was employed. Full automation of image classification was not feasible due to the heterogeneous landscape and indistinct boundaries, particularly in aquaculture zones. As a result, manual digitization techniques were applied to delineate aquaculture ponds, especially where pond embankments could not be reliably distinguished through automated classification algorithms, in contrast to agricultural or other land use features.

Finally, this study employed comprehensive ethical safeguards including the University of Queensland Human Research Ethics approval (Application #2024/HE002085) and the National Research and Innovation Agency - Badan Riset dan Inovasi Nasional (BRIN) Ethical clearance approval (No.089/KE.01/SK/02/2025).

1.5. Limitations and Uncertainties

The economic valuation results contain several important limitations affecting interpretation and application. Benefit transfer methods used for some ecosystem services may not fully capture local conditions and values, particularly for cultural services where context-specificity is especially high. Contingent valuation results for willingness to pay may overestimate actual payment behavior due to hypothetical bias and social desirability effects common in survey-based methods.

Temporal dynamics present significant analytical challenges, with ecosystem service values potentially changing substantially over IKN's development timeline. Climate change impacts on ecosystem service provision remain uncertain, particularly regarding sea level rise effects on mangrove distribution and carbon storage stability. Seasonal and annual variability in ecosystem service provision, particularly for fisheries and tourism services, may not be fully captured in point-in-time assessments. Long-term ecological monitoring data remains limited, creating uncertainty about ecosystem service provision trends and sustainability under different management scenarios.

The study's focus on households engaged in mangrove-related activities may not fully represent broader community values and preferences regarding conservation. Non-user values, which can be substantial for charismatic ecosystems like mangroves, require additional assessment through broader population sampling including urban residents and future IKN inhabitants.

The survey's predominantly male composition (73.7% male, 26.3% female) represents a significant limitation affecting result interpretation and generalizability. This gender imbalance reflects broader patterns of male representation in formal community roles and land ownership but potentially under-represents women's perspectives on ecosystem service values and conservation priorities.

The gender bias may have led to under-representation of women's non-monetary dependencies on mangrove ecosystems, subsistence-level resource use patterns, and their preferences in the design of conservation initiatives. Given that female respondents demonstrated higher average willingness to pay (IDR 42,000 vs 38,500 monthly), broader female participation might have resulted in different community valuation patterns or conservation priorities.

The limited female representation may mask important gender-differentiated relationships with mangrove ecosystems, potentially leading to PES mechanisms that inadvertently exclude women from benefit streams or fail to recognize their ecosystem stewardship contributions.

Finally, corrective actions for future work include monitoring and community consultations employing stratified sampling to ensure at least 40-50% female participation to capture a more representative view of community-wide priorities. This should include separate women's focus groups, targeted outreach to women's organizations, and timing of data collection that accommodates women's work schedules and domestic responsibilities.

2. Mangroves in IKN

2.1. Mangrove Policy and Management Frameworks in Indonesia and IKN

Indonesia has established comprehensive policy frameworks for mangrove management through various laws and regulations, with the foundation laid by Law No. 27 of 2007, later amended by Law No. 6 of 2023 concerning Management of Coastal Areas and Small Islands. The Roadmap Rehabilitasi Mangrove Nasional 2021-2030 outlines phased approaches for mangrove rehabilitation across Indonesia, targeting 600,000 hectares for rehabilitation by 2024.

Several national frameworks particularly relevant to coastal management include Indonesia FOLU Net Sink 2030, recognizing mangroves' critical role in carbon sequestration; Nusantara Net Zero Emission 2045, integrating mangrove conservation into long-term climate targets; and Payment for Ecosystem Services regulations providing frameworks for economic valuation. It is important to highlight that most of these national-level mangrove and coastal management instruments do not explicitly or adequately cover and integrate gender and tenure issues.

IKN operates under a special framework that operationalizes national policies through IKN-specific regulations, with authority levels enabling optimal implementation of evidence-based approaches. Government Regulation No. 27 of 2023 grants OIKN comprehensive authority over biodiversity management, coastal and marine management, customary community recognition, and spatial planning integration.

The IKN Spatial Plan (RTR-KSN) 2022-2042 sets frameworks for optimal ecosystem service delivery, with total protected areas of 11,668.45 hectares[1] designated for protection, carbon mitigation potential exceeding 3 million tCO_2e over 20 years, and economic value ranging USD 221-570 million over 20 years in ecosystem service benefits.

Recent institutional developments strengthen the framework through the IKN Biodiversity Masterplan (Head of OIKN Decree No. 36 of 2024), providing strategic frameworks for biodiversity protection; Local Wisdom Guidelines (OIKN Circular Letter No. 002 of 2024), establishing procedures for recognizing traditional knowledge; and Coastal Management Regulations under development for specific coastal zone provisions.

2.1.1. Mangrove Land Ownership, Use, and Certification in IKN

As stipulated in Article 65 of Presidential Regulation No. 64 of 2022 concerning the Spatial Plan for the National Strategic Area (RTR KSN) of the Capital City of Nusantara, the IKN area is divided based on the Spatial Pattern Plan into:

A. Protected Areas
B. Cultivation Areas

With the provision that within the Protected Area, the allocation of Protected Area Space includes public green open space (RTH) of at least 65% of the IKN area, and 35% is allocated for Cultivation Areas.

[1] The discrepancy with the study reported figure of 10,922.8 hectares is due to the latest National Strategic Area Delineation Map of the National Capital (IKN), as outlined in Law Number 21 of 2023 of the Republic of Indonesia.

Ownership and use in Protected Area can be described as follows:

In Protected Areas, there are mangrove forest areas or areas with mangrove cover that are inhabited by women, men, and communities, especially those near the coast. Land ownership or control is currently in the form of freehold, leasehold, right of use, protected, and unregistered land. With the issuance of Presidential Regulation No. 64/2022 and Presidential Regulation No. 65/2022 on Land Acquisition and Land Management in the Nusantara Capital City, and the implementation of other regulations related to land administration in the IKN area, the following considerations apply:

a. Ownership rights remain with the holders who acquired them prior to the designation of the IKN area.
b. Right-of-use and usufruct rights remain valid until their expiration in accordance with applicable provisions, after which their management reverts to the IKN Authority. Protected Areas retain their protective functions and remain designated as such.
c. Unregistered land - identification and inventory must be conducted, with management carried out in accordance with applicable laws and regulations.

In Protected Areas, there are also locations and areas that are not mangrove forest or have no mangrove cover and are factually inhabited by communities or used for business activities. These may involve ownership rights, business rights, or usage rights, as well as unregistered land. With the issuance of Presidential Regulation No. 64/2022 and Presidential Regulation No. 65/2022 on Land Acquisition and Land Management in the Nusantara Capital City, and the implementation of other relevant regulations regarding land administration in the IKN area, the following considerations apply:

a. Ownership rights remain with the holders who acquired them prior to the designation of the IKN area.
b. Right of use or right of occupation may remain valid until their expiration in accordance with applicable provisions, after which their management is returned to the IKN Authority.
c. Unregistered land: identification and inventory must be conducted, and control is determined based on applicable laws and regulations.

Ownership and use in the Cultivation Area can be described as follows:

The Cultivation Area includes areas that are still covered by mangrove forest and inhabited by communities and businesses with ownership rights, usage rights, or land use rights, as well as unregistered land. With the issuance of Presidential Regulation No. 64/2022 and Presidential Regulation No. 65/2022 on Land Acquisition and Land Management in the Nusantara Capital City, and the implementation of other regulations related to land administration in the IKN area, the following considerations apply:

a. Ownership rights remain with the holders who acquired them prior to the designation of the IKN area.
b. Right of use or right of occupancy may still apply until expiration in accordance with the relevant provisions and may be extended in accordance with regulations issued by the IKN Authority.

Cultivation Areas also include residential areas or community settlements where business activities already exist under ownership rights, usage rights, or land use rights, including unregistered land. With the issuance of Presidential Regulation No. 64/2022 and Presidential Regulation No. 65/2022 on Land Acquisition and Land Management in the Capital City of

Nusantara, and the implementation of other relevant regulations regarding land administration in the IKN area, the existing status of such lands remains unchanged.

Based on this context and as referred to in Presidential Regulation No. 65/2022, it is stated that the assets under the control of the Nusantara Capital Authority (referred to as ADP) are lands within the Nusantara Capital area that are not related to the administration of government. The Authority holds management rights, which are sovereign rights of the state, and their exercise is partially delegated to the holder of management rights.

2.1.2. Rights, Restrictions, and Responsibilities (3R) Framework

Indonesia's land law framework is established by the Basic Agrarian Law (BAL) of 1960. It legally recognizes various types of land rights (see Table 2.1 below for examples). Notably, Article 9(2) explicitly recognizes women's and men's equal rights to land and its benefits.

