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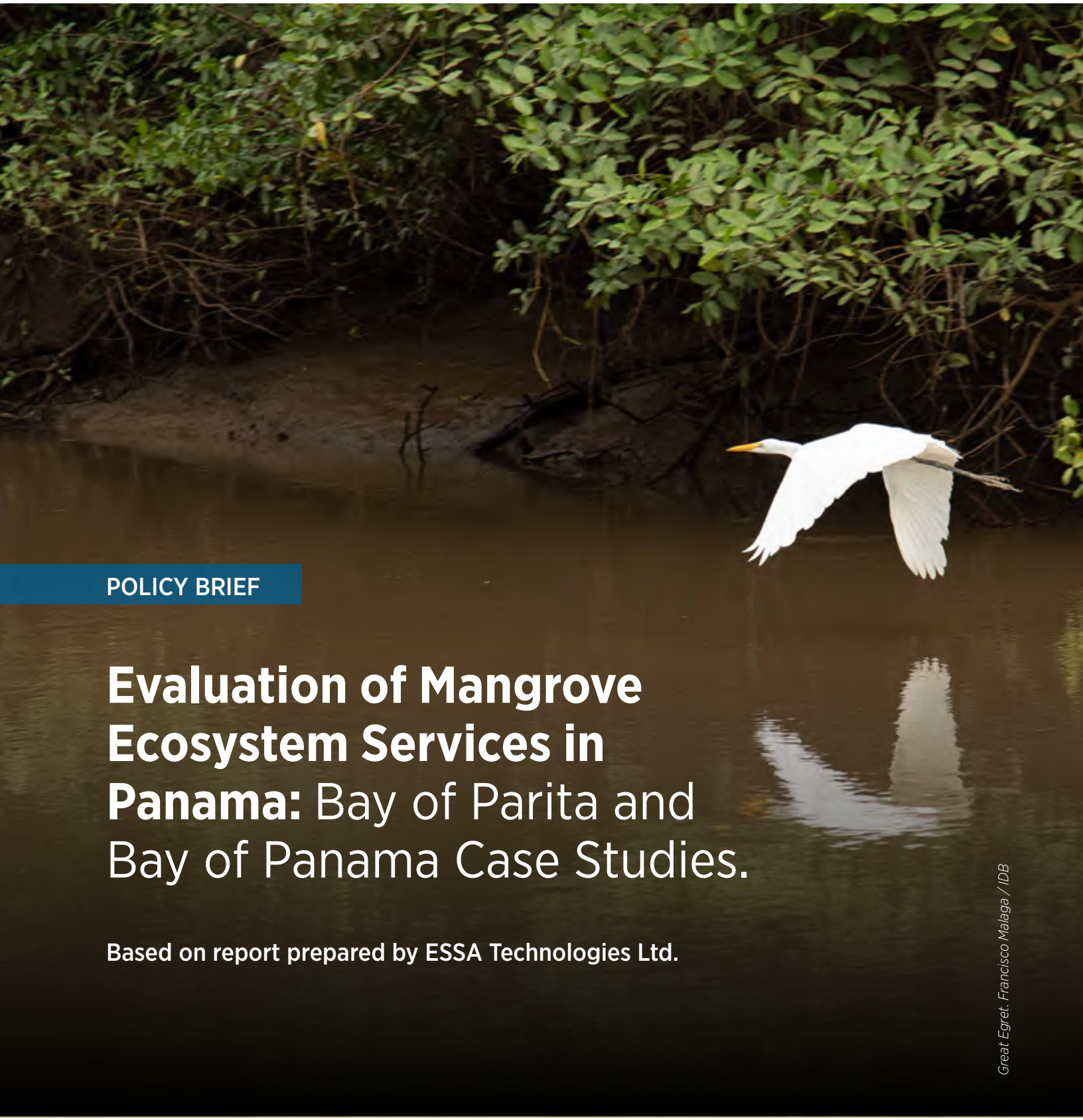

POLICY BRIEF

Evaluation of Mangrove Ecosystem Services in Panama: Bay of Parita and Bay of Panama Case Studies.

Based on report prepared by ESSA Technologies Ltd.

Great Egret. Francisco Malaga / IDB

ESSA
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INTRODUCTION

Among the many rich natural resources along Panama's coasts, mangroves are a remarkable treasure. Panama hosts 12 of the 65 mangrove species found globally and has the highest mangrove diversity in the Americas. Its vital mangrove ecosystems offer a range of essential services such as protecting coastlines, supporting biodiversity, providing local livelihoods and mitigating climate change.

Many of Panama's mangrove forests are in good condition. Their rich biodiversity is enabled by formal protections, rules, and regulations. Nevertheless, these valuable ecosystems face serious economic, social, and environmental pressures — including human activities, coastal development, and climate change impacts — that jeopardize their ability to sustain their essential services to human communities and wildlife.

