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# The Sustainable Implementation of Ecosystem-Based Adaptation to Climate Change in Coastal Area: Lessons from Indonesia

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**Abstract:** Climate change has significantly impacted coastal areas of developing Asian countries, causing rising sea levels, frequent extreme weather events, and ecosystem degradation. In recent years, ecosystem-based adaptation (EbA) policies have played a vital role in addressing climate change and bringing many benefits to local residents by establishing a sustainable green economy. This study finds that although Ecosystem-based Adaptation (EbA) projects have been widely implemented in coastal areas of Indonesia, their effectiveness and sustainability still need improvement. The long-term success of these projects depends on the cooperation mechanisms among the government, communities, and implementing organizations, with the enforcement of EbA policies being particularly crucial. Additionally, funding shortages or inadequate financial oversight are common challenges EbA projects face worldwide. At the project level, issues such as flawed design and insufficient community participation hinder sustainability. More importantly, coastal ecosystems are not static; they evolve throughout the project's implementation, potentially leading to outcomes that deviate from expectations or cause negative impacts. Based on these factors, this study categorizes the key factors affecting the sustainability of EbA projects into four dimensions: policy and governance, finance, socio-economic aspects, and ecological environment. In response to these challenges, several policy recommendations are proposed, including promoting community participation, attracting high-level talent, establishing economic incentive mechanisms, securing long-term financial support, and integrating indigenous knowledge into project design. This study not only analyses the sustainability challenges of coastal EbA projects but also provides practical guidance and future directions for EbA implementation and research.

**Keywords:** Climate Change; Coastal Area; Ecosystem-Based Adaption; Indonesia; Sustainable Implementation

## 1. Introduction

The coastal areas of the world are facing the devastating consequences of climate change, with escalating events of intense rainfall, cyclones, flooding, and sea-level rise [1]. Consequently, the Intergovernmental Panel on Climate Change (IPCC) predicts that by 2050, approximately 3 billion people in the Ganga-Brahmaputra-Meghna delta in Bangladesh and 7 million in the Mekong delta in Vietnam will be displaced due to sea level rise [2]. In addition, the Southeast Asian region, with its vulnerable topography and marginalized populations, is particularly vulnerable to climate change risks [3]. In the past few decades, Java Island in Indonesia has been strongly affected by climate change. Especially in the northern part of Java Island, with the rise of sea levels and land subsidence, the socio-economic development and ecological balance of coastal areas have been greatly affected. Mangroves in Indonesia serve as critical buffers against storm surges and coastal flooding. However, a study by Indonesia's Ministry of Environment and Forestry shows that over the past two decades, approximately 40% of mangroves in Java's coastal areas have been lost to climate change and human activities [4]. Data from the Intergovernmental Panel on Climate Change (IPCC) suggests that the sea level along Indonesia's coasts is rising at an average rate of 6–10 mm per year, exacerbating coastal erosion and saline intrusion [3].

To address the challenges posed by climate change, Ecosystem-based Adaptation (EbA) is crucial for sustaining community livelihoods and reducing vulnerability [2]. Ecosystems provide essential environmental and socio-economic services, including storm surge protection, flood retention, nutrient cycling, food, and livelihood support [4]. EbA has been implemented in various coastal areas, yielding significant improvements in local ecosystems. For instance, in Indonesia, the implementation of EbA has helped slow the degradation of mangroves, enhancing coastal regions' resilience to rising sea levels. Similarly, in countries like Bangladesh, EbA strategies have improved coastal agriculture and fisheries, while also increasing ecosystem resilience and the capacity to adapt to climate change.

However, the success of EbA strategies is not guaranteed, as they face numerous challenges during implementation, particularly in coastal areas where complex geographical conditions and underdeveloped socio-economic systems prevail [5]. The sustainability of these strategies has become a critical issue in such contexts. This paper adopts a comparative case study approach to focus on the sustainability of EbA projects in coastal areas of Indonesia, analyzing the factors influencing the sustainable development of EbA strategies and proposing recommendations for the sustainable implementation of EbA programs. Therefore, this paper proposes the following research question: What are the factors that affect the sustainability of implementation of ecosystem-based adaptation projects in coastal areas? The second part mainly summarizes the current situation of climate change in coastal areas of the Asia-Pacific region, defines the EbA theory, analyzes the implementation of the project in coastal areas, and summarizes the current gaps in the research on the implementation of EbA projects. The third part explains the research methods of this article, including the research methods of this article, the selection of cases, and the data sources. The fourth part is the findings of this study, analyzing the factors affecting the sustainable development of the project from the perspectives of policy and government, funding, ecological environment, and socio-economic conditions in coastal areas. The fifth part is suggestions for improving the sustainability of EbA projects.

## 2. Methodology

This study reviews the recent literature on climate change adaptation through the ecosystem-based adaptation approach, revealing that one of the key issues in the current development of Ecosystem-based Adaptation (EbA) is the sustainability of project implementation. Consequently, this paper uses several EbA projects implemented in Indonesia in recent years as case studies to explore potential factors that may hinder the smooth implementation of EbA projects and the achievement of sustainable social and economic benefits. The results will be discussed from four perspectives: policy, socio-economic, financial, and environmental.