More recently, ATR/BPN introduced the 3R framework, an innovative approach for addressing diverse legal claims and responsibilities in land and resource management. This framework guides ATR/BPN in granting land rights and, in practice, could be applied to land certification in mangrove areas within the intended new capital city. By integrating principles from both customary law and modern statutory frameworks, the 3R approach bridges traditional governance systems with contemporary legal structures.

The rights component secures both individually-held land by women and men and community-held land claims, creating legal certainty that underpins sustainable land management. Restrictions establish boundaries designed to protect environmental integrity while ensuring sustainable resource use. Responsibilities assign clear obligations to landholders and resource managers regarding natural resource stewardship. The table below presents a list of rights, restrictions, and responsibilities on a land parcel/space according to Indonesian law.

Table 2.1. Type of Rights, Restrictions, and Responsibilities on Land Parcel/Space.

Type of Rights on Land Parcel/Space (equally available to women and men)		
No.	**Type**	**Definition**
1	Ownership Rights (Hak Milik)	Rights of ownership are hereditary rights and are the strongest, and the fullest right one can have on land that may be possessed by an Indonesian citizen and legal entity. This right may go over to and transferred to another party.
2	Exploitation/Cultivation Rights (Hak Guna Usaha)	Rights to cultivate the land, which is controlled by the state, for a period of time. This right is typical in farming, plantations, fishing, or cattle-raising, which may go over and be transferred to another party. The validity of the exploitation rights is for periods of 25 or 35 years and can be further extended for another 25 years based on a formal assessment.
3	Building Rights (Hak Guna Bangunan)	Rights to construct and to own buildings on the land, which is not one's property for a period of no longer than 30 years. The right of the building, including its requirements of granting as well as its transfer and annulment of that right must be registered according to provisions.

4	Rights of Use (Hak Pakai)	Rights to use and collect the product from land that is controlled by the State or land owned by an individual who give the rights and obligations designated in the decision upon granting this right by the authority, or in an agreement.
5	Rights of Using Water, of Breeding, and of Catching Fish	Rights to obtain water for a specific purpose and to flow it over another person's land.
6	Rights of Profit-Sharing	Rights of profit sharing on land owned by another person based on an agreement held between the owner and the cultivator from the concession on the land of the owner.
7	Ownership Right of Stacked or Apartment Unit	The ownership rights of an apartment unit, including joint ownership of public space in a building complex. The strata title concept separates rights from several strata or levels, namely the rights to the land surface, the earth below the ground, and the air above it.

Type of Restrictions on Land Parcel/Space

No.	**Type**	**Definition**
1	Zoning Regulations	The provisions governing the use of space and control mechanisms for each zone by the detailed spatial plan. The basic rules referred to include: a. provisions on activities and land use; b. provisions on spatial utilization intensity; c. provisions on building layout; d. provisions on minimum infrastructure and facilities; e. special provisions; f. technical standards; and implementation provisions.
2	Licensing Guidelines (Arahan Perizinan)	A spatial utilization permit is a permit required for space utilization activities in accordance with the provisions of laws and regulations.
3	Incentive and Disincentive Guidelines (Arahan Insentif Dan Disinsentif)	Incentives are given to encourage the use of space according to established spatial patterns, for example by providing awards or tax reductions.
4	Sanctions Guidelines (Arahan Sanksi)	Sanctions for violations of spatial planning regulations.

Type of Responsibilities on Land Parcel/Space

No.	**Type**	**Definition**
1	Protect the Environment and Ecosystem	To maintain the preservation of environmental functions and to prevent and overcome pollution and destruction.
2	Provide Information about	To provide correct and accurate information regarding environmental

	Environmental Management	management performed in specific land owned or controlled.
3	To Utilize Land Parcel within Schedule Prescribed in the Zoning Regulation and in Accordance with the Land Designation or Spatial Plan	To utilize or perform an activity on a land parcel or space according to zoning regulation
4	Compliance with Permitting	To utilize or perform an activity on a land parcel or space according to permit.
5	Maintain and Improve the Quality of Land or Space	To perform a necessary activity in maintaining or improving the quality of land or space owned or controlled and public space.
6	To Provide Access	Provide access or waterways, or other facilities for enclosed yards or plots of land.

Source: (Indrajit et al., 2020) – Complemented with information taken from: *Basic Agrarian Law (Number 5 of 1960); Apartment Law (Number 20 of 2011 and Number 6 of 2023); Spatial Planning Law (Number 26 of 2007 and Number 6 of 2023) and Regulation of the Minister of Agrarian Affairs and Spatial Planning/Head of the National Land Agency of the Republic of Indonesia Number 16 of 2018 concerning Guidelines for the Preparation of Detailed Spatial Planning Plans and Zoning Regulations for Regencies/Cities; and Environmental Protection and Management Law (Number 32 of 2009 and Number 6 of 2023)*.

2.1.3. Gendered Dimensions of Land Tenure and Ecosystem Service Rights

Land governance systems, including ATR/BPN's 3R framework and the Complete System Land Registration (PTSL) program, operate within gendered contexts that can either perpetuate or challenge existing inequalities in resource access and control. Traditional land tenure patterns in coastal Indonesia often favor male ownership and decision-making authority and heighten the risk of excluding women from formal recognition of ecosystem service rights despite their substantial roles in mangrove-dependent livelihoods, including aquaculture, processing, and marketing activities.

The integration of ecosystem service rights into land certification presents both opportunities and risks for gender equity. Without explicit attention to women's inclusion, conservation initiatives could reinforce existing patterns where men hold formal rights to land and resources while women's contributions remain invisible and uncompensated. Conversely, gender-responsive implementation of 3R certification could ensure individual titling, joint titling or co-ownership arrangements, recognize women's ecosystem stewardship roles, and design benefit-sharing mechanisms that reach women directly. Research from other contexts demonstrates that women's secure tenure rights correlate with improved forest conservation outcomes, suggesting that gender-inclusive approaches to ecosystem service rights could enhance both equity and conservation effectiveness (Yang et al. 2018).

2.2. IKN Mangrove Ecosystem Conditions

The IKN coastal area encompasses approximately 68,189 hectares of coastal waters bordered by the Mahakam Delta and Balikpapan Bay, extending to the Makassar Strait. Within this region, mangrove ecosystems represent a critical component of coastal biodiversity, covering a total area of 10,922.8 hectares across five distinct mangrove land condition categories:

1. **Healthy Mangrove:** Mangrove stands that remain largely undisturbed, characterized by a dominance of mature mangrove trees with closed canopies. The aboveground tree biomass carbon stock is at least 65 Mg C per hectare.
2. **Moderately Disturbed (Medium) Mangrove:** Mangroves that have been affected by anthropogenic activities, such as selective logging. The vegetation includes a mix of mature trees and regenerating individuals. Aboveground tree biomass carbon ranges between 10 and 60 Mg C per hectare.
3. **Degraded Mangrove:** Mangroves that have been severely impacted by human activities. Vegetation primarily consists of shrubs and a few low-quality trees. Aboveground tree biomass carbon is estimated between 0.5 and 10 Mg C per hectare.
4. **Regenerating Mangrove:** Previously non-mangrove areas where mangrove vegetation is gradually reestablishing. These areas are dominated by shrubs and small regenerating trees. Tree biomass carbon ranges from 0.5 to 10 Mg C per hectare.
5. **Non-Mangrove Areas:** Former mangrove areas that have been entirely cleared or converted to other land uses. These sites are currently abandoned with little to no tree cover.

Figure 2.1. Spatial distribution of mangrove conditions across the IKN region.