To tackle this issue, the Blue Natural Heritage (BNH) project — led by the Inter-American Development Bank in partnership with the National Audubon Society and its local partner, Sociedad Audubon de Panamá — was established to raise the natural capital profile of Panama's marine-coastal ecosystem by fostering its valuation, protection, and enhancement.

This study, conducted by ESSA Technologies, Ltd, is part of a comprehensive set of research activities designed to lay the technical and scientific foundations to support the Panama government's climate and conservation agenda. Its objective is a valuation of mangrove ecosystem services in two critical bird habitats: Parita Bay and Panama Bay.

The study focuses on the valuation of mangroves as natural assets through a comprehensive inventory, an assessment of current conditions and future risks, and biophysical modeling. The research quantifies the benefits provided by these coastal ecosystems and identifies areas with significant potential for restoration and protection. The results offer a clear perspective on the value of mangroves and the challenges they face, providing a solid basis to guide management and policies for mangrove conservation.

This policy brief highlights the key findings of the study and offers actionable recommendations to safeguard Panama's valuable mangroves and their ecosystem services.

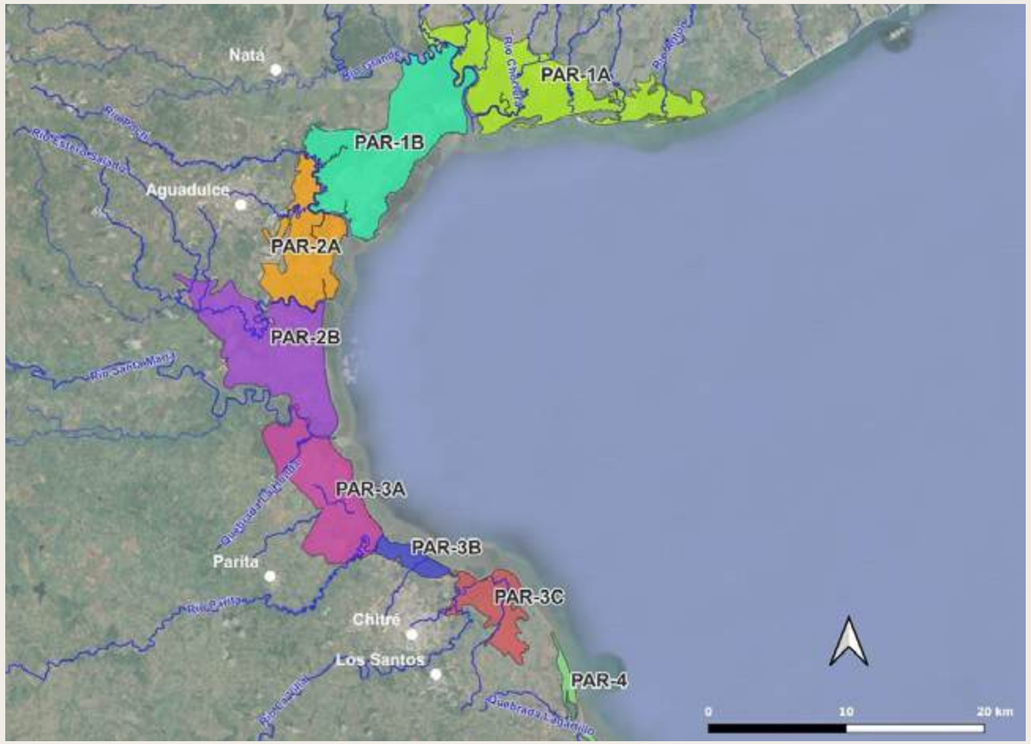
Mike Fernandez / National Audubon Society

Tocumen study area, Panama Bay wetlands

METHODOLOGY

The study area encompasses two pilot areas in the Pacific coast of Panama of critical importance for migratory birds and with significant mangrove coverage - Parita Bay and Panama Bay. These two areas were divided into multiple planning units based on similar regional characteristics, typically using major rivers to define boundaries. For each unit, a unique identifier was assigned (e.g., PAN-1B). A summary of the research methodology follows.