### 2.1. Cases Study Area

The research sites for this study are concentrated in coastal areas. As an island nation, Indonesia aligns closely with the objectives of this research. Indonesia is rich in marine resources, and the government significantly emphasizes the development and utilization of these resources, the economic growth of coastal regions, and ecological protection. In recent years, Indonesia has implemented numerous EbA projects in its coastal areas, with initiatives such as mitigating tidal erosion and protecting mangroves being relatively well-established. This makes Indonesia a highly representative case for discussing EbA projects. Additionally, the availability of public data from many of these projects is another key reason for selecting this country, as it ensures access to comprehensive case data for analysis.

### 2.2. The Data Source

This study primarily relies on secondary data to evaluate the sustainability of ecosystem-based adaptation (EbA) projects in coastal areas of Indonesia. Secondary data serve as a cornerstone for this research, offering a robust foundation of pre-existing information to analyze the performance, challenges, and long-term viability of these projects. To ensure accuracy and comprehensiveness, the secondary data were meticulously sourced from various reliable organizations and literature.

The key types of secondary data utilized in this study include detailed project reports, evaluations, and case studies. These data were primarily obtained from established organizations actively involved in climate adaptation efforts, such as The Adaptation Fund, which supports adaptation projects worldwide, including in Indonesia; WRI (World Resources Institute) Indonesia, which focuses on sustainable development and resilience building; and The International Climate Initiative (IKI), which funds climate and biodiversity projects globally. For example, reports from The Adaptation Fund detail projects addressing mangrove restoration and community-based adaptation in Indonesian coastal regions, emphasizing their implementation timelines, resource allocation, and socio-environmental outcomes. Similarly, IKI provides insights into EbA initiatives, such as coral reef management and sustainable fisheries, highlighting their contributions to ecological preservation and community resilience.

In addition to these organizational reports, the study incorporates findings from peer-reviewed literature that analyze EbA project implementation in Indonesia. Notable studies include case analyses of mangrove rehabilitation programs in North Java from example project from Suroso, D.S.A., et al. and coral reef restoration in Bali [6,7], which provide quantitative and qualitative evaluations of project sustainability. These scholarly contributions complement the organizational reports by offering a broader context, including insights into challenges such as funding continuity, community engagement, and ecological efficacy. By combining these diverse and reliable sources, this study ensures a comprehensive and well-rounded analysis of EbA projects in Indonesian coastal areas, identifying critical factors influencing their sustainability and drawing lessons for future adaptation initiatives.

## 3. Literature Review

### 3.1. Impacts of Climate Change on Coastal Ecosystems in the Asia-Pacific Region

The coastal ecosystem is complex and dynamic, influenced by multiple factors including natural geographical features, climate change, and human activities. In recent years, the intensification of global climate change has posed unprecedented challenges to coastal ecosystems [8]. These changes are reflected not only in rising sea levels, increased temperatures, frequent extreme weather events, and ocean acidification, but also in altered precipitation patterns and issues related to human adaptability (see **Table 1**) [9–27]. This section aims to systematically review the multifaceted impacts of climate change on coastal ecosystems and summarize the key trends in these changes [8].

**Table 1.** Impacts of Climate Change on Coastal Ecosystems [9–27].

| Type of Impact | Location | Detailed Impact on Coastal Ecosystems |
|---|---|---|
| Sea level rise [9–12] | New Zealand and Limassol Cyprus | **Erosion:** Rising sea levels will increase coastal erosion, impacting habitats and human settlements.<br>**Inundation:** Low-lying areas and wetlands face permanent flooding, reducing ecosystems and land for human use.<br>**Seawater Intrusion:** Rising sea levels enable seawater to infiltrate freshwater aquifers, affecting freshwater species and agricultural lands. |
| Ocean acidification [13,14] | worldwide | **Coral Reefs:** Higher $CO_2$ levels lead to ocean acidification, weakening coral skeletons and causing bleaching and biodiversity loss.<br>**Marine Life:** Acidification disrupts shell-forming organisms like mollusks and some plankton, impacting food webs. |
| Temperature changes [15,16] | Worldwide (Hungary, Europe, USA, Canada, England, Mediterranean region, Japan, China, Australia) | **Species Distributions:** Increased sea temperatures shift species distributions, with some migrating to cooler areas, altering local biodiversity.<br>**Phenology:** Changes in the timing of biological events (e.g., reproduction and migration) disrupt ecological relationships.<br>**Thermal Stress:** Rising temperatures can cause mass mortality among marine species, particularly corals and certain fish, with narrow temperature tolerances. |
| Extreme weather [17–19] | US Atlantic and Gulf coast regions | **Storm Surges and Hurricanes:** More frequent and severe storms lead to coastal ecosystem damage, including erosion and habitat destruction.<br>**Flooding:** Increased rainfall and storm surges cause flooding, washing away vegetation and soil and impacting coastal agriculture and habitats. |
| Changes in precipitation patterns [20–22] | Worldwide, USA | **Freshwater Inflow:** Changing precipitation patterns affect freshwater entering coastal ecosystems, influencing salinity and nutrient flows.<br>**Drought:** Increased drought frequency reduces water availability, impacting freshwater and estuarine ecosystems. |
| Human impacts and adaptation [23–27] | Worldwide | **Infrastructure:** Coastal protection measures (e.g., seawalls) can disrupt natural processes and cause habitat loss.<br>**Land Use:** Human adaptation to climate impacts can lead to land use changes that further degrade coastal ecosystems.<br>**Conservation:** Initiatives like marine protected areas (MPAs) and restoration projects aim to mitigate adverse impacts. |

### 3.2. EbA as Adaptation Measures in Coastal Areas in the Asia-Pacific Region

The definition of Ecosystem-based Adaptation (EbA) to climate change by Ojia (2015) is: "Practices that promote socio-ecological resilience by fostering ecosystem services, through ecosystem management that enable people to adapt to the impacts of climate change and reduce their vulnerability." The definition emphasizes the management and utilization of ecosystems to enhance human resilience to climate change, reduce vulnerability, and achieve a balance between social and ecological systems. This aligns with the core goal of Ecosystem-based Adaptation (EbA), which is to help people better adapt to the impacts of climate change by maintaining and enhancing the service functions of ecosystems.