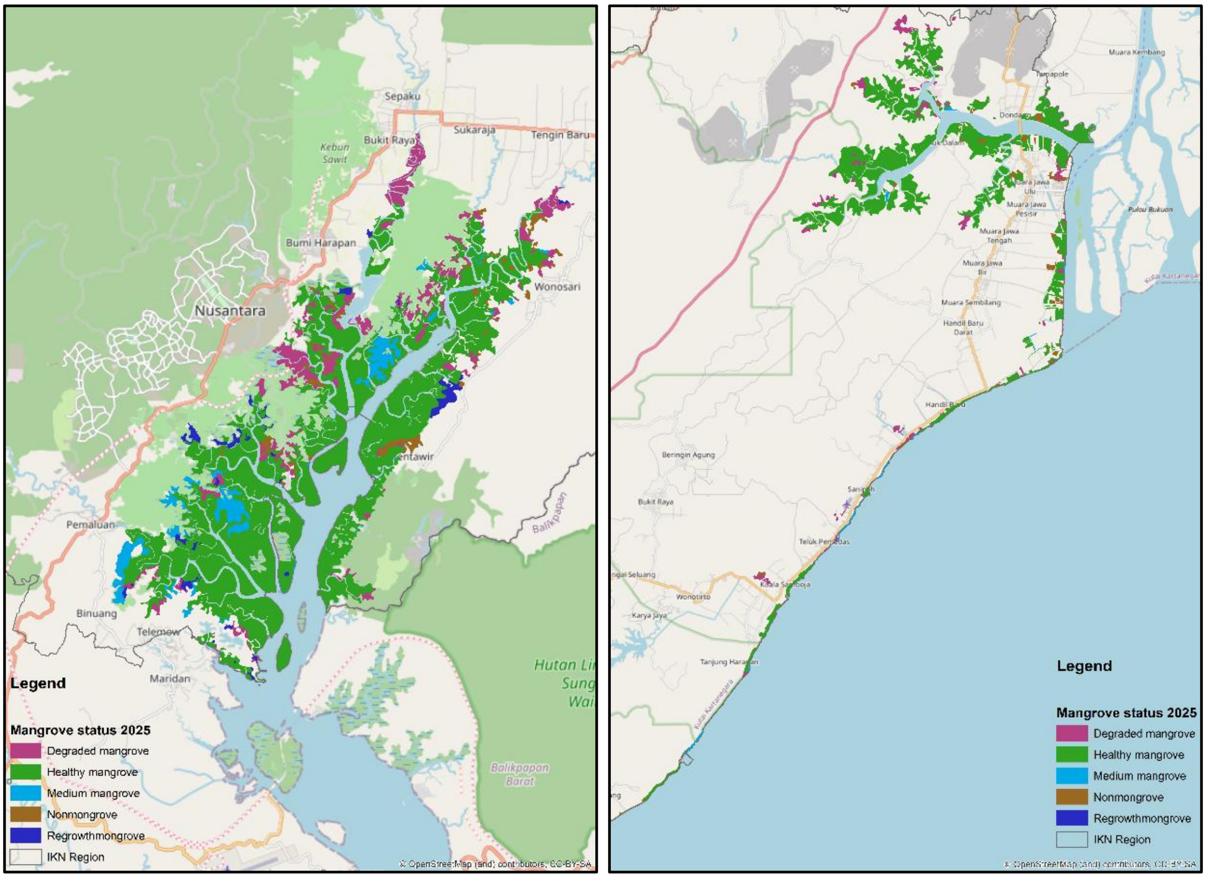


Table 2.2. IKN's Mangrove Status in 2025.

Type*	***Area (ha)***
Healthy mangrove	8,655.2
Medium mangrove	525.5
Regrowth mangrove	188.8
Degraded mangrove	1,155.5
Non-mangrove	397.7

The distribution reveals significant variation in ecosystem quality and conservation status. Healthy mangroves represent the largest category (8,655.2 hectares, 79.2%), indicating substantial areas of healthy, intact mangrove forest that provide optimal ecosystem service delivery. Degraded mangroves (1,155.5 hectares, 10.6%), while comprising a smaller proportion, represent important restoration opportunities with high potential returns on conservation investment.

Balikpapan Bay demonstrates notably high mangrove diversity, supporting 32 recorded species compared to 23 species in the Mahakam Delta. This diversity includes the endangered species *Camptostemon philippinensis*, documented at Lango Beach and Koangan, with potential presence within the broader IKN area. These forests also serve as key biodiversity habitats, supporting endangered species including the proboscis monkey and Irawaddy dolphin.

2.3. Communities and Mangroves in IKN

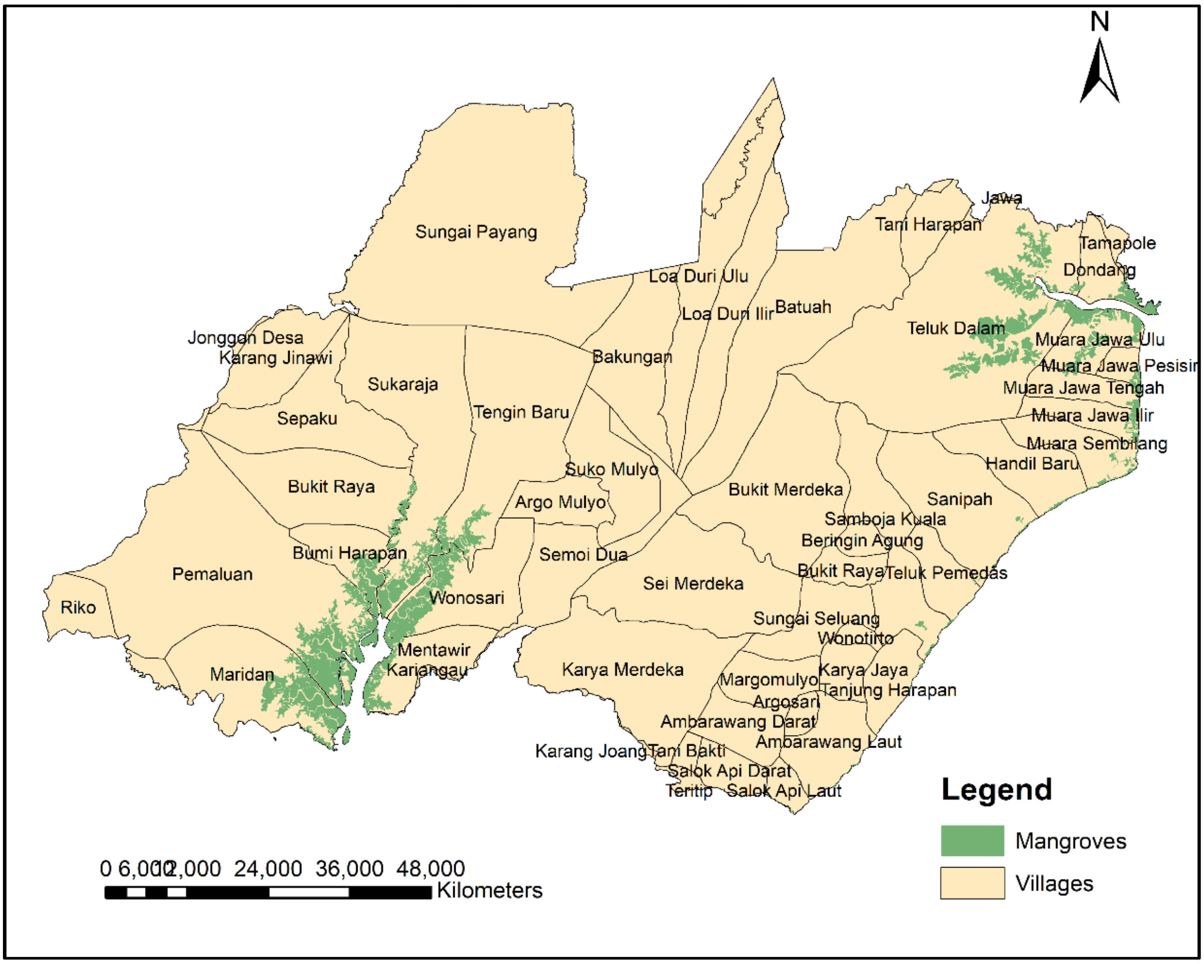
The coastal communities within the IKN mangrove areas represent diverse demographic and livelihood patterns across the three districts, with communities having deep historical connections to mangrove ecosystems predating industrial and urban development. Survey data from 190 households reveals heterogeneous population structure with varied relationships to mangrove resources and ecosystem services.

Table 2.3. Mangroves in Different Villages (Kelurahan and Desa) in IKN.

Village	**Mangrove area (ha)**
Teluk Dalam	2,253.9
Pemaluan	2,003.0
Maridan	1,420.9
Wonosari	1,138.8
Sukaraja	878.4
Muara Jawa Ulu	653.7
Bumi Harapan	524.5
Mentawir	476.1
Tengin Baru	435.9
Dondang	230.4
Muara Sembilang	114.8
Muara Jawa Ilir	114.6
Muara Jawa Tengah	111.4

Bukit Raya	97.8
Muara Jawa Pesisir	66.2
Samboja Kuala	57.7
Sanipah	42.9
Tamapole	41.6
Handil Baru	34.4
Tanjung Harapan	13.4
Ambarawang Laut	13.1

Figure 2.2. Mangrove distribution across IKN's Villages (Kelurahan and Desa).



2.3.1. Household Demographics and Characteristics

Age and Gender Distribution – The survey captured a representative demographic profile with a mean age of 45.2 years (range 18-75 years). The age distribution shows: 18-30 years (22.1%), 31-45 years (38.9%), 46-60 years (28.4%), and 60+ years (10.5%). Gender distribution reflects traditional coastal community patterns with males comprising 73.7% (140 respondents) and females 26.3% (50 respondents) of survey participants.