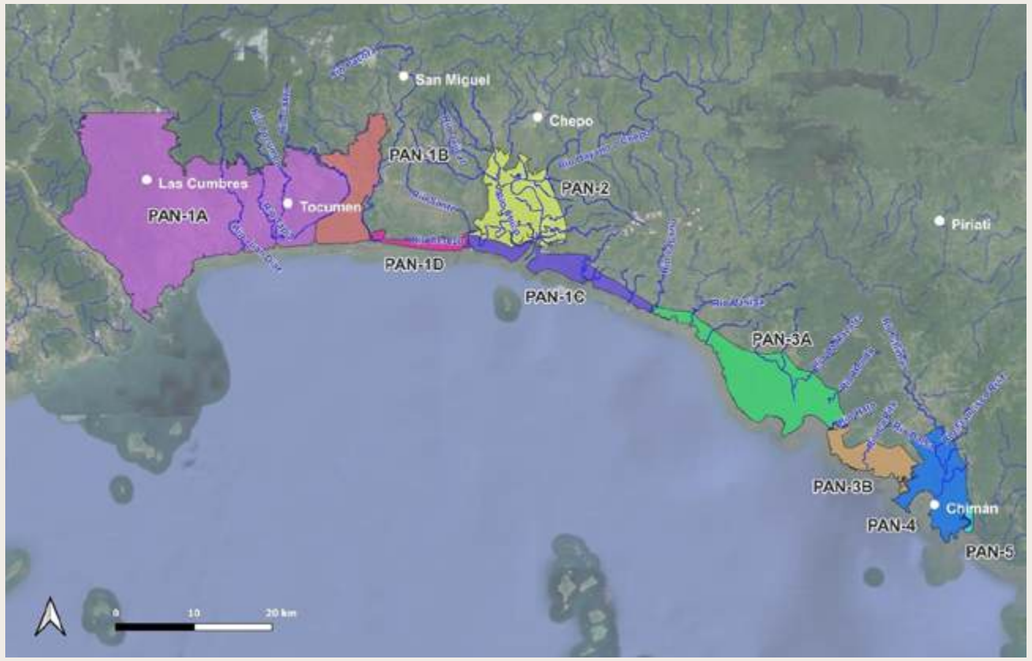
Figure 1: Planning units in Parita Bay study area.



PAR - 1A
PAR - 1B
PAR - 2A
PAR - 2B
PAR - 3A
PAR - 3B
PAR - 3C
PAR - 4

The establishment of planning units allows for focus on specific areas within a site, and attention to more local dynamics.

Figure 2: Planning units in Panama Bay study area.



PAN - 1A
PAN - 1B
PAN - 1C
PAN - 1D
PAN -2
PAN - 3A
PAN - 3B
PAN - 4
PAN - 5

Estuary in Parita Bay pilot site

Mike Fernandez / National Audubon Society

Inventory

To evaluate the mangroves' ecological state, the researchers began by developing a detailed inventory of mangrove ecosystems in the Bay of Panama and Bay of Parita, assigning condition and risk scores to planning units. Using data, scientific literature, and workshop inputs, researchers assessed stressor indicators and aggregated scores into condition and risk indices. These findings were visualized in an interactive dashboard, highlighting key stressors that affect mangrove health.

Economic Valuation

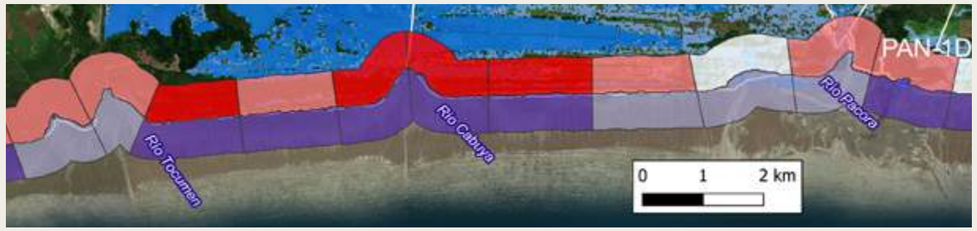
Next, researchers modeled and quantified the carbon sequestration, coastal protection, and fish-production benefits provided by mangroves in the target areas and estimated the economic value of those benefits where possible. To measure the economic value that mangroves in the study areas provide via carbon sequestration, researchers applied a production function with benefit transfer, using the social cost of carbon accompanied by sensitivity analysis using carbon market values. For coastal protection services, a production function with avoided-damage costs was used. A simple area-based benefit transfer was employed to value fish production, which could not be modeled due to data limitations.

Selection of Mangrove Management Scenarios

Management models simulate the impact that adding or removing mangrove areas would have on ecosystem services. Both disturbance-based scenarios (loss of mangroves due to timber harvesting, pollution, development, or shrimp farming) and conservation-based scenarios (gaining mangroves through active reforestation or passive growth in newly protected areas) were considered, and alternative management strategies were simulated.