Various adaptation measures have been implemented to address the impacts of climate change, particularly in coastal areas of the Asia-Pacific region. Ecosystem-based Adaptation (EbA) projects, such as mangrove restoration and coral reef protection, have been key efforts, each with its advantages and challenges. These projects have demonstrated the potential of using natural ecosystems to enhance resilience against climate impacts [28].

In coastal regions, particularly the Pacific Islands, EbA initiatives target the restoration of coral reefs and mangroves, which serve as natural defenses against storm surges and coastal erosion [29]. Mangrove forests act as protective barriers while supporting biodiversity and local livelihoods, whereas coral reefs help disperse wave energy, reducing storm impacts. Wetland protection also plays a crucial role, as wetlands absorb excess water during heavy rains and storm surges, mitigating flood risks and supporting diverse ecosystems. Integrated marine spatial planning is essential in coordinating the sustainable use of marine and coastal resources, ensuring that development and ecosystem protection go hand in hand [30].

Additionally, EbA measures in small island developing states focus on water and food security, combining traditional knowledge with modern approaches to maintain subsistence gardens and water catchments. These efforts are vital for ensuring resilience in climate change [29]. Several EbA projects have been reviewed, particularly those focusing on restoring mangrove and coral reef protection. Some studies highlight integrating these projects with marine spatial planning, emphasizing the importance of coastal ecosystems in shoreline protection and their cost-effectiveness.

### 3.3. Research Gaps in EbA in Coastal Areas of the Asia-Pacific Region

Reviewing previous literature, the study identifies key research gaps in Ecosystem-based Adaptation (EbA) in coastal areas of the Asia-Pacific region. These gaps cover several critical areas, including implementation challenges, long-term monitoring, cross-sectoral integration, community participation, sustainable financing, social acceptance, and ecosystem resilience. Addressing these gaps is essential for the continued success of EbA programs.

In terms of institution and governance, while some countries like the Philippines and Vietnam have integrated EbA into national adaptation plans, broader policy integration remains limited [31]. Effective governance structures across national, regional, and local levels are crucial for implementation. Still, comprehensive research on cross-sectoral integration—particularly between sectors like agriculture, fisheries, and urban planning—is lacking [32, 33]. Moreover, the gap between policy formulation and practical implementation remains significant [34].

From a financial perspective, international funding mechanisms, such as the Green Climate Fund (GCF), are vital for launching EbA projects in developing countries [35]. Studies have shown that EbA is more cost-effective in the long term than traditional engineering solutions [36]. However, there is a lack of research on sustainable, long-term financing models that include private-sector investment [37]. Additionally, comprehensive economic evaluations of the ecosystem services EbA provides remain limited [38]. Socio-economic factors also play a crucial role in the effectiveness of EbA. Community involvement in the planning and implementation process significantly enhances the sustainability of projects [39]. EbA can potentially improve local livelihoods by providing resources like fisheries, tourism, and storm protection [40]. However, research on ensuring equity and inclusiveness, particularly in reaching vulnerable populations, is sparse [41]. Furthermore, the cultural and social dynamics that affect the acceptance of EbA initiatives have not been thoroughly studied [42].

Regarding ecosystem and environmental considerations, EbA provides multiple ecosystem services, including biodiversity conservation, carbon sequestration, and water regulation [43]. Successful restoration projects, such as mangrove reforestation and coral reef restoration, demonstrate the potential of EbA, though further research is needed [44]. Gaps in long-term monitoring persist, making it difficult to assess the effectiveness of these projects over time [45]. Finally, limited research exists on the resilience of different ecosystems to climate change and their capacity to withstand future climate impacts.

This study categorizes the aforementioned research gaps into four areas: Policy & Governance, Finance, Socioeconomics, and Ecological Environment. It summarizes and analyzes ongoing or completed EbA projects in coastal regions of Indonesia, examining the factors affecting the sustainability of these projects from the perspective of these four aspects. Additionally, it provides recommendations on ensuring that Ecosystem-based Adaptation measures deliver long-term ecological and social benefits.

### 3.4. The Research Framework

Based on a literature review, four key factors influencing the sustainability of EbA projects in Indonesia are identified: Political, socio-economic, fiscal, and local environment (**Table 2**).

**Table 2.** Challenges Associated with the Sustainability of EbA Programs.

| | |
|---|---|
| **Policy & Governance** | **Policy Integration and Coordination:** EbA is not well integrated into development or environmental policies at national and local levels. There is insufficient coordination across government levels and sectors like fisheries, forestry, and water resources.<br>**Awareness and Knowledge Gaps:** Many policymakers lack understanding of EbA benefits and how to implement, monitor, and evaluate its **effectiveness**, even when measures are in place. |
| **Financial challenges** | **Funding Challenges:** Securing long-term funding for EbA is difficult, with insufficient short-term mechanisms. International funding tends to favor conventional infrastructure over nature-based solutions. |
| **Socio-economic challenges** | **Community Involvement:** Incorporating local knowledge is crucial, but communities are often excluded from participation or unaware of EbA. Conflicts of interest and social dynamics can limit equitable benefits. |
| **Ecosystem and environmental challenges** | **Ecosystem Degradation:** Many coastal ecosystems are degraded, complicating EbA implementation. Restoring these ecosystems is vital but requires significant time and resources.<br>**Uncertainty of Climate Impacts:** The dynamic nature of climate change, including shifting temperatures and extreme weather, makes the long-term **effectiveness** of EbA measures difficult to predict. |