Education and Socioeconomic Status – Education levels vary considerably: no formal education (5.3%), primary school (28.9%), secondary school (24.2%), high school (32.1%), college/university (8.9%), and postgraduate (0.5%). The average household size is 3.8 members, with respondents having lived in the area for an average of 32.5 years, indicating established community connections to local resources.

Income Distribution – Monthly household income distribution shows: less than 1,000,000 IDR (15.8%), 1,000,000-3,000,000 IDR (52.6%), 3,000,001-5,000,000 IDR (21.1%), 5,000,001-10,000,000 IDR (8.9%), and more than 10,000,000 IDR (1.6%). This distribution reflects typical rural coastal community economic patterns with moderate income levels predominating.

2.3.2. Mangrove Use Patterns and Dependence

Frequency of Interaction – Community engagement with mangrove areas is substantial, with 75.2% of households visiting mangrove areas at least monthly. The frequency distribution shows: daily (31.6%), weekly (18.9%), monthly (24.7%), rarely (21.1%), and never (3.7%). This high engagement level indicates strong community connections to mangrove resources and ecosystem services.

Resource Use Activities – Fishing emerges as the predominant mangrove-related activity, with 68.4% of respondents regularly engaged in fishing activities. Other important activities include collecting firewood (34.2%), tourism/recreation (22.1%), collecting medicinal plants (18.9%), collecting handicraft materials (15.8%), research/education (8.4%), and honey collection (5.3%). These diverse-use patterns demonstrate the multiple ecosystem services supporting community livelihoods.

Economic Dependence Patterns – Economic dependence on mangrove activities shows interesting patterns: 42.1% of households derive no direct income from mangrove activities, 36.8% derive 1-25% of household income, 15.8% derive 26-50%, 4.2% derive 51-75%, and 1.1% derive 76-100%. Overall, 57.9% of households derive some income from mangrove-related activities, with 21.1% being moderately to highly dependent (>25% of income).

Temporal Changes in Resource Use – Changes in mangrove resource use over the past five years show: increased use (15.8%), decreased use (31.6%), and remained the same (52.6%). The decrease in resource use may reflect both conservation awareness and alternative livelihood development, while the increase may indicate growing economic opportunities from sustainable mangrove-based activities.

2.3.3. Community Perceptions of Ecosystem Services

Survey results reveal strong community recognition of mangrove ecosystem services, with consistently high ratings across multiple service categories. Respondents rated ecosystem services on a scale from 1 (Not Important) to 5 (Very Important), with notably high valuations for regulatory and supporting services.

Table 3.2. Community Perception of Ecosystem Services.

Ecosystem Service	Mean Rating (1-5)	Standard Deviation	Very Important (%)	Community Priority Level
Coastal Protection	4.68	0.62	83.1%	Very High
Water Quality Improvement	4.52	0.71	67.4%	Very High
Supporting Wildlife	4.48	0.69	74.2%	Very High
Providing Food	4.41	0.83	70.8%	High
Tourism & Recreation	4.23	0.91	58.4%	High
Carbon Storage	4.15	0.89	56.3%	High
Wood & Materials	3.87	1.12	41.1%	Moderate
Cultural/Spiritual Value	3.22	1.34	28.9%	Moderate

Source: Community perception survey (n=190).

Coastal protection received the highest mean rating of 4.68, with 83.1% of respondents recognizing this as very important. This high recognition aligns with the substantial coastal protection capacity provided by the 8,655.2 hectares of healthy condition mangroves. Water quality improvement services achieved a mean rating of 4.52, indicating strong community awareness of mangroves' filtration and purification functions.

Wildlife support services received a mean rating of 4.48, reflecting community understanding of biodiversity conservation values. Providing food services achieved a mean rating of 4.41, directly reflecting the economic importance of these services for local livelihoods, particularly given that 68.4% of respondents engage in fishing activities.

2.3.4. Environmental Awareness and Change Perception

Climate Change Awareness – The survey demonstrates high climate change awareness among respondents, with 76.8% (146 respondents) having heard of climate change, 17.4% (33 respondents) not having heard of climate change, and 5.8% (11 respondents) providing no response. This high awareness level provides a strong foundation for climate-focused conservation messaging and programs.

Perceived Climate Impacts – Community members have observed various climate-related changes affecting their area. The most frequently mentioned impacts include: changing rainfall patterns (67.4%), extreme weather events (52.1%), rising sea levels (43.7%), longer dry seasons (38.9%), temperature changes (34.2%), and coastal erosion (29.5%). These observations align with projected climate change impacts for the region (FAO, 2025).

Mangroves and Climate Change – A substantial majority (74.2%, 141 respondents) believe that mangroves help address climate change, while only 7.4% (14 respondents) disagree and 12.6% (24 respondents) are unsure. Among believers, the most commonly understood mechanisms include: carbon absorption (62.3%), coastal protection from storms (54.7%), temperature regulation (43.2%), and flood prevention (38.1%).

Environmental Change Observations – Community awareness of environmental changes is high, with 68.4% of respondents noticing changes in mangroves over the past five years, and 76.3% being aware of threats to mangroves. The most commonly identified threats include: coal mining activities (42.1%), deforestation (31.6%), development pressure (28.9%), and pollution (24.2%).

3. Mangrove Ecosystem Services Valuation in IKN

The economic valuation of mangrove ecosystem services in the IKN area reveals substantial benefits across multiple service categories, demonstrating the critical importance of these ecosystems for both local communities and broader climate objectives. The study employed multiple valuation methodologies following established international guidelines (Barbier et al., 2011; Pendleton et al., 2015).

This section presents the valuation findings based on data gathered from the study as well as from the literature review. The values are presented in tables, with each table listing the factors considered for each service, the methodology employed, and the values along with their respective references.

3.1. Coastal Protection Values (Replacement Cost)

Community survey results reveal the highest recognition of coastal protection services among all ecosystem services, with a mean rating of 4.68 out of 5. This exceptional community valuation reflects local understanding of mangroves' critical role in protecting against storm surges, coastal erosion, and rising seas, consistent with global evidence of mangrove effectiveness for coastal protection (Narayan et al., 2016).

The economic valuation of coastal protection services employed replacement cost methodology, estimating the cost of artificial infrastructure required to provide equivalent protection services (Barbier, 2007; Menéndez et al., 2020). This approach has been widely applied in mangrove valuation studies and is recommended by international guidelines for ecosystem service assessment (IUCN, 2017).

Table 3.1. Coastal Protection Economic Assessment.

Protection Service	Methodology	Annual Value (USD/ha)	Reference
Wave attenuation	Replacement cost	1,120-1,369	WACA Program, 2017
Erosion prevention	Avoided damage	2,000-5,000	Narayan et al., 2016
Storm surge protection	Infrastructure replacement	5,000-15,000	Menéndez et al., 2020
Total Protection Value	**Combined methods**	**8,120-21,369**	**Multiple sources**

Sources: International coastal protection valuation studies.

Research demonstrates that mangrove forests can reduce wave heights by 13-66% over distances of 100m, with effectiveness varying by forest density and structure (Narayan et al., 2016). For IKN's planned infrastructure investment and coastal location, these protection services provide substantial value for safeguarding public and private assets while offering cost-effective alternatives to artificial coastal defenses.

3.2. Fisheries and Provisioning Services

Survey data reveals fishing as the dominant mangrove-related activity, with 68.4% of respondents (130 out of 190) reporting regular fishing activities. The high rating of food provisioning services (mean 4.41 out of 5) confirms the recognized importance of mangroves for supporting local fisheries, consistent with global evidence of mangrove-fishery linkages (Rönnbäck, 1999; Barbier, 2003).

Mangrove ecosystems serve as essential nursery grounds and habitat for numerous commercially valuable species. Meta-analyses demonstrate that fish abundance in mangrove areas is significantly higher than in adjacent non-mangrove habitats, with nursery value contributing substantially to overall fisheries productivity (Mumby et al., 2004; Aburto-Oropeza et al., 2008).

Table 3.2. Fisheries Economic Valuation.

Fisheries Service	Assessment Method	Annual Value (USD/ha)	Community Dependence	Reference
Nursery habitat	Production function	1,500-3,000	High - 68.4% engaged	Rönnbäck, 1999
Spawning grounds	Market price	500-1,000	Medium - seasonal	Barbier, 2003
Aquaculture support	Enhanced productivity	300-800	Medium - pond integration	IUCN, 2017
Total Fisheries Value	**Multiple methods**	**2,300-4,800**	**Primary livelihood**	**Multiple sources**

Sources: Fisheries valuation studies and local assessments.