DETERMINING ECOLOGICAL STATE OF MANGROVES

1 Inventory of mangrove extent



2 Preliminary score

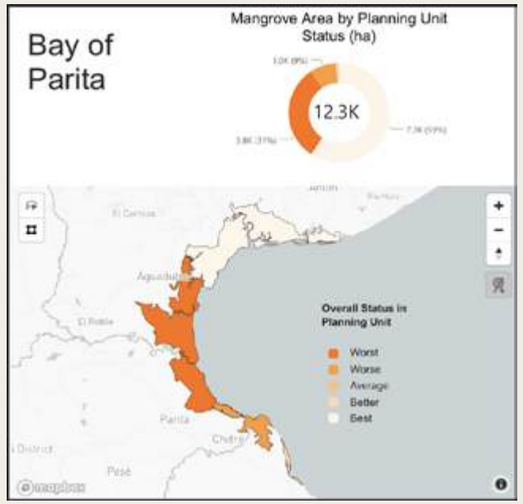
Current	Future/Potential
12 condition indicators	12 classes of risk
Stressor 1	Stressor 1
Stressor 2	Stressor 2
Stressor 3	Stressor 3
Condition assessments	Risk assessments

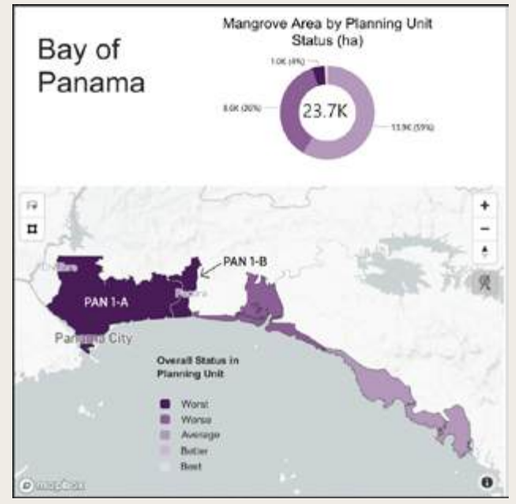
3 Combined score

Risk

Condition		Best/preferred 1	2	3	4	High 5
Worst	1	1	1	1	1	1
	2	2	2	2	2	1
	3	3	3	3	2	1
	4	4	4	3	2	1
Best/preferred	5	5	4	3	2	1

4 Interactive dashboard





5 Priorization results

Risk

Condition	Lower	Higher
Better	• Opportunity for protection • PAR-1A, PAR-1B, PAN-3A, PAN-4, PAN-5	• High priority opportunity for protection • PAR-4
Worse	• High priority opportunity for restoration • PAR-2B	• Opportunity for restoration • PAR-2A, PAR-3A, PAR-3B, PAR-3C • PAN-1A, PAN-1B

After establishing an inventory of the mangroves' ecological condition, scores were assigned to the current condition and future risks of mangroves in each subregion, per planning unit. Then, a valuation matrix was used to generate combined scores of the mangroves' ecological state and risks and identify priority areas for protection and restoration efforts.

PARITA BAY

Summary of Results

Mangroves in Parita Bay span 12,894 hectares, mostly within planning units that are in relatively good condition. Between 1982 and 2022, the mangrove area expanded by 1,014 hectares, likely due to decreased demand for wood and the creation of protected areas. While this growth is promising, evaluating the site's overall condition requires an examination of factors such as ecosystem services, which are influenced by mangrove age and exposure to threats. The loss of mature mangroves has a profound impact on ecosystem services, which cannot be quickly replaced by the growth of new mangroves.

- The mangroves located in PAR 1-A (4,243 hectares), PAR 1-B (3,039 hectares), PAR 2-B (1,218 hectares), and PAR 4 (120 hectares) are strong candidates for protection, and account for 8,500 hectares. These mangroves are in relatively good current condition but have different ranges of future risk. Those with higher future risk are of higher priority for protection.
- A significant portion (3,800 hectares) of the mangroves in Parita Bay that have the worst overall status are located in PAR-2A (742 hectares), PAR-2B (1,218 hectares), PAR-3A (1,873 hectares), PAR-3B (224 hectares), and PAR-3C (825 hectares). These mangroves face significant future risks and conservation challenges. A preliminary exercise from the project suggests that there are significant opportunities for restoration in these areas.
- In planning units PAR-2A and PAR-2B, the overall poor status relative to other planning units in Parita Bay is primarily driven by aquaculture development, agricultural expansion, industrial/urban development, sea level rise, and agricultural pollution. The future risk of aquaculture development sets these two units apart from other units. The poorer condition of PAR-3A is due to high agricultural pollution, higher road density, and past clearing for aquaculture.