## 4. Findings

### 4.1. The Implementation of EbA Programs in Indonesia

As a country of many islands, Indonesia has a more considerable coastline (**Figure 1**). Most of the EbA projects in Indonesia are focused on the waterfront, which aims to address the challenges posed by climate change, such as rising sea levels and extreme weather events. We analysed the EbA projects currently publicly available in Indonesia and highlighted five related to climate change. By extracting key information about each project, including the name of the project, the region where it was carried out, the status of the project, the main sponsors, and the main measures taken. This information is summarized in **Table 3** to help us gain a more intuitive understanding and analysis [46–49].

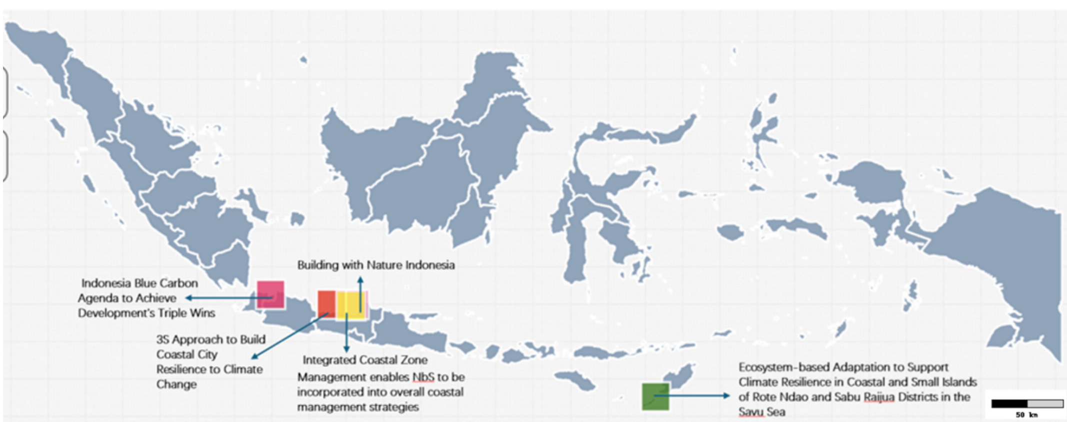


**Figure 1.** The Map of Ecosystem-Based Programs in the Coastal Area of Indonesia.

**Table 3.** The Ecosystem-Based Programs in the Coastal Area of Indonesia [46–49].

| Project | Area | Status | Main Sponsors | Main Measures |
|---|---|---|---|---|
| 3S Approach to Build Coastal CityResilience to Climate Change [46] | Pekalongan, Indonesia | 2021–2024 Ongoing | Adaptation fund | Constructing wave deflection berms, restoring beach sediment, and planting mangroves using innovative methods. |
| Building with Nature Indonesia [47] | Demak region, Central Java | completed09/2015 till 06/2021 | Stichting Wetlands International (WI) - Netherlands | Through a unique integration of mangrove restoration, small-scale hard engineering, and sustainable land use. |
| Indonesia Blue Carbon Agenda to Achieve Development's Triple Wins [48] | Indonesia ocean area | Ongoing | The Ministry of Environment and Forestry and the Ministry of Marine Affairs and Fisheries | Integrated marine ecosystems (including mangroves, seagrass beds, estuaries, or brackish/brackish marshes and coral reefs) |
| Ecosystem-based Adaptation to Support Climate Resilience in Coastal and Small Islands of Rote Ndao and Sabu Raijua Districts in the Savu Sea [49] | Rote Ndao and Sabu Raijua Districts in the Savu Sea. | Jan 2023 –Mar 2025 (ongoing) | Adaptation fund | Knowledge Management; Ecosystem Rehabilitation, Management and Sustainable Livelihood; Strengthening governance and institution |
| Integrated Coastal Zone Management enables NbS to be incorporated into overall coastal management strategies [50] | Semarang, Indonesia | Not mentioned | The city of Semarang and the Indonesian government | Flood control in low-lying areas, embankment and drainage systems, shoreline reclamation, pumping stations, and polder facilities. strengthening the organizational framework for disaster management, coastal planning and management, and education. |

## 4.2. Challenges of the Sustainable Implementation of Ecosystem-Based Adaptation in Indonesia

While EbA brings changes to Indonesia's coastal areas, there are also certain limitations and obstacles through the analysis and summary of the existing cases in Indonesia (including completed cases and ongoing cases). We divide these limitations into four parts, which are from the four aspects of policy & governance, finance, socio-economy, and ecosystem & environment.

### 4.2.1. Policy & Governance

A critical issue in EbA projects is the lack of effective communication and collaboration between various stakeholders, including local governments, community members, non-governmental organizations (NGOs), and international donors. Poor coordination can result in conflicting priorities, duplication of efforts, and missed opportunities for synergy. For example, a study on mangrove restoration in Java highlighted that the lack of alignment between local government departments and project sponsors led to delays in securing permits and difficulties in mobilizing resources [6]. Furthermore, local residents, who are key beneficiaries and participants in EbA projects, are often not adequately involved in the decision-making process, leading to mistrust and resistance to project activities [51].