The valuation methodology followed established approaches for quantifying mangrove contributions to fisheries productivity, accounting for the proportion of commercially important species dependent on mangrove nursery habitat during critical life stages (Mumby et al., 2004). Local community dependence on these services, with over two-thirds of surveyed households actively engaged in fishing, demonstrates the critical socioeconomic importance of maintaining healthy mangrove ecosystems.

3.3. Carbon Storage and Sequestration Services

Community survey results demonstrate high valuation of carbon storage services, with respondents rating carbon storage at a mean of 4.15 out of 5, making it the sixth highest-rated ecosystem service. This community recognition aligns with scientific evidence demonstrating that mangroves are among the most carbon-rich ecosystems globally, storing three to five times more carbon per unit area than other forest ecosystems (Murdiyarso et al., 2015).

Field surveys in the IKN area revealed carbon storage densities consistent with Indonesia's national mangrove carbon inventory. Based on the comprehensive biomass and carbon assessment conducted, **healthy condition mangroves demonstrate average total carbon storage of 1,038 Mg/ha**, while **degraded areas show significantly lower storage at 488 Mg/ha**. These values align with Murdiyarso et al. (2015) findings showing national mean carbon density of 1,083 tCO_2e per hectare across Indonesian mangroves.

Table 3.3. Carbon Economic Valuation.

Carbon Service Type	Quantity (tCO_2e/ha)	Value Range (USD/tCO_2)	Economic Value (USD/ha/ year)	Implementation Area (ha)	Source

Conservation (reduced emissions)	15.9*	20-60	318-954	8,655.2	Blended portfolio calculation
Restoration (active sequestration)	8.0	20-60	160-480	1,553.2	Murray et al., 2011 adapted
Enhancement (improved management)	5.0	20-60	100-300	714.3	Management improvement estimates
Total storage potential	*Variable*	**20-60**	**284-842**	**10,922.8**	**-**

**Average annual reduced emissions: 2,345,559 total tCO_2e ÷ 17 years ÷ 8,655.2 ha = 15.9 tCO_2e/ha/year.*

Sources: Multiple carbon valuation studies and field assessments.

The economic valuation applies carbon pricing scenarios ranging from USD 20 to USD 60 per tCO_2e, reflecting current voluntary carbon market prices to projected compliance market values under ambitious climate scenarios (UNEP, 2014). Conservation and restoration of IKN's 10,922.8 hectares under the blended portfolio approach generates annual carbon credits of 153,972 tCO_2e, with economic value ranging from USD 3.1 to 9.2 million annually over the 2025-2042 implementation timeline, totaling USD 37 to 111 million NPV depending on carbon pricing scenarios.

3.4. Cultural Values (Contingent Valuation)

Cultural and spiritual values received a moderate rating of 3.22 out of 5 in the community survey, representing the lowest among all services assessed but still indicating meaningful importance to communities. This relatively lower rating may reflect challenges in quantifying intangible cultural benefits rather than actual low importance (Himes-Cornell et al., 2018). Tourism and recreation services received a higher importance rating (mean 4.23 out of 5), indicating strong community recognition of potential economic opportunities.

The economic valuation of cultural services employed multiple approaches including contingent valuation for spiritual and heritage values, travel cost methods for recreation, and benefit transfer for tourism potential (Vegh et al., 2014). These methodologies are particularly important for capturing non-use values that may not be reflected in market transactions.

Table 3.4. Cultural and Tourism Service Valuation.

Cultural Service	Valuation Method	Annual Value (USD/ha)	Development Potential	Reference
Ecotourism	Travel cost method	300-1,000	High - unique biodiversity	Yong, 2014
Cultural heritage	Contingent valuation	150-500	Medium - traditional knowledge	Thiagarajah et al., 2015
Recreation	Benefit transfer	200-600	Medium - community access	Himes-Cornell et al., 2018
Spiritual values	Participatory assessment	100-300	High - sacred sites	Moore et al., 2022
Total Cultural Value	**Multiple methods**	**750-2,400**	**Emerging sector**	**Multiple sources**

Sources: Cultural and tourism valuation studies.

Areas such as Mentawir Village demonstrate significant potential for sustainable ecotourism development, combining unique biodiversity with traditional cultural knowledge and practices. The integration of cultural heritage with ecosystem conservation can enhance both conservation outcomes and economic benefits while maintaining community ownership and cultural integrity (Moore et al., 2022).

3.5. Other Ecosystem Services (Benefit Transfer)

Several ecosystem service values in this study employed benefit transfer methodology, transferring value estimates from comparable studies to the IKN context. Specific applications include:

Water Purification Services – Values derived from WACA Program (2017) Ghana coastal studies, adjusted for local economic conditions and service demand. The transfer site comparison is justified by similar coastal development pressure and institutional capacity for service provision.

Cultural and Tourism Services – Baseline values transferred from Thiagarajah et al. (2015) Singapore mangrove studies and Yong (2014) Malaysian ecotourism assessments, with adjustments for IKN's unique biodiversity and international profile. These transfer sites provide reasonable comparisons given similar development contexts and tourism market access.

The study introduced potential margins of error of ±25-40% in transferred values, particularly for cultural services where context-specificity is highest. The age of some transferred data (5-10 years) may not fully reflect current market conditions or service demand. Future assessments should prioritize primary data collection for all service categories to improve accuracy and local relevance.

3.6. Total Economic Value Assessment

Aggregating all quantified ecosystem services provides a comprehensive economic assessment of IKN's mangrove ecosystems. The total annual economic value ranges from USD 67.4 to 123.0 million across 10,922.8 hectares, representing per-hectare values of USD 6,170 to 11,260 annually. This positions IKN's mangroves among Indonesia's highest-performing coastal ecosystems (Barbier et al., 2011; Murdiyarso et al., 2015).

Table 3.5. Total Economic Value Summary.

Ecosystem Service	Annual Value (USD million)	2025-2042 NPV* (USD million)	Community Priority Ranking
Coastal protection	24.1-35.2	290-424	Highest (4.68)
Water quality regulation	2.8-8.9	34-107	Very High (4.52)
Fisheries support	28.7-42.3	346-509	Very High (4.41)
Tourism and recreation	8.2-26.2	99-315	High (4.23)
Carbon sequestration/storage	3.1-9.2	37-111	High (4.15)
Raw materials	0.5-1.2	6-14	Moderate (3.87)
Total Annual Value	**67.4-123.0**	**812-1,480**	**-**

**Using a social discount rate of 5%.*
Source: Aggregated ecosystem service valuation.

These values position IKN's mangrove ecosystems among the highest-performing coastal ecosystems in Indonesia, reflecting the combination of good ecological condition (79.2% in healthy condition), high community dependence and recognition, and substantial economic development pressure creating high demand for ecosystem services. The 17-year (2025-2042) net present value of USD 812-1,480 million provides strong economic justification for proactive conservation investment and innovative management approaches.

3.7. Community Willingness to Pay

The assessment of community willingness to pay (WTP) for mangrove conservation services, based on 190 household surveys, provides crucial insights into local valuation of ecosystem services and potential financing mechanisms for sustainable management. Understanding community willingness to participate financially in conservation efforts is essential for designing PES, as it indicates both the social license for conservation programs and the potential for community co-financing alongside external payments from ecosystem service beneficiaries such as government agencies, private developers, and international climate finance mechanisms.

3.7.1. Descriptive Statistics

The survey reveals substantial community support for mangrove conservation financing, with clear patterns in participation willingness and payment preferences that inform PES design.

Table 3.6. Willingness to Pay Distribution.

WTP Response	Number of Respondents	Percentage	Implications
Yes	85	44.7%	Strong conservation support
Maybe	55	28.9%	Conditional willingness
No	41	21.6%	Limited support
Not specified	9	4.8%	Non-response
Total potentially willing	**140**	**73.6%**	**High participation potential**

Source: Household survey data (n=190).

The survey reveals strong community support for mangrove conservation financing, with 73.6% expressing definite or potential willingness to contribute. This high participation rate provides robust foundation for community-based conservation financing mechanisms and compares favorably with similar studies in Southeast Asian coastal contexts (Datta et al., 2012, Nyangoko et al., 2021).

3.7.2. Payment Amount Preferences

The distribution of payment amounts among willing participants shows concentration in lower payment brackets, reflecting both community capacity and realistic contribution patterns.

Table 3.7. Monthly Payment Amount Distribution.

Payment Range (IDR)	Respondents	Percentage of Willing	Average USD/month*	Estimated Annual Revenue (USD)

< 10,000	37	26.4%	0.64	2,848
10,000-50,000	60	42.9%	2.14	15,408
50,001-100,000	12	8.6%	5.36	7,714
100,001-500,000	5	3.6%	21.43	12,857
> 500,000	3	2.1%	39.29	14,143
Not specified	23	16.4%	-	-
Total	**140**	**100%**	**Variable**	**52,970**

Based on exchange rate 1 USD = 14,000 IDR.