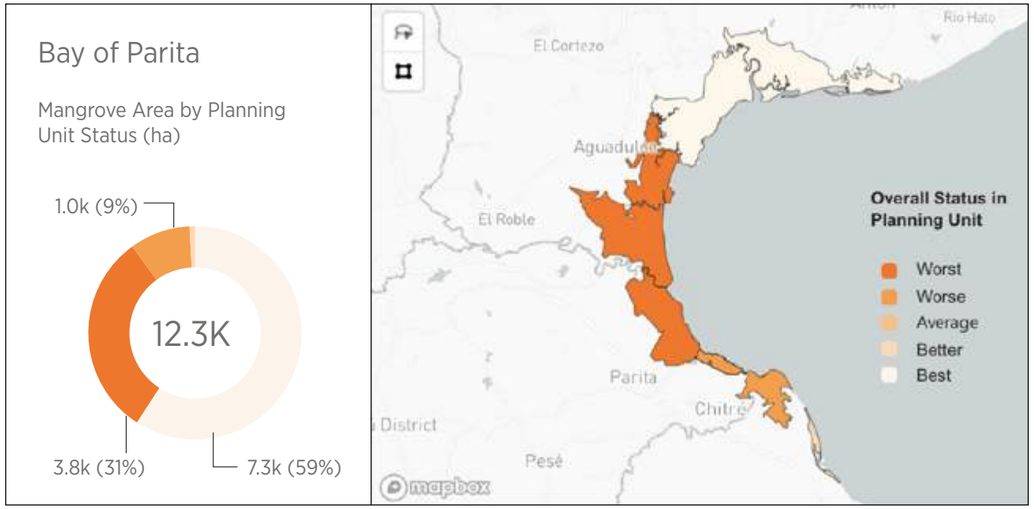
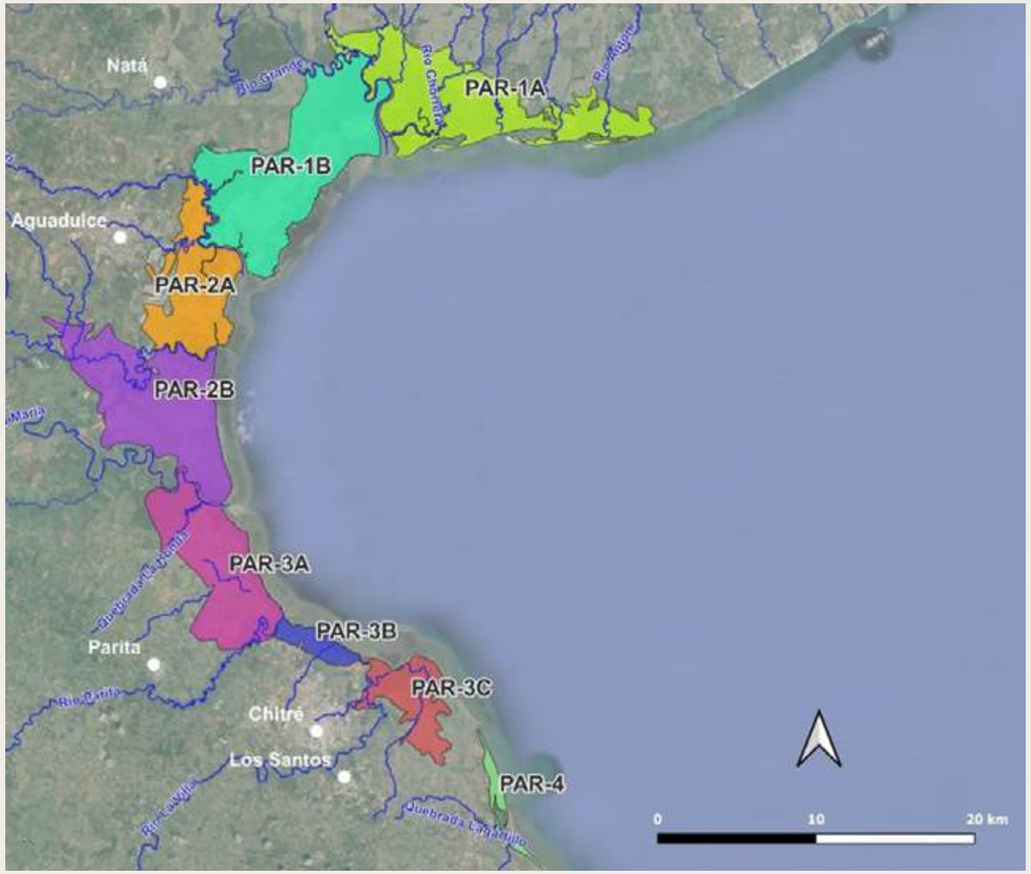


Figure 3: Mangrove coverage condition in Parita Bay - general status of the geographic subregion.

Priority Areas for Protection and Restoration

- In Parita Bay, high-priority protection areas extend from the Juan Hombrón mangroves to the Pocrí River and the surrounding area of Peñón de La Honda.
- Restoration efforts should focus on the zone between the Pocrí River and 1 km west of the La Villa River's mouth in Parita.

Figure 4: Ecological state and management recommendations for Parita Bay.