Effective joint coordination among stakeholders is essential for the smooth implementation and long-term sustainability of EbA projects. For instance, the success of a coral reef restoration project in Bali was attributed to a well-established partnership between local communities, environmental NGOs, and the government, with regular meetings to discuss progress and challenges. This collaborative approach ensured that the project addressed both ecological goals and community needs, leading to increased buy-in and active participation from all parties involved [46–48].

In North Java, efforts to restore mangrove ecosystems faced significant challenges because much of the land targeted for restoration was privately owned by shrimp farmers. These landowners were often reluctant to relinquish or repurpose their lands due to economic concerns, such as losing income from aquaculture [6]. Additionally, unclear land tenure systems exacerbated the situation, as overlapping claims between private owners and local governments created conflicts that were difficult to resolve. This situation highlighted the need for participatory land-use planning processes to balance ecological objectives with the economic interests of local stakeholders.

### 4.2.2. Finance

Funding is a problem faced by almost all EbA projects. By comparing the above five cases, we found that the funding sources of EbA projects in Indonesia's coastal areas mainly rely on temporary grants from international organizations, non-profit organizations, and the government. Since the project time is usually 2–3 years, this short-term funding support is insufficient to support the long-term socio-economic benefits of EbA projects. For example, many EbA projects rely on a single funding source, such as government grants or international aid. This funding structure has great uncertainty. Once these funding sources are affected by external economic or political factors, the project will face the risk of a broken funding chain [47–50].

The mangrove restoration projects in Central Java, supported by The Adaptation Fund, were funded for three years with a budget of USD 3 million [52]. Although the initial phase successfully restored 500 hectares of mangroves, the lack of follow-up funding jeopardized maintenance efforts, such as replanting in degraded areas or addressing pest issues. Similarly, a coral reef restoration initiative in Bali funded by the International Climate Initiative (IKI) faced challenges after its funding period ended, leaving community-based monitoring programs under-resourced and inconsistent. One of the key problems is that many EbA projects rely on a single funding source, such as government grants or international aid, making them vulnerable to external economic or political factors.

#### 4.2.3. Socio-Economy

**Incomplete Project Design**

Most EbA projects in Indonesia have a short lifespan, usually only 1–2 years. The project implementation time is too short to allow local residents to understand the project and actively participate fully. Active participation from local residents is essential for the success and continuity of any adaptation initiative. When projects are implemented over a brief period, there is often not enough time to conduct proper outreach, education, and capacity-building efforts. However, with insufficient time for proper outreach and education, many residents remain uninformed or under-involved, which can undermine the project's outcomes. In addition, climate change is a dynamic process, especially in coastal areas where the ecosystem is more complex. If the project lifespan is too short, there will be no reasonable planning for the future, and it will be difficult to generate long-term sustainable social and economic benefits [49,50].

**Lack of Participation**

From a community perspective, residents' lack of understanding and support for ecosystem-based adaptation (EbA) projects significantly contributes to low participation rates in their implementation. For example, a survey of coastal communities in Indonesia revealed that only 32% of residents were aware of ongoing EbA projects in their area, and among those, fewer than 20% actively participated in activities such as mangrove planting or coral reef monitoring [53].

In addition, the gendered division of labour in productive, reproductive, and political spheres—reinforced by sociolinguistic constructs and traditional cultural norms—has resulted in unequal power relations between men and women in many Indonesian coastal communities [49]. This structural inequality amplifies women's social vulnerability, particularly under the compounded impacts of climate change. In the EbA project implemented in the Coastal and Small Islands of Rote Ndao and Sabu Raijua Districts in the Savu Sea, the social structure was described as patrilineal-patrilocal, in which familial authority and inheritance follow the male lineage, granting men greater power and public representation. As a result, women are often excluded from public forums and underrepresented in local decision-making structures at both the village and district levels. The project report further noted that men and women face unequal access to marine and fishery resources, exacerbating existing gender disparities and making women more susceptible to climate-induced environmental stressors [49].

**Brain Drain**

The deterioration of the local ecological environment, lagging economic development, and lack of employment opportunities have led to many young people choosing to leave the coastal areas and give up agriculture and other traditional livelihoods [53,54]. For example, data from Indonesia's Central Bureau of Statistics (BPS) shows that rural-to-urban migration among youth in coastal regions increased by 15% between 2015 and 2020, driven by declining agricultural productivity and limited job prospects [54].

Due to the lack of sufficient social security and development opportunities, the welfare of the younger generation has not been fully guaranteed, further exacerbating the outflow trend of young people [54]. For instance, a United Nations Development Programme (UNDP) report highlights that only 30% of coastal residents under 35 have access to formal employment with social security benefits in Indonesia's rural areas [55]. The implementation and sustainable development of the project require sufficient labour and talents with certain skills to promote it [56]. Coastal EbA projects rely heavily on skilled labour for tasks such as mangrove planting, reef restoration, and sustainable aquaculture development. However, with the loss of young labour, the project faces a talent shortage during implementation, resulting in reduced efficiency, project delays, and even failure to advance successfully [53]. A survey by WRI Indonesia found that nearly 40% of EbA projects in the country reported delays due to inadequate labour availability, particularly among younger, skilled workers. Without the participation and support of young people, the long-term sustainability of the project is also at risk.