The majority of willing participants (42.9%) prefer contributions of IDR 10,000-50,000 monthly (USD 0.71-3.57), suggesting that universal payment schemes targeting this range could maximize participation while remaining affordable for its implementation.

3.7.3. Key Determinants of Willingness to Pay

Analysis of willingness to pay patterns reveals important socio-economic and demographic correlations that inform the design of conservation initiatives. The survey data allows for examination of how different characteristics influence conservation support.

Table 3.8. Demographic Correlations with Willingness to Pay.

Demographic Factor	Positive WTP (%)	Correlation Strength	Implications
Age 18-30 years	52.4%	Moderate positive	Younger more willing
Age 31-45 years	45.9%	Neutral	Mixed willingness
Age 46+ years	38.5%	Moderate negative	Older less willing
Higher education	58.8%	Strong positive	Education increases WTP
Land ownership	56.9%	Moderate positive	Ownership increases WTP
Higher income	64.7%	Strong positive	Income positively related

Source: Statistical analysis of survey data.

Critically, the data shows greater willingness to pay for conservation by land-owners and younger respondents, in addition to higher income households. These patterns provide important guidance for targeting and designing: (1) community and youth engagement strategies; and (2) land rights strengthening activities, especially targeting female and male youth and women more broadly, given women's underrepresentation as documented land rights holders.

3.7.4. Gender Analysis of Willingness to Pay

Recognizing the importance of gender dimensions, the analysis examined differences in conservation willingness between male and female respondents.

Table 3.9. Gender Differences in Conservation Support.

Gender	Sample Size	Willing to Pay (%)	Maybe Willing (%)	Not Willing (%)	Average WTP (IDR/month)

Male	140 (73.7%)	46.4%	27.9%	21.4%	38,500
Female	50 (26.3%)	40.0%	32.0%	22.0%	42,000

Source: Gender-disaggregated analysis of survey data.

Interestingly, while male respondents show slightly higher definite willingness to pay (46.4% vs 40.0%), female respondents demonstrate higher average payment amounts when willing (IDR 42,000 vs 38,500 monthly). The "maybe willing" category is higher among women (32.0% vs 27.9%). Notably, women's willingness to pay is higher, even in a background where the norm is for documented land ownership in the names of men.

The finding that women demonstrate higher average payment amounts when willing to contribute (IDR 42,000 vs 38,500 monthly) reveals important insights for a PES design. This pattern suggests that while women may face greater barriers to initial participation— potentially reflecting household decision-making dynamics, economic constraints, limited access to information, or gender inequality in land ownership and status—those who do engage show stronger financial commitment to conservation. The higher "maybe willing" category among women (32.0% vs 27.9%) indicates potential for increased female participation with appropriate design addressing their specific concerns and constraints.

These patterns have significant implications for PES sustainability and effectiveness. Women's higher payment commitments, combined with extensive research demonstrating women's effective natural resource management in coastal contexts (Yang et al., 2018, Nyangoko et al., 2021, Merven et al., 2023) suggest that gender-inclusive PES design could enhance both revenues and conservation outcomes. However, realizing this potential requires addressing underlying barriers including women's lack of formal land rights, restricted participation in household and community decision-making forums, and potential exclusion from ecosystem service benefit streams. PES design should therefore include specific mechanisms ensuring women's meaningful participation in PES governance, gender equitable rights to land, equitable access to benefit flows, and recognition of their ecosystem stewardship contributions and dependence in terms of food security and resilience to climate change.

3.7.5. Climate Change Awareness and Conservation Initiatives

The survey demonstrates exceptionally high climate change awareness among respondents, with important implications for designing conservation initiatives.

Table 3.10. Environmental Awareness and Conservation Support.

Environmental Indicator	Yes	No	Not Sure	Conservation Implication
Heard of climate change	146 (76.8%)	33 (17.4%)	11 (5.8%)	High baseline awareness
Mangroves help address climate change	141 (74.2%)	14 (7.4%)	24 (12.6%)	Strong service recognition
Willing to participate in conservation	140 (73.6%)	41 (21.6%)	9 (4.8%)	Action readiness

Source: Community awareness survey (n=190).

This high awareness correlates with the strong valuation of carbon storage services (4.15 out of 5) and likely contributes to willingness to pay for conservation. Communities commonly mentioned climate impacts including changing rainfall patterns, extreme weather events, and rising sea levels, demonstrating direct experience with climate-related challenges that mangroves help address.

3.7.6. Resource Use Patterns and Conservation Motivation

The survey reveals important patterns in how communities interact with mangrove ecosystems that influence their willingness to contribute to conservation financing.

Table 3.11. Mangrove Use Frequency and Payment Willingness.

Visit Frequency	Number of Respondents	Percentage	Typical WTP Response	Conservation Implication
Daily	60	31.6%	Higher willingness	Direct dependency drives support
Weekly	36	18.9%	Higher willingness	Regular users value services
Monthly	47	24.7%	Moderate willingness	Periodic users recognize value
Rarely	40	21.1%	Moderate willingness	Indirect benefits recognized
Never	7	3.7%	Lower willingness	Limited connection to services

Source: Survey data on resource use patterns.

The data shows that those who use mangrove areas more frequently demonstrate higher willingness to pay, but importantly, even those who rarely visit still show moderate willingness to pay, suggesting recognition of ecosystem services beyond direct use benefits such as coastal protection and climate regulation.

3.7.7. Implications for PES Design

The survey results provide clear guidance for designing conservation financing mechanisms that maximize community participation while remaining fiscally sustainable. With 42.9% of willing contributors preferring IDR 10,000-50,000 (USD 0.71-3.57) monthly, a universal payment scheme targeting this range could maximize participation while generating meaningful revenue. Based on the 444 households engaged with mangrove resources identified, and assuming similar participation rates, community contributions could generate approximately USD 53,000 annually. While this represents meaningful community investment, it constitutes only a fraction of total conservation financing needs, indicating necessity for diversified funding sources including government investment, private sector engagement, and international climate finance.

The analysis demonstrates that community willingness to pay and conserve mangrove forest, even when facing an unfavorable and discouraging land and resource tenure context, highlights a crucial component of a diversified financing strategy. The strong environmental awareness, high ecosystem service valuation, and willingness to participate in conservation activities provide solid foundation for implementing community-based conservation initiatives alongside payments from external ecosystem service beneficiaries including coastal developers, government agencies purchasing coastal protection services, and carbon credit buyers.

4. Discussion: Feasibility for Payment for Ecosystem Services in Mangrove Areas in IKN

4.1. Community Support and Participation Potential

The study reveals exceptionally strong community foundation for PES implementation in the IKN area, with survey results demonstrating significant willingness to participate in conservation financing.

Community readiness for PES implementation is evidenced by multiple indicators. The 73.6% combined willingness to participate (44.7% definite plus 28.9% conditional) provides robust foundation for community-based conservation financing. This participation rate significantly exceeds typical community program participation in Indonesia, where 40-60% participation rates are considered successful (Datta et al., 2012).

High environmental awareness (76.8% climate change awareness) combined with strong ecosystem service recognition (mean ratings 3.22-4.68 across all categories) creates informed community understanding supporting sustained participation. The dominance of coastal protection (4.68) and water quality improvement (4.52) as highest-rated services aligns with global PES market opportunities in coastal resilience financing and water quality improvement programs (WACA Program, 2017).

Community willingness extends beyond financial contributions to active conservation engagement, with majority expressing willingness to participate in planting, monitoring, and management activities. This multi-dimensional engagement enables hybrid payment mechanisms combining monetary contributions with in-kind labor and materials, effectively increasing total community contribution value while reducing cash payment requirements.

Existing conservation activities demonstrate practical engagement capacity. Communities in Kampung Lama, Mentawir, Bumi Harapan, Maridan, and Tanjung Harapan currently engage in planting activities, nursery development, and monitoring, providing operational foundation for expanded PES implementation.

4.2. Institutional Readiness

Within its framework of authority, the IKN Authority, guided by national legal and regulatory frameworks and supported by technical capacity and experience, can develop its potential to strengthen the fundamental pillars for PES implementation.

Legal conditions for PES implementation are exceptionally favorable compared to other Indonesian coastal areas, with OIKN possessing comprehensive authority that eliminates many coordination challenges typically constraining PES implementation. Government Regulation No. 27 of 2023 grants OIKN authority over biodiversity management, coastal and marine management, customary community recognition, and spatial planning integration.

This comprehensive authority structure enables rapid decision-making and implementation without the multi-agency coordination challenges that frequently delay or compromise PES initiatives in other contexts. The unique governance framework allows for innovative approaches that may not be feasible under normal Indonesian administrative arrangements.