Higher future risk,
more potential for restoration

PAR - 2A PAR - 2B
PAR - 3A PAR - 3B PAR - 3C

Better conserved,
high coastal protection value

PAR - 1A
PAR - 1B PAR - 4

Parita Bay mangroves and background salt flats (“albinas”)

Mike Fernandez / National Auubon Society

Value of Blue Carbon: $39 Million in Economic Benefits

The coastal blue carbon model demonstrated that mangroves provide significant carbon sequestration benefits in Parita Bay. Over the next century, mangroves in Parita Bay ,will sequester 6.5 million tons of CO_2, valued at $39 million per year.

Results: Value of Blue Carbon

Scenario	*Annualized value of sequestration (net present value) Difference from reference value (in millions of US$, 2022)	
	Direct disturbance	Indirect disturbance
Baseline for Parita Bay	$39M/year	
Development of Megaport	($1.3M/year)	($4.4M/year) -($8.1M/year)
Expansion of rice and sugar cane crops	N/A	($0.6M/yr) - ($13M/yr)
Reactivation of Shrimp Farms	($0.1M/year)	N/A
Recovery of Shrimp Farming Areas	$3.4M/year	N/A

*Based on the social cost of carbon; discount rate of 1.5%. (The social cost of carbon is the global damage expected from climate change through the emission of one additional tonne of CO_2 in the atmosphere in a given year.)

Blue Carbon Benefits: Ours to Preserve, Enhance or Lose

Carbon Sequestration Scenarios : The proposed Megaport development in the Bay of Parita could result in a loss of carbon sequestration benefits of at least $1.38 million per year, assuming only direct effects of mangrove removal within the development footprint. If potential indirect effects — such as pollutant runoff, altered hydrology, and increased boat traffic — are considered, this loss could increase to as much as $8.09 million per year. Shrimp farm reclamation was identified as a promising mangrove restoration opportunity in the Bay of Parita, with potential carbon sequestration benefits of at least $3.43 million per year.

Coastal Protection: Mangroves help to stabilize coastlines, reduce erosion, and mitigate coastal flooding. While modeling shows mangroves have limited direct impact on flood risk in Parita Bay, they maintain the geomorphology of the coast and may act as “shock absorbers” for extreme river discharge and heavy rain.

Fish Production: Mangroves serve as essential habitats and food sources for commercially valuable fish and invertebrates in both study areas. However, data gaps in the study areas hindered a comprehensive assessment of the economic value of fishery production. By using a coarse approach that relied on findings from a previous study in Chiriquí, a value of $9.39 per hectare to calculate the artisanal fish production was used as a proxy to develop net fish production benefits valued at $115,347 per year in the Bay of Parita.

Local team supporting blue carbon sampling

Mike Fernandez / National Auubon Society

Red mangroves in one Parita Bay carbon monitoring unit

Mike Fernandez / National Audubon Society

Priority Areas for Protection and Restoration

In Parita Bay, high-priority protection areas extend from the Juan Hombrón mangroves to the Pocrí River and the surrounding area of Peñón de La Honda.

Condition	Risk: Lower	Risk: Higher
Better	• Opportunity for protection • PAR-1A, PAR-1B	• High priority opportunity for protection • PAR-4
Worse	• High priority opportunity for restoration • PAR-2B	• Opportunity for restoration • PAR-2A, PAR-3A, PAR-3B, PAR-3C

PANAMA BAY

Summary of Results

Mangroves in Panama Bay cover 23,306 hectares, with 95 % located in planning units of average or worse condition. Areas in poor condition and at high future risk (e.g., PAN-1A and PAN-1B) offer opportunities for restoration, while those in better condition with low future risk (e.g., PAN-3A, PAN-4, PAN-5) are suitable for strengthening its protection. Between 1982 and 2022, mangrove cover in Panama Bay decreased by 64.71 hectares, primarily due to rice production expansion near the Bayano River and possibly coastal erosion.

- Mangroves near Panama City (PAN-1A and PAN-1B), covering 4% (1,000 hectares) of the total mangrove area, are in the poorest ecological condition and face the highest risk of future loss in Panama Bay. These units are strong candidates for restoration if stressors can be addressed.
- The poor condition of mangroves in PAN-1A and PAN-1B stems from industrial and urban development, high road density (PAN-1A), agricultural pollution, and weak canopy cover (PAN-1B). PAN-1B also faces greater future risks from sea level rise and further development. A 2020 World Bank study found that mangrove loss in the lower Tocumen River basin has worsened coastal erosion and reduced buffering against high tides. This area, within these planning units, is identified as a potential site for mangrove restoration.