**Ecosystem & Environment**

Sea-level rise, land subsidence, and climate-induced extreme events are increasingly converging to amplify disaster risks in coastal Indonesia. Globally, sea levels have risen at an average rate of 3.3 mm/year since 1993, but in parts of Indonesia, particularly the northern coast of Java, the rate exceeds 7–10 mm/year [53,57]. The failure of geo-tube structures in Semarang and Demak further illustrates how rising seas and subsidence jointly undermine conventional engineering solutions. Within just two years of installation, tidal flooding (rob) and high-energy wave action exceeded the embankments' design thresholds, causing structural failure and erosion. These cases underscore the urgent need for ecosystem-based approaches that account for subsurface dynamics, hydrological shifts, and climate uncertainties [6]. Saltwater intrusion has severely impacted drinking water and aquaculture. In North Java, salinity levels in aquifers exceed 1,000 mg/L of total dissolved solids (TDS), making water unsafe for consumption. Increasing salinity has also reduced shrimp yields by 30–40% in brackish ponds [53]. Erosion and wave action have caused widespread mangrove planting failures. Erosion rates of 5–8 meters per year in North Java have lowered mangrove survival rates to below 20% in some areas due to unstable soils and wave impact.

In Jakarta, land subsidence—driven primarily by excessive groundwater extraction, urban overload, and the natural consolidation of soft alluvial soil—has reached alarming rates of 10 to 25 cm per year, among the highest in the world. This subsidence not only offsets coastal protection efforts but actively exacerbates flooding frequency and severity, leading to recurrent inundation in districts like North Jakarta [58,59]. To mitigate the compounding threats of flooding, coastal erosion, and ecosystem degradation, the Indonesian government has launched a national-scale strategy: relocating the capital to East Kalimantan, a region perceived to be geologically more stable. This move aims to reduce ecological burdens on Java and support more balanced national development. However, East Kalimantan itself is an ecologically sensitive zone, home to tropical rainforests, biodiversity hotspots, and Indigenous communities with complex land tenure systems. The rapid development of Nusantara, the planned new capital, raises serious concerns about deforestation, ecosystem fragmentation, and potential social conflict over land and resources [60]. These risks highlight the critical need to incorporate ecosystem-based planning principles into the new city's design, including green urban infrastructure, equitable land-use frameworks, and participatory environmental governance, to avoid replicating past patterns of environmental overreach.

## 5. Discussion and Future Research Direction

In the fourth part, the coastal EbA projects in Indonesia are summarized, and the factors affecting the sustainability of project implementation are explained from the perspectives of policy, finance, socioeconomics, and ecological complexity of coastal areas. In the fifth part, this study will make targeted suggestions on improving the sustainability of project implementation and promoting the long-term benefits based on the above factors.

### 5.1. Policy and Governance

#### 5.1.1. Sustainable Land Use Planning

Coastal areas are inherently fragile ecosystems that are particularly susceptible to environmental degradation and socio-economic pressures. Scientific and sustainable land use planning plays a critical role in ensuring the successful implementation of ecosystem-based adaptation (EbA) projects while minimizing negative impacts on both ecological health and economic development. Poorly planned land use systems, such as unregulated aquaculture or deforestation for agriculture, have been shown to exacerbate erosion, biodiversity loss, and carbon emissions, ultimately undermining the resilience of coastal ecosystems [53]. At the same time, land use planning that overly prioritizes ecological optimization, such as designating extensive conservation zones without adequate livelihood support, can unintentionally marginalize local communities by reducing their access to income-generating activities like farming and fishing [6]. Balancing these competing demands requires a comprehensive approach that aligns environmental conservation with economic viability. Studies such as those by Dahdouh-Guebas et al. have highlighted the importance of participatory land use frameworks [61], where local stakeholders collaborate with policymakers to ensure that land use regulations address both ecological and socio-economic needs. In Indonesia, the Social Forestry Program has provided a promising example of such an approach, granting land management rights to communities and fostering sustainable practices that benefit both people and the environment. However, limitations persist. Many existing studies focus disproportionately on regions like Java, overlooking the unique ecological and economic dynamics of less-represented areas such as Kalimantan, Sumatra, and Papua. Furthermore, the short duration of many EbA projects often precludes an assessment of long-term outcomes, while the lack of high-resolution spatial data limits the accuracy of land use planning in coastal zones [50]. To address these gaps, future research should expand geographic coverage, conduct longitudinal studies to assess the enduring impacts of land use decisions, and integrate advanced tools like GIS and remote sensing to enhance planning precision. Additionally, further exploration of community-based participatory approaches can provide valuable insights into how local involvement influences the sustainability of land use practices in vulnerable coastal areas. By advancing these efforts, sustainable land use planning can more effectively support both the ecological resilience and socio-economic well-being of coastal communities.

#### 5.1.2. Community Involvement

Ecosystem-based adaptation (EbA) projects go beyond ecological optimization; they play a crucial role in enhancing the resilience of local communities and improving their capacity to withstand disasters. Effective and continuous implementation of these projects can create long-lasting benefits for both people and ecosystems. In the context of coastal areas in Indonesia, the active involvement and cooperation of local residents significantly influence the success and sustainability of EbA initiatives. Similar findings in existing literature highlight that integrating EbA with community-based adaptation (CBA) approaches strengthens outcomes by leveraging indigenous knowledge and fostering community ownership [61]. For instance, CBA methods that include community-led mangrove planting and participatory monitoring have shown higher survival rates and long-term commitment compared to projects that exclude local input. However, challenges remain, such as uneven community participation, limited awareness, and lack of training, which can undermine project sustainability. Future research should focus on developing frameworks that effectively combine EbA and CBA, explore incentives for greater community involvement, and assess the long-term socio-economic impacts of these integrated approaches. By emphasizing community inclusion, EbA projects can achieve dual goals of ecological restoration and community resilience [62].