ATR/BPN's 3R framework provides robust legal foundation for recognizing ecosystem service rights, establishing clear restrictions for ecosystem protection, and defining responsibilities for conservation performance. The ongoing Land Registration and the PTSL program in IKN creates opportunities to integrate ecosystem service rights into land certification processes, providing legal foundation for PES participation that is unavailable in most other Indonesian contexts. Moreover, OIKN has promoted efforts to explicitly support property rights for women (held individually and jointly) in coastal areas, under the Draft Regulation of the Head of OIKN on the Protection and Management of Coastal Areas and Small Islands in IKN, in alignment with Article 9(2) of the Basic Agrarian Law. These coastal women's land rights rules, once promulgated, would provide a strong legal basis for coastal women's equal inclusion in land certification processes as well as their integration in integrated ecosystem service rights efforts.

Current policy frameworks support PES development through multiple complementary mechanisms. The IKN Spatial Plan (RTR-KSN) 2022-2042 designates 11,751.7 hectares for protection, creating legal basis for conservation requirements. The IKN Biodiversity Masterplan and Local Wisdom Guidelines establish procedures for integrating traditional knowledge and community participation in conservation planning. Additionally, the Basic Agrarian Law, Presidential Instruction No. 9/2000 on Gender Mainstreaming in National Development, and Indonesia's National Medium-Term Development Plan (RPJMN) 2025-2029 also support gender mainstreaming, including the strengthening of women's land rights to reinforce PES development.

Finally, existing community experience with incentive programs demonstrates institutional readiness for PES scaling. In Maridan, community members have gained practical understanding of PES concepts through Forest Carbon Partnership Facility (FCPF) incentive fund experience, using payments for tree nurseries and planting activities. This experience provides crucial foundation for broader implementation while identifying key success factors including clear area designations, transparent benefit distribution, and measurable conservation outcomes. There is great opportunity to grow women and youth's technical capacity and experience to center their inclusion within broader implementation efforts.

Government technical capacity exists through OIKN's environmental management units, while academic partnerships and other non-government collaborations provide ongoing technical assistance. The latter is particularly important to ensure the technical capacity necessary to promote gender mainstreaming, coastal women's land rights, and women's inclusion in PES. International cooperation through organizations including the World Bank and various climate finance mechanisms offers additional technical and financial support for effective and inclusive PES development.

4.3. Key Considerations for a PES

Based on economic valuation results, as well as community willingness and institutional readiness, a PES in mangrove areas in IKN should consider integrating multiple ecosystem services to maximize economic sustainability and conservation impact while reducing dependence on single market mechanisms.

Based on economic valuation results showing USD 67.4 to 123.0 million annually in total ecosystem service value, sustainable PES payments of USD 340-600 per hectare annually are justified at 4 – 10 % of total service value. This payment level significantly exceeds regional opportunity costs (USD 1,000-3,000 per hectare in comparable East Kalimantan areas) while remaining fiscally sustainable and competitive with alternative land uses. The multi-service approach provides diversified revenue streams, reducing market risks while capturing synergistic benefits across service categories.

The design of a PES should be gender responsive. Effective PES implementation in IKN requires explicit attention to gender dimensions throughout design, implementation, and monitoring. Gender-responsive PES framework elements should include: (1) assessment of cross-cutting gender-mangrove-tenure issues; (2) joint or women-specific ecosystem service rights certification, recognizing women's stewardship roles; (3) benefit-sharing mechanisms ensuring direct payments to women participants rather than exclusively to household heads which are predominately men; (4) women's equal representation in PES governance structures including the proposed Multi-Stakeholder Mangrove Management Body (See Section 4.4); and (5) targeted capacity building addressing women's specific socio-economic, technical, and financial literacy needs.

The framework should also address gender-differentiated ecosystem service contributions and dependencies. Women's roles in mangrove-based aquaculture, post-harvest processing, medicinal plant collection, and tourism services often remain invisible in conventional economic analyses but represent substantial ecosystem service dependencies requiring protection and compensation. PES design should therefore recognize and value these contributions through differentiated payment mechanisms, technical support programs, and leadership development opportunities specifically targeting women participants.

Failure to address gender dimensions risks perpetuating or exacerbating existing inequalities while undermining PES effectiveness. Conversely, gender-responsive implementation, that includes women’s equal rights to land and natural resources, can enhance its sustainability through women's demonstrated commitment to conservation, improve household welfare through more equitable benefit distribution, and contribute to broader social transformation supporting sustainable development goals. The substantial gender differences observed in this study—both in payment willingness and amounts—demonstrate the critical importance of gender-responsive PES design for realizing IKN's full conservation and development potential and contributing national goals for SDG achievement, including SDG 5 on gender equality and women’s land rights.

Finally, three key mangrove ecosystem services should be considered for a PES: carbon service payments, coastal protection service payments, and tourism integration, in line with the national regulatory framework for carbon projects in Indonesia and a regulatory framework set by OIKN for coastal protection and eco-tourism[2].

Carbon services represent the largest potential revenue stream with established market mechanisms and growing demand. Conservation payments range from USD 318-954 per hectare per year based on 15.9 tCO_2e/ha/year of reduced emissions at USD 20-60/tCO_2 pricing. Restoration payments provide USD 160-480 per hectare annually based on 8 tCO_2e annual sequestration rates. Implementation through carbon markets offers immediate revenue potential. The high carbon storage capacity documented in IKN mangroves (total 11,036,190 Mg) positions these areas competitively in both voluntary and compliance carbon markets.

The high community valuation of coastal protection services (mean 4.68) reflects substantial economic value that justifies payments from infrastructure developers, property owners, and government agencies. Annual protection payments of USD 1,500-4,000 per hectare represent 10-25% of total protection service value, while development impact fees of USD 5,000-15,000 per hectare provide one-time payments for coastal developments. IKN's planned development density and infrastructure investment create high demand for coastal protection services, making these payments economically justified from user perspectives. The integration of

[2] According to Government Regulation No. 27 of 2023 concerning the Special Authority of the IKN Authority, IKN has authority related to environmental governance, including aspects of water, ambient air, land cover, soil, atmosphere, and biodiversity, with the exception of environmental services related to carbon storage and/or absorption.

natural infrastructure with urban planning provides cost-effective alternatives to artificial coastal protection while delivering multiple co-benefits.

Tourism revenue sharing provides USD 300-1,000 per hectare annually (20-40% of tourism revenue) with cultural integration premiums of USD 150-500 per hectare for heritage site management. Areas like Mentawir with established tourism potential can generate immediate revenue while other areas develop tourism capacity over time.

4.4. Institutional Architecture and Implementation

Successful PES implementation requires robust institutional architecture bringing together diverse stakeholders while maintaining clear authority and accountability. It is suggested to consider a Multi-Stakeholder Mangrove Management Body (MSMMB) with OIKN leadership that provides strategic guidance and policy integration, in a systematically gender inclusive manner. The MSMMB should also include government agency representatives to ensure coordination across sectors; community representatives from each major mangrove area with equal representation for women and men; traditional leaders maintaining customary authority; academic institutions and civil society organizations providing technical expertise; and private sector representatives contributing market knowledge. To ensure PES implementation is gender-responsive the MSMMB should include a working group for gender mainstreaming in natural resources management.

Clear mandates should include coordinating implementation of PES across all service categories, overseeing fund management and benefit distribution, resolving conflicts between stakeholders, monitoring ecosystem health and conservation effectiveness, gender mainstreaming, and recommending policy adjustments based on outcomes. Regular meetings, transparent decision-making processes, and public reporting should be considered to ensure accountability and stakeholder engagement.

In terms of payment flows and verification systems, payment flows should operate through clearly defined mechanisms linking service buyers, providers, and intermediaries. Service buyers could include government agencies purchasing coastal protection and carbon services, private developers paying impact mitigation fees, tourism operators contributing to habitat maintenance, and international climate finance organizations purchasing carbon credits. Payment flows and verification systems should pay particular attention to ensure payments systematically reach women and are gender-responsive.

Service providers ought to equitablly encompass women and men community members with certified land rights, customary institutions managing traditional territories, and conservation groups (including women as well as youth conservation groups) implementing restoration activities. Intermediaries could include OIKN providing verification and coordination, including with respect to ensure gender inclusion; ATR/BPN certifying rights, restrictions, and responsibilities; and financial institutions processing payments and managing funds.

Verification systems should ensure service delivery through permanent monitoring plots tracking ecosystem health, satellite imagery and field verification confirming compliance, community-based monitoring through gender-balanced supervision groups, and annual reporting on conservation outcomes and payment distribution, including providing data disaggregated by gender and age.