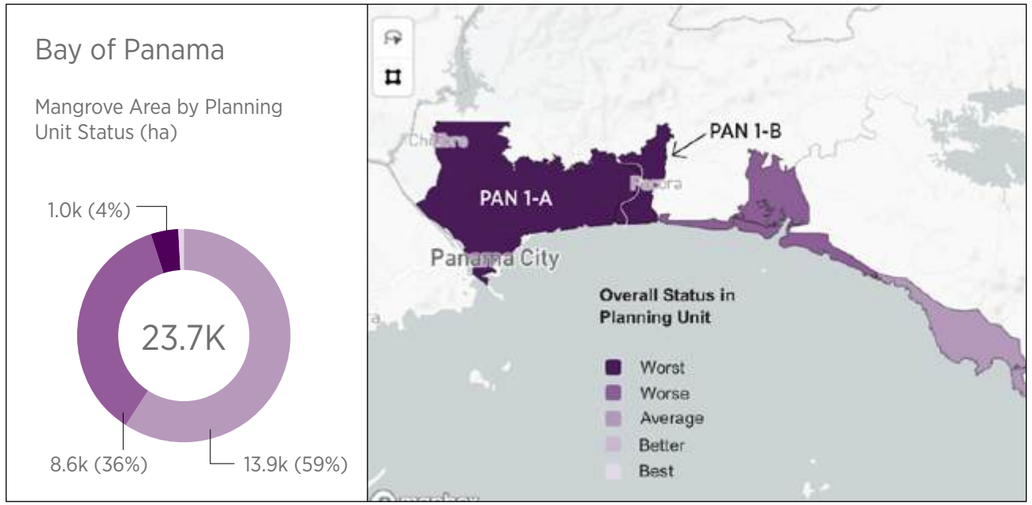


Figure 5: Mangrove coverage condition in Panama Bay - general status of the geographic subregion.

Results Panama Bay

Figure 6: Ecological state and management recommendations for Panama Bay.

Low coverage (4%), suitable for restoration

PAN - 1A PAN - 1B

High coverage (95%), suitable for protection

PAN - 3A PAN - 3B PAN - 4 PAN - 5

View of Panama City from Bay of Panama Wetlands Wildlife Refuge

Mike Fernandez / National Auubon Society

Value of Blue Carbon : $116 Million in Economic Benefits

The coastal blue carbon model demonstrated that mangroves provide significant carbon sequestration benefits in Panama Bay. Over the next century, mangroves in Panama Bay are projected to sequester 20.1 million tons of CO_2, providing $116 million annually in economic benefits.

Results: Value of Blue Carbon

Scenario	*Annualized value of sequestration (net present value) Difference from reference value (in millions of US$, 2022	
	Direct disturbance	Indirect disturbance
Baseline for Panama Bay	$116M/year	
Tocumen Airport Expansion	($0.01M/year)	($0.01M/year) - ($0.24M/year)
Urban development	($0.3M/year)	($0.6M/year) -($2.9M/year)

*Based on the social cost of carbon; discount rate of 1.5%. (The social cost of carbon is the global damage expected from climate change through the emission of one additional tonne of CO_2 in the atmosphere in a given year.)

Blue Carbon Benefits: Ours to Preserve, Enhance or Lose

Economic Benefits: Based on growth projections, disturbances to Panama Bay mangroves due to economic development could result in approximately $300,000 in direct losses of economic benefits per year, and up to $3.9 million in indirect losses.

Coastal Protection: Mangroves help to stabilize coastlines, reduce erosion, and mitigate coastal flooding. As in Parita Bay, modeling shows mangroves have limited impact on flood risk in Panama Bay, but they maintain the geomorphology of the coast and may act as "shock absorbers" for extreme river discharge and heavy rain. Their loss would accelerate the rates of coastal erosion and shoreline retreat. The World Bank highlights high risks for developments near mangroves south of Tocumen Airport, including the airport's expansion. The Blue Natural Heritage Project calls for integrated basin management, combining nature-based solutions with flood mitigation strategies such as beach nourishment, permeable structures, and tidal barriers.

Fish Production: Mangroves serve as essential habitats and food sources for commercially valuable fish and invertebrates in both study areas. However, data gaps in the study areas hindered a comprehensive assessment of the economic value of fishery production. By using a coarse approach that relied on findings from a previous study in Chiriquí, a value of $9.39 per hectare to calculate the artisanal fish production was used as a proxy to develop net fish production benefits valued at $222,402 per year in the Bay of Panama.

Register of belowground carbon sample core

Mike Fernandez / National Auubon Society

Panama City and Panamá Viejo UNESCO World Heritage Site bordering Bay of Panama site

Mike Fernandez / National Audubon Society

Priority Areas for Protection and Restoration

In Panama Bay, high-priority protection areas extend from the Lagarto River to the Majagual River (Chimán). Additionally, restoration efforts should focus on the entire Panama City peri-urban wetland (coastal).