### 5.2. Finance

#### 5.2.1. Incentive Mechanisms

Incentive mechanisms are crucial for supporting ecosystem-based adaptation (EbA) projects by aligning economic benefits with environmental goals. The 2023 partnership between the World Economic Forum (WEF) and the Indonesian government to promote blue carbon creation and marine conservation demonstrates how collaborative frameworks can incentivize sustainable practices. This initiative leverages Indonesia's mangrove and seagrass ecosystems to generate carbon credits, funding conservation while benefiting local communities [63]. Similar approaches, such as payment for ecosystem services (PES) in Vietnam, have proven successful in engaging communities, though challenges like equity and reliance on external funding remain [64]. In Indonesia, limited institutional capacity and unclear policies hinder the scalability of such mechanisms, especially in regions outside Java. Future efforts should focus on evaluating current programs, ensuring equitable benefit distribution, and exploring innovative financing tools to enhance both ecological and socio-economic outcomes [54].

#### 5.2.2. Long-Term Financing Mechanisms

A mixed-finance model combines public, private, and philanthropic funding to ensure sustainable, long-term financing for ecosystem-based adaptation (EbA) projects. Public funds can cover initial costs, philanthropic contributions support community engagement, and private investments drive scalability through opportunities like carbon credits or eco-tourism. This diversified approach reduces financial risks, ensures resilience, and attracts private sector participation by aligning conservation with profit-oriented goals. However, challenges such as equitable benefit-sharing and strong governance need to be addressed to maximize effectiveness. Future efforts should explore innovative tools like blended finance and green bonds to strengthen this model [54].

### 5.3. Socio-Economic

#### 5.3.1. Properly Absorb Indigenous Knowledge

Ecosystem-based Adaptation (EbA) projects must respect local traditions, social norms, and cultural values to ensure effective implementation and long-term sustainability. Integrating culturally sensitive approaches fosters trust within communities, encouraging collaboration and aligning conservation efforts with local practices. For example, in Indonesia, traditional knowledge systems such as sasi, a customary marine management practice in Maluku, have demonstrated success in conserving coastal ecosystems by regulating fishing seasons and protecting breeding grounds [65]. Similarly, in Bali, the subak system—a UNESCO-recognized irrigation and land management tradition—has shown how cultural practices can be integrated into modern environmental projects to enhance water conservation and agricultural sustainability. Studies have also found that communities are more likely to engage in conservation efforts when their cultural identities are acknowledged and reinforced, resulting in higher project success rates [61]. However, many EbA projects fail to adequately consider these cultural dimensions, which can lead to community resistance or project abandonment. Future research should focus on documenting and integrating indigenous knowledge into EbA frameworks and developing participatory planning tools that empower communities to incorporate their cultural values into conservation initiatives. By aligning projects with local traditions, EbA efforts can achieve both ecological and socio-cultural resilience.

#### 5.3.2. Education and Awareness

Raising awareness of EbA policies and emphasizing the role of residents as key stakeholders can foster a sense of ownership and increase motivation for long-term participation. Studies have shown that when communities understand the direct benefits of ecosystem protection such as improved fisheries, reduced flood risks, and enhanced agricultural productivity they are more likely to engage in and sustain conservation efforts. For example, a mangrove restoration project in Java reported a 30% increase in community participation after workshops demonstrated how mangroves stabilize shorelines and support fisheries [53]. Tailored communication strategies that consider local languages and cultural contexts are essential for ensuring messages resonate effectively. In Aceh, using traditional forums like meunasah (village meetings) helped bridge gaps between policymakers and residents, significantly improving participation rates [6]. However, challenges such as low literacy levels and cultural differences often hinder outreach efforts. Future initiatives should integrate participatory tools, visual aids, and local narratives to communicate the long-term benefits of EbA and create a shared vision for ecosystem protection, thereby aligning community interests with conservation goals.

### 5.4. Ecosystem & Environment

#### 5.4.1. Build a Scientific Ecological Assessment and Detection System

The ecological environment in coastal areas is extremely complex, so using advanced science and technology such as big data or remote sensing monitoring to monitor project implementation areas in real-time can help better understand the changes in the ecosystem brought about by the implementation of EbA policies and adjust policies in a timely manner. Develop methodologies to quantify and evaluate ecosystem services effectively. By highlighting their role in disaster risk reduction and showcasing the economic value they provide, these evaluations can strengthen support for ecosystem-based planning. Decision-making should be agile and informed by the latest research findings. Establishing robust systems for data collection and scientific monitoring will support evidence-based decisions. Encouraging interdisciplinary collaboration among scientists, policymakers, and practitioners ensures that diverse expertise is integrated [47].

#### 5.4.2. Develop EbA Policies Based on Local Conditions

Tailoring Ecosystem-based Adaptation (EbA) to the specific local context is essential for ensuring that solutions are appropriate, effective, and sustainable. Local ecological, social, and economic conditions should be carefully considered during project design and implementation to address unique challenges and opportunities. For instance, mangrove restoration in Indonesia has proven effective in reducing wave energy by up to 66%, minimizing coastal erosion and storm surge impacts [66]. However, in areas where mangroves alone are insufficient to withstand extreme events, combining EbA with engineered solutions can enhance resilience. A notable example is the use of hybrid approaches in Demak, Central Java, where mangrove restoration was paired with permeable barriers to reduce wave energy and sediment loss, restoring coastal stability while enhancing natural regeneration. This integration of nature-based and engineered solutions provides multiple benefits, including ecological recovery, disaster risk reduction, and improved community livelihoods. Nevertheless, challenges remain in scaling such hybrid approaches, including financial constraints and technical expertise. Future efforts should focus on developing frameworks for integrating EbA and engineered solutions, supported by local knowledge and stakeholder engagement, to maximize both ecological and infrastructural resilience.