4.5. Gender-Responsive Mangrove Land Certification and Application of the 3R Framework

The gender-responsive 3R (Rights, Restrictions, Responsibilities) framework application in IKN creates unprecedented opportunities for innovative ecosystem service rights certification that transforms abstract environmental values into concrete, marketable assets. Unlike traditional land rights focused primarily on use and exclusion and done in a gender neutral manner, the proper combination of women's and men's equal rights, restrictions and responsibilities could grant explicit and equal rights for women and men to specific ecosystem services including carbon sequestration revenues, coastal protection service payments, and tourism development opportunities, while strengthening ecosystem stewardship and support to government targets and development plans, including with respect to SDG achievement.

An example of a proposed 3R combination for an enabling land certificate that could allow women and men landholders to equally benefit from ecosystem services, while complying with OIKN's Spatial Pattern Plan in forested mangrove areas currently designated as *Protected Areas*, could be:

- Right – Ownership Rights (Hak Milik)
- Restriction – Zoning Regulation – Prohibition for cutting trees
- Responsibility – Provide information about environmental management

With this suggested land certificate and considering the potential to engage in a PES mechanism (including a carbon project), women and men landholders could equally benefit from conserving standing mangrove forests, while also gaining equal formal access to non-timber forest products and other resources from healthy mangrove ecosystems.

Another example of a proposed 3R combination that could serve as an incentive for mangrove reforestation in *Protected Areas* without mangrove cover, while still allowing for ecosystem service benefits and adhering to OIKN's Spatial Pattern Plan, could be:

- Right - Ownership Rights (Hak Milik)
- Responsibility – Maintain and improve the quality of land or space
- Responsibility – Provide information about environmental management

With this configuration, if a PES mechanism is available, the land certificate could act as an enabling incentive for mangrove forest reforestation by both women and men land rights holders, while also allowing for sustainable and equal use of non-timber forest products and other resources derived from restored mangrove areas.

Finally, in the case of *Cultivation Areas* that currently maintain mangrove forest cover or has no mangrove cover, a proposed 3R combination that could serve as an incentive for mangrove conservation and reforestation, if supported by a PES mechanism, could be:

- Right - Ownership Rights (Hak Milik)
- Responsibility - Provide information about environmental management

This option supports the conservation of existing mangrove forests in *Cultivation Areas* as well as reforestation of areas without mangrove cover, offering a formal pathway for women and men to benefit from ecosystem services while encouraging sustainable land stewardship.

This certification approach represents fundamental departure from conventional property rights by recognizing and protecting rights to flow of services rather than just stock of resources, as well as ensuring the rights to follow of service are equally enjoyed by women and men. Under this type of certification, women and men rights holders receive formal recognition through land certificates specifying the opportunity for carbon credit revenue entitlements, coastal protection service payment eligibility and tourism development participation rights.

Implementation requires careful design, maintaining and acknowledging critical public goods while enabling private benefits. Subsistence fishing access, navigation rights, and cultural uses should remain in public domain preventing conflicts over traditional access patterns. The certification process should also distinguish between privatizable services (carbon credits, commercial tourism) and public services (community fishing access, cultural practices, emergency shelter).

The integration of this suggested approach with the PTSL program could enable ecosystem service rights incorporation into standard land certification processes—both advanced in a gender-responsive manner— creating a systematic and inclusive approach applicable across Indonesia's coastal areas. This innovation could position Indonesia as global leader in gender-responsive ecosystem service rights recognition while providing practical foundation for scaled PES implementation.

4.6. Implementation and Scaling Uncertainties

PES implementation faces significant institutional and financial uncertainties that may affect actual outcomes compared to feasibility projections (See Table 4.1). Carbon market price volatility creates uncertainty about long-term financing sustainability, while regulatory frameworks for ecosystem service rights recognition remain under development at national level.

Community participation sustainability requires ongoing demonstration of tangible benefits, which may take years to materialize fully. The transition from traditional open access resource use to formal PES participation involves significant behavioral and institutional changes that implementation timelines may underestimate. Additionally, women's equal inclusion and land rights will likewise involve significant social norms, behavioral, and institutional changes.

Access for ecosystem services faces regulatory and technical barriers that may limit revenue potential. Certification requirements, monitoring costs, and transaction expenses may reduce net benefits to communities while creating barriers to participate.

Table 4.1. Implementation Risk and Mitigation Register.

Risk Category	Specific Risk	Impact Level	Probability	Mitigation Strategy
Financial	Carbon market price collapse	High	Medium	Diversify revenue streams across multiple services; establish minimum price guarantees; develop buffer funds
Social	Lack of community buy-in	High	Low	Extensive consultation; transparent benefit-sharing; community ownership of governance

Political	Political interference/ leadership change	Medium	Medium	Multi-party support building; legal frameworks; international partnerships
Institutional	Elite capture of funds	High	Medium	Transparent payment systems; direct household payments; strong audit mechanisms
Technical	Monitoring system failure	Medium	Low	Redundant monitoring systems; community-based backup monitoring; regular system updates
Market	Limited carbon credit market access	Medium	Medium	Pre-certified carbon project development; international broker partnerships
Environmental	Climate change ecosystem degradation	High	High	Adaptive management protocols; ecosystem restoration fund; assisted migration planning
Legal	Land tenure disputes	High	Low	Comprehensive gender-inclusive 3R certification; dispute resolution mechanisms; legal clarity establishment

Risk mitigation approaches require adaptive management approaches enabling continuous learning and adjustment based on monitoring outcomes and stakeholder feedback. Regular monitoring and evaluation systems should track both ecosystem service provision and community participation outcomes which are disaggregated by gender and age, enabling early identification of implementation challenges and opportunities for improvement.

Diversified financing strategies reduce dependence on any single revenue stream while providing resilience against market and policy uncertainties. Integration of multiple ecosystem services in PES design provides hedging against service-specific risks while capturing synergistic benefits across service categories.

Finally, stakeholder engagement mechanisms should ensure ongoing community support and private sector participation while providing early warning of emerging conflicts or concerns. Transparent communication about uncertainties and limitations maintains credibility while building support for adaptive management approaches.

5. Conclusions

This comprehensive study demonstrates that **IKN's mangrove ecosystems provide exceptional economic, ecological, and social value** strongly justifying proactive conservation through innovative management approaches. The **total annual ecosystem service value of USD 67.4 to 123.0 million across 10,922.8 hectares** positions these ecosystems among Indonesia's highest-performing coastal areas, **with per-hectare benefits of USD 6,170 to 11,260 annually** far exceeding national averages.

The **dominance of healthy condition mangroves** (79.2% of total area) **storing 11,036,190 Mg of carbon** provides both immediate conservation value and substantial climate mitigation potential. Community recognition of ecosystem services, with consistently high ratings across all service categories and particularly strong valuation of coastal protection (4.68) and water quality improvement (4.52), demonstrates local understanding supporting conservation implementation.

Community willingness, including willingness of women, **to participate in conservation financing** (73.6% expressing definite or potential willingness) **combined with high environmental awareness** (76.8% climate change awareness) provides **robust foundation for inclusive Payment for Ecosystem Services implementation**. The institutional framework through OIKN's comprehensive authority, ATR/BPN's 3R framework, and the Government of Indonesia’s commitment to climate goals and the SDGs creates unprecedented opportunities for integrating ecosystem service rights with land tenure systems; and doing so in a gender-responsive and social inclusive manner to promote sustainable development realization through women’s equal inclusion, land rights, and benefits.

The **integration of ecosystem service economics with innovative land tenure arrangements** creates a replicable model for transforming environmental conservation from regulatory burden to economic asset. The **demonstrated potential for PES payments of USD 340-600 per hectare annually, representing 4 – 10 % of total ecosystem service value**, provides sustainable financing while maintaining fiscal responsibility. **Gender-responsive ecosystem service rights certification** under these innovative land tenure arrangements can leverage OIKN’s current efforts to explicitly support property rights for women (held individually and jointly) in coastal areas, under the Draft Regulation of the Head of OIKN on the Protection and Management of Coastal Areas and Small Islands in IKN, in alignment with Article 9(2) of the Basic Agrarian Law, as well as other national legal frameworks that strengthen women’s land rights to reinforce PES development.

Multi-service payment structures combining carbon credits, coastal protection payments, and tourism revenue sharing create diversified revenue streams reducing dependence on single market mechanisms. Success in IKN's manageable scale provides crucial proof-of-concept for national scaling across Indonesia's 3.29 million hectares of mangroves, benefitting over one hundred million coastal women and men depending on mangroves, with potential economic benefits exceeding USD 1.1 billion annually through optimal management. **The methodological innovations in gender-responsive ecosystem service rights certification and performance-based conservation finance have broad applicability beyond mangrove ecosystems**. Moreover, this integrated approach supports Indonesia’s NDC commitments and net-zero targets by advancing nature-based solutions at the landscape scale, while also reinforcing the country’s broader goals for achieving the SDGs.

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