Condition	Risk: Lower	Risk: Higher
Better	• Opportunity for protection • PAN-3A, PAN-4, PAN-5	• High priority opportunity for protection
Worse	• High priority opportunity for restoration	• Opportunity for restoration • PAN-1A, PAN-1B

RECOMMENDATIONS

To protect Panama's coastal ecosystems, key recommendations include conducting economic valuations, prioritizing the protection and restoration of critical mangrove areas, enhancing climate resilience efforts, and implementing flood mitigation strategies. Collaboration and public awareness are essential to ensuring the long-term conservation of Parita and Panama Bay.

1 Replication of economic valuation across Panama and beyond

Expand economic valuation efforts across Panama and beyond. Analyses should include:

- Mangrove ecological status
- Future risks
- Management strategies for mangroves and other coastal wetlands
- Economic valuation (supported by robust databases with essential variables)

These analyses can guide site- and sector-specific discussions for effective planning and decision-making, and can include assessments of additional ecosystem services such as the social and cultural significance of mangroves.

2 Protection and restoration

Strengthen efforts to protect and sustainably manage identified priority areas for mangrove protection and restoration (consistent with local conservation plans), and implement restoration initiatives in areas that have significant potential for mangrove recovery, such as former shrimp farming regions.

3 Climate ambition

Continue to prioritize the conservation and restoration of coastal wetlands, particularly mangroves, in Panama's Nationally Determined Contributions (NDC). Recognize their critical role in carbon sequestration and their ability to contribute to emissions reduction targets while also addressing biodiversity loss and protecting vulnerable coastal communities from climate change impacts.

4 Flood mitigation

Collaborate with government agencies, NGOs, and other organizations to:

- Integrate mangroves into flood mitigation strategies, especially in coastal areas vulnerable to heavy rainfall and river flooding.
- Promote a comprehensive approach to flood mitigation and hydrological solutions, combining mangroves' natural coastal protection with other methods, such as green-gray infrastructure.

5 Awareness and collaboration

- Raise public awareness about the critical importance of mangroves and other coastal ecosystems in sustaining Panama's natural capital.
- Encourage collaboration among government agencies, multilateral organizations, NGOs, civil society, and private sector stakeholders to work together in protecting and preserving these valuable resources

6 Data collection and research

- Support comprehensive data collection and research by strengthening the National Institute of Statistics and Census and ARAP, while building local capacity. Focus on understanding the full scope of fishery production supported by mangroves and the impact of mangrove area changes on fish populations. This will enable informed decisions on sustainable fishery management and highlight the economic value of these resources.
- Encourage the creation of effective monitoring systems and the integration of information platforms, especially those utilizing data from established baselines.

7 Green infrastructure

Incorporate green infrastructure, such as mangrove conservation and restoration, into coastal development plans to strengthen climate resilience and minimize economic losses from climate-related disasters.

8 Long-term conservation

- Panama Bay: Strengthen management by leveraging studies from the Blue Natural Heritage project, specifically the rapid ecological assessment of the Tocumen airport area and the current situation and policy recommendations for land use planning and watershed management of the Juan Díaz River.
- Parita Bay: Support Parita Bay's Conservation Plan by:
  - Promoting sustainable practices in aquaculture, agriculture, livestock, and fishing.
  - Encouraging ecotourism, bird watching, and rural agritourism in wetland areas.
  - Enhancing the technical, financial, and operational capacities of regional and local authorities.
  - Advocating for land management plans, ecological criteria, and improved site connectivity.
  - Building capacity in watershed management and governance while developing data collection and monitoring systems.

CONCLUSION

The mangroves of Panama Bay and Parita Bay play a key role in coastal protection, carbon sequestration, and fish production. Their preservation and sustainable management are essential to ecological and economic resilience.

The study demonstrated that mangroves provide important ecosystem services, and clarified opportunities for protection and restoration as well as scenarios in which mangroves could be lost or enhanced. Generally, planning units with the worst overall status of mangroves are those with the largest human populations, indicating a potential trade-off between conservation and development.

This study emphasizes the economic value of mangrove ecosystem services, offering a foundation for informed decisions and collaborative action. The results underscore the importance of safeguarding and enhancing Panama's coastal natural capital. To ensure that these ecosystems continue to provide vital services to future generations, collaboration and commitment to conservation will be essential.

By embracing the recommendations outlined in this policy brief, Panama can support the long-term resilience and prosperity of mangroves and associated coastal ecosystems as well as the communities that depend on them.

Measurements for determining aboveground carbon stock

Mike Fernandez / National Audubon Society

Value of Blue Carbon:

$155 million in economic benefits from carbon sequestration in these two bays alone.

Inventory and Condition of Mangroves

The study demonstrated that mangroves provide important ecosystem services, and clarified opportunities for protection and restoration as well as scenarios in which mangroves could be lost or enhanced. Generally, planning units with the worst overall status of mangroves are those with the largest human populations, indicating a potential trade-off between conservation and development.

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