## 6. Conclusions

Rising global temperatures have increased disaster risks in coastal areas, leading to challenges such as rising sea levels, declining marine species, and damaged ecosystems that threaten the economic stability and safety of residents. This paper examines five coastal areas in Indonesia to identify factors affecting the sustainability of ecosystem-based adaptation (EbA) projects and provides recommendations to improve their success. The study highlights four key factors: (1) Effective coordination among governments, communities, and external partners is essential to avoid land-use conflicts and ensure smooth project planning. (2) Consistent funding, achieved through diversified financial sources and long-term planning, is critical to preventing project disruptions. (3) Socio-economic engagement, including creating jobs, improving livelihoods, and promoting women's participation, enhances community support and equity. (4) Scientific monitoring tools are necessary for managing the complexity of coastal ecosystems and adapting projects as needed.

In addition, the findings highlight the importance of integrating policy, finance, socio-economic considerations, and ecological complexities into project planning and implementation. Sustainable land use planning, community involvement, and hybrid approaches that combine EbA with engineered solutions are critical for enhancing resilience. Effective financing models, such as mixed-finance and incentive mechanisms, can secure long-term funding, while education and awareness campaigns foster community ownership. Furthermore, culturally sensitive approaches and the integration of indigenous knowledge strengthen local engagement and align conservation goals with community needs. Finally, scientific ecological assessment systems and tailored EbA policies based on local conditions are essential for addressing the unique challenges of Indonesia's coastal regions.

As Indonesia embarks on a major national transition through its capital relocation, this moment also presents a policy window for advancing the institutionalization of ecosystem-based adaptation (EbA). While the new capital, Nusantara, is intended to relieve socio-ecological stress on Java—particularly in Jakarta's subsiding urban zones—it also introduces significant risks of ecological degradation and land-use conflict in East Kalimantan [58,59]. Despite these concerns, the scale and visibility of this transition offer a strategic opportunity to integrate EbA into national development planning. Measures such as incorporating urban wetlands, restoring degraded forest buffers, and embedding nature-based flood protection into core infrastructure design can enhance long-term climate resilience. Moreover, the influx of public funds and foreign investments associated with the new capital creates a rare financing window for EbA, which has traditionally suffered from fragmented, project-based funding. Instruments like green bonds, nature-based PPP models, and multilateral climate finance mechanisms could be aligned to support large-scale, community-centered adaptation initiatives. As a new administrative centre, Nusantara also has the potential to pioneer more integrated governance frameworks that link disaster risk reduction, ecological conservation, and sustainable urban growth. Future research should explore how such large-scale national projects can help embed EbA into long-term policy systems and accelerate resilience-building at scale. Future research should explore how such large-scale national projects can help embed EbA into long-term policy systems and accelerate resilience-building at scale, particularly in regions beyond Java where ecological sensitivity and institutional capacity vary widely.

While this study primarily focuses on Java Island due to the availability of documented EbA cases, it is crucial to acknowledge the distinct ecological and socio-economic challenges faced by other regions of Indonesia. For instance, in West Kalimantan, forest-dependent rural communities such as those in Nanga Jemah and Tubang Jaya are increasingly vulnerable to compound climate risks, including floods, droughts, and vector-borne diseases. Changes in rainfall patterns have disrupted cropping cycles, reduced river water levels vital for transportation, and intensified disease outbreaks. Traditional ecological knowledge, once central to community-based adaptation, is proving less effective due to climate unpredictability and limited access to meteorological information [67].

Similarly, in South Sumatra's Banyuasin District, adaptation planning faces obstacles related to land subsidence, coastal inundation, and rapid industrial development. The Banyuasin Valley, in particular, is projected to have 46% of its area at high or very high water-related climate risk by 2030. These risks stem from sea-level rise, extreme tides, and urban expansion around the Tanjung Api-api Port. Proposed adaptation strategies include artificial catchment development, rainwater harvesting, spatial planning controls, and integration with the Strategic Environmental Assessment (SEA) and National Action Plan for Climate Change Adaptation (RAN–API) [68].

These regional experiences underscore several limitations of the present study. The Java-centric focus constrains the geographic applicability of our findings. Moreover, the short duration of many EbA initiatives hinders evaluation of their long-term sustainability and socio-ecological impacts—especially regarding ecosystem regeneration and intergenerational knowledge transfer. Finally, gaps in spatial data and weak monitoring systems limit our ability to assess ecological change and program effectiveness. Addressing these challenges is essential for refining EbA strategies and enhancing resilience across Indonesia's diverse landscapes.

## Author Contributions

Conceptualization, Y.W., Y.T., N.K., A.R., and A.; methodology, Y.W.; writing—original draft preparation, Y.W., Y.T., N.K., A.R., A., and R.S.; writing—review and editing, Y.W. and A.; supervision, R.S. All authors have read and agreed to the published version of the manuscript.

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No new data were created or analyzed in this study. Data sharing is not applicable to this article.

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## Conflicts of Interest

The authors declare no conflict of interest.